Final Report
December 31, 2010

Grand Forks Signal Coordination Study

- Columbia Road
- Washington Street
- Gateway Drive
- DeMers Avenue
- 42nd Street

Prepared for:

- City of Grand Forks
- North Dakota Department of Transportation
- Grand Forks-East Grand Forks Metropolitan Planning Organization

ALLIANT
ENGINEERING, INC.

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Executive Summary

The Grand Forks – East Grand Forks Metropolitan Planning Organization (MPO), working together with the North Dakota Department of Transportation (NDDOT) and the City of Grand Forks, have been working towards improving the traffic signal timings along the arterial corridors of the community. The Grand Forks Traffic Signal Coordination Study (Signal Coordination Study) included five main corridor segments throughout the city of Grand Forks, North Dakota. The following section provides a brief overview and highlights key results obtained as part of the Signal Coordination Study.

Study Corridors

The Signal Coordination Study included five study corridors containing a total of 36 intersections:

- **Columbia Road.** Columbia Road between 28th Avenue and 6th Avenue. Columbia Road represents part of one signalized interconnect zone and consists of 8 signalized intersections.
- **Washington Street**: Washington Street between 32nd Avenue and 5th Avenue. Washington Street includes one interconnect zone with a total of 10 signalized intersections.
- **Gateway Drive**: Gateway Drive between 47th Street and 3rd Street. The Gateway Drive corridor includes one interconnect zone with a total of 10 signalized intersections.
- **DeMers Avenue**: DeMers Avenue between 20th Street and 42nd Street. DeMers Avenue is part of one interconnect zone and includes three signalized intersections.
- **42nd Street**: 42nd Street between 17th Avenue and 6th Avenue. The 42nd Street corridor is part of one interconnect zone and includes six signalized intersections.

Project Description and Purpose

The primary goal of the Signal Coordination Study is to provide improved traffic flow along each of the arterial corridors, reduce vehicle delays, vehicle stops, fuel consumption and improve safety. This was accomplished through installing optimized signal timing plans and upgrading traffic signal equipment. The Signal Coordination Study consisted of the following major components:

- Collecting traffic data (traffic volume counts, travel time studies, intersection average delay studies and crash history).
- Conducting a roadway and signal system inventory and evaluating the existing quality of traffic flow.
- Developing a traffic model to support preparing the new signal system timing coordination plans for each corridor.

- Installing new traffic signal controller equipment.
- Implementing the new timing plans to the street and fine-tuning them to real traffic conditions.
- Installing Transit Signal Priority (TSP) equipment on City Area Transit (CAT) buses and in the signal controller cabinets.
- Programming the controllers to accommodate TSP timing for transit vehicles.
- Developing timing plans at select intersections to help improve event entering and exiting at the Alerus and Ralph Engelstad Arenas.
- Developing additional timing plans to better suit "adverse weather" driving conditions.
- Conducting a "before" and "after" analysis and documenting the project benefits.
- Conducting a comprehensive evaluation of each corridor and providing the MPO with low cost intersection improvements to further maximize operational efficiencies.

Elements of Study

An evaluation of the existing condition was completed. Key components of the existing conditions include collection of intersection and traffic volume characteristics, signal timing characteristics, development and calibration of the traffic model and collection/evaluation of current measures of effectiveness. The Synchro7.0 and SimTraffic7.0 models developed in evaluation of the existing conditions were used to create optimized signal timing plans. The traffic signal optimization included developing timing plans consisting of new cycle lengths, intersection splits and offsets for each of the signalized zones and intersections.

After implementation of the timing plans, Alliant Engineering conducted field reviews and fine-tuned the signal coordination during the months of October 2009 (Columbia Road) and October 2010 (Gateway Drive, 42nd Street, Washington Street and DeMers Avenue). During the field reviews, minor adjustments were made to the optimized timing plans to further improve traffic flow and minimize cross-street delays. Following the completed implementation of the signal timing plans, the event timing plans and TSP timing parameters were installed and fine-tuned. Field studies were conducted for the "after" condition and compared to the "before" conditions. A benefit/cost analysis was also completed to evaluate the overall cost-effectiveness of the implemented signal timing plans.

The purpose of this document is to present the results of the Signal Coordination Study as will be discussed in the following sections:

- Introduction (Section 1.0)
- Existing Conditions (Section 2.0)
- Signal Timing Optimization and Implementation (Section 3.0)
- Ralph Engelstad Arena and Alerus Center Event Timing Plans (Section 4.0)
- Transit Signal Priority (Section 5.0)

- Adverse Weather Timing Plans (Section 6.0)
- Project Benefit Analysis (Section 7.0)
- Potential Improvement Measures (Section 8.0)

Signal Equipment Upgrades

As part of the Signal Coordination Study, the MPO installed new signal equipment, hardware and software in the existing signal cabinets. The signal equipment upgrades were made to accommodate the signal coordination and Transit Signal Priority (TSP) components. The following signal equipment/hardware/software upgrades were made:

- The existing 2070 Oasis controllers (16 controllers) on Columbia Road and 32nd Avenue were loaded with Econolite ASC3 software. The ASC3 software is operating on the existing rack mount 2070 controller processor unit.
- The existing 170 type controllers were replaced with Econolite ASC3 software operating on a rack mount 2070 processor controller to match Columbia Road and 32nd Avenue.
- Installation of four Econolite ASC2M master controllers.
- Installation of fiber optic communication cable along 32nd Avenue (31st Street to 34th Street).
- Replaced the existing Translink32 operating system with Aries Zone Monitoring software.
- Reconfigured the communication network to include four direct connect interconnect zones (Zone 1 to Zone 4) and individual system identification numbers. The direct connect interconnect between the Grand Forks Public Works Maintenance Building and the master controller occurs via the city wireless network system.

Event Timing Plans

The City of Grand Forks hosts two major entertainment/convention facilities, the Alerus Center with a seating capacity over 20,000 persons and the Ralph Engelstad Arena (REA) having a seating capacity of approximately 11,000 persons. Prior to and after a large event at either of the facilities, traffic volumes at adjacent intersections are considerably higher than normal and require special consideration. As part of the Signal Coordination Study, event traffic patterns at both facilities were reviewed and inbound and outbound traffic signal timing plans were developed to help improve the traffic flow at key intersections surrounding the arenas.

Transit Signal Priority

Transit Signal Priority (TSP) is the operation strategy used to provide advantage to buses at signalized intersections. The transit vehicle benefits from TSP by automatically adjusting the signal timing through green extension and red truncation. Green extension grants extra green time for a transit vehicle so the vehicle can safely pass through a traffic signal that is about to turn red. Red Truncation shortens other signal phases so that a transit vehicle receives a green light sooner than it normally would.

The TSP system uses GPS technology to determine the location and speed of transit vehicles. This information is broadcast to traffic signals equipped with special equipment. The traffic signal uses this information to determine how to adjust green and red times to better service the transit vehicle. The TSP equipment included:

- GTT (Global Traffic Technologies) phase selector installed in each signal cabinet.
- GPS receiver and radio installed on the traffic signal mast arm.
- GPS transmitter and vehicle computer unit (VCU) installed on the CAT buses and wired to the bus turn signal.
- Econolite ASC3 signal controller with Econolite TSP logic data key.

The MPO and the City of Grand Forks identified 28 intersections to receive TSP equipment. The following list highlights the intersections where TSP equipment is installed.

- 32nd Avenue and 38th Street
- 32nd Avenue and 34th Street
- 32nd Avenue and Columbia Road
- 32nd Avenue and 24th Street
- 32nd Avenue and 20th Street
- Columbia Road and 28th Avenue
- Columbia Road and 24th Avenue
- Columbia Road and 17th Avenue
- Columbia Road and 13th Avenue
- Columbia Road and 11th Avenue
- Columbia Road and 2nd Avenue
- Columbia Road and University Avenue
- Columbia Road and 6th Avenue
- Washington Street and 47th Avenue
- Washington Street and Campbell Drive
- Washington Street and 17th Avenue
- Washington Street and 13th Avenue
- Washington Street and DeMers Avenue
- Washington Street and University Avenue
- Washington Street and 5th Avenue
- Gateway Drive and I-29 East Ramp

- Gateway Drive and I-29 West Ramp
- Gateway Drive and 20th Street
- Gateway Drive and 3rd Street
- 42nd Street and University Avenue
- 17th Avenue and 20th Street
- 17th Avenue and 34th Street
- 24th Avenue and 20th Street

Adverse Weather Timing Plans

The presence or aftermath of heavy rain storms, snow storms or ice storms can result in motorists traveling and accelerating much more cautious and slower than under normal conditions. As the vehicle travel and acceleration speeds reduce, the normal dry weather timing plans can become unsuitable in providing vehicle progression along the corridor. To help manage traffic conditions and provide the best operation possible under adverse weather conditions, special timing plans were developed.

Key strategies in developing the timing plans included:

- Operating each corridor with less timing plans than normal conditions. Only an a.m. peak, mid-day and p.m. peak plan were developed for the weekdays.
- A Saturday adverse weather timing plan was developed for 32nd Avenue, Columbia Road and Washington Street.
- The same cycle length was used as the dry weather timing plans and common cycle lengths with inter-zone coordination between each of the corridors was maximized when appropriate.
- Left turn arrow and cross-street green times were increased wherever feasible.

Based on an operation analysis, the adverse weather timing plans are expected to improve motorist delay by 5 to 10 percent. It should be noted, the largest variable is the motorist travel speed. The analysis and premise of the adverse weather timing plans is they are enabled when the network travel speed is reduced to approximately 25 mph. Outside of this travel speed, the operational benefit would be much less.

The adverse weather timing plans are designed for short durations and are not meant to operate for extended periods of time. The following guidelines provide the City of Grand Forks some general parameters to assist in deciding if and when to turn on the adverse weather timing plans:

- The platoon travel speed along the major roadways is observed to be 25 mph or less.
- A measurable amount of snow has fallen within an hour.
- The roadways are snow or ice packed resulting in significantly reduced vehicle travel speeds.
- Ice storm resulting in ice covered roadways.

- Blowing snow resulting in less than 500 feet of visibility.

Before/After Vehicle Travel Time Results

A comparison of the "before" and "after" travel time field studies was made. Table ES-1 and Table ES-2 provide an overall summary of the travel time runs and percent improvement accomplished during the a.m. and p.m. peak periods, respectively.

As shown, the comparison of the "before" and "after" field collected travel times found the following:

- All routes and directions field measured were found to experience a travel time improvement during both the a.m. and p.m. peak hour and overall three-hour peak periods.
- Columbia Road experienced a significant travel time improvement during both the a.m. and p.m. peak periods (both directions), ranging from 21 percent to 40 percent. The largest improvement was found traveling southbound from 6th Avenue to 32nd Avenue during the p.m. peak hour.
- Washington Street experienced a significant travel time improvement during both the a.m. and p.m. peak periods (both directions), ranging from 6 percent to 27 percent. The largest improvement was found traveling northbound from 32nd Avenue to 5th Avenue during the p.m. peak hour.
- Gateway Drive experienced a significant travel time improvement during both the a.m. and p.m. peak periods (both directions), ranging from 15 percent to 24 percent. The largest improvement was found traveling eastbound from 47th Street to 3rd Street during the p.m. peak hour.
- DeMers Avenue experienced a travel time improvement during both peak periods in both directions. An improvement of two percent was achieved traveling westbound from Washington Street to 42nd Street. However, once a vehicle is given a green at Washington Street the improvement increases to 12 percent. The largest improvement of 19 percent was found traveling eastbound from 42nd Street to Washington Street.
- 42nd Street experienced a travel time improvement during all peak periods. Peak hour improvements ranged from six to 16 percent. The largest improvement was found traveling southbound during the p.m. peak hour.

Table ES - 1. Before/After Travel Time Comparison – A.M. Peak Period

Northbound/Eastbound

	Free Flow	AM Peak Hour (730 - 830)			AM Overall (700 - 900)			Peak Hour Average Speed (mph)	
		Before	After	Percent Improvement	Before	After	Percent Improvement	Before	After
	Min Sec	Min Sec	Min Sec		Min Sec	Min Sec			
Columbia Road - 32nd Avenue to 6th Avenue	4 33	8 7	5 44	**30%**	7 45	5 52	**24%**	19.3	27.3
Washington Street - 32nd Avenue to 5th Avenue	4 50	7 33	5 54	**22%**	7 9	5 28	**24%**	20.0	25.5
Gateway Drive - 47th Street to 3rd Street	4 24	6 22	4 53	**23%**	5 58	4 51	**19%**	25.4	33.1
DeMers Avenue - 42nd Street to Washington Street	3 21	4 36	4 10	**9%**	4 21	4 8	**5%**	29.1	32.1
42nd Street - 17th Avenue to 6th Avenue	3 8	4 10	3 49	**8%**	3 57	3 43	**6%**	29.0	31.6

Southbound/Westbound

	Free Flow	AM Peak Hour (730 - 830)			AM Overall (700 - 900)			Peak Hour Average Speed (mph)	
		Before	After	Percent Improvement	Before	After	Percent Improvement	Before	After
	Min Sec	Min Sec	Min Sec		Min Sec	Min Sec			
Columbia Road - 6th Avenue to 32nd Avenue	4 48	7 18	5 30	**25%**	6 48	5 24	**21%**	22.6	30.0
Washington Street - 5th Avenue to 32nd Avenue	4 54	5 44	5 23	**6%**	5 41	5 18	**7%**	22.4	23.8
Gateway Drive - 3rd Street to 47th Street	4 17	6 2	4 52	**19%**	5 35	4 45	**15%**	25.5	31.6
DeMers Avenue - Washington Street to 42nd Street	3 31	4 45	4 2	**15%**	4 35	4 8	**10%**	29.6	34.8
42nd Street - 6th Avenue to 17th Avenue	3 5	4 19	3 37	**16%**	4 7	3 27	**16%**	25.8	30.8

1. Ulteig Engineers field collected data in September of 2009, March of 2010, and April of 2010 (Before) and October of 2009, November of 2010, and December of 2010 (After)

Table ES - 2. Before/After Travel Time Comparison – P.M. Peak Period

Northbound/Eastbound

	Free Flow	PM Peak Hour (430 - 530)			PM Overall (300 - 600)			Peak Hour Average Speed (mph)	
		Before	After	Percent Improvement	Before	After	Percent Improvement	Before	After
	Min Sec	Min Sec	Min Sec		Min Sec	Min Sec			
Columbia Road - 32nd Avenue to 6th Avenue	4 33	8 7	5 44	**30%**	7 45	5 52	**24%**	19.3	27.3
Washington Street - 32nd Avenue to 5th Avenue	4 50	8 42	6 28	**26%**	8 36	6 16	**27%**	17.3	23.3
Gateway Drive - 47th Street to 3rd Street	4 24	6 45	5 8	**24%**	6 14	5 3	**19%**	24.0	31.5
DeMers Avenue - 42nd Street to Washington Street	3 21	5 25	4 23	**19%**	5 11	4 22	**16%**	24.7	30.5
42nd Street - 17th Avenue to 6th Avenue	3 8	4 34	3 59	**13%**	4 33	3 51	**15%**	26.4	30.3

Southbound/Westbound

	Free Flow	PM Peak Hour (430 - 530)			PM Overall (300 - 600)			Peak Hour Average Speed (mph)	
		Before	After	Percent Improvement	Before	After	Percent Improvement	Before	After
	Min Sec	Min Sec	Min Sec		Min Sec	Min Sec			
Columbia Road - 6th Avenue to 32nd Avenue	4 48	10 16	6 11	**40%**	9 59	6 8	**38%**	16.1	26.7
Washington Street - 5th Avenue to 32nd Avenue	4 54	7 20	5 58	**19%**	7 8	5 50	**18%**	17.5	21.5
Gateway Drive - 3rd Street to 47th Street	4 17	5 47	4 25	**24%**	5 47	4 27	**23%**	26.6	34.9
DeMers Avenue - Washington Street to 42nd Street	3 31	4 38	4 31	**2%**	4 40	4 22	**6%**	30.3	31.1
42nd Street - 6th Avenue to 17th Avenue	3 5	4 29	3 46	**16%**	4 35	3 37	**21%**	24.9	29.7

1. Ulteig Engineers field collected data in September of 2009, March of 2010, and April of 2010 (Before) and October of 2009, November of 2010, and December of 2010 (After)

Project Benefit

A benefit/cost analysis was completed to establish the annual economic savings incurred as a result of the Signal Coordination Study. Typical measures of effectiveness (MOE) used in estimating the benefit of signal optimization projects include approach vehicle delay, vehicle stops and fuel consumption. Table ES-3 illustrates the overall daily and annual "before" and "after" network MOE comparison and percent improvement.

Table ES - 3. Measures of Effectiveness – Network Performance Comparison

Total Network - Columbia Road

MOE	Daily Benefit (Weekday)				Annual Net Reduction
	Before	After	Net Reduction	Percent Improvement	
Stops (no. of veh)	173,808	145,749	**28,059**	**16.1%**	**7,042,684**
Delay (hr)	1,777	1,566	**211**	**11.9%**	**52,871**
Fuel Consumption (gal)	4,520	4,327	**193**	**4.3%**	**48,456**

Total Network - Washington Street

MOE	Daily Benefit (Weekday)				Annual Net Reduction
	Before	After	Net Reduction	Percent Improvement	
Stops (no. of veh)	164,036	143,415	**20,622**	**12.6%**	**5,175,997**
Delay (hr)	1,964	1,790	**174**	**8.9%**	**43,794**
Fuel Consumption (gal)	5,069	4,855	**214**	**4.2%**	**53,676**

Total Network - Gateway Drive

MOE	Daily Benefit (Weekday)				Annual Net Reduction
	Before	After	Net Reduction	Percent Improvement	
Stops (no. of veh)	120,398	89,547	**30,850**	**25.6%**	**7,743,413**
Delay (hr)	942	833	**109**	**11.5%**	**27,238**
Fuel Consumption (gal)	3,620	3,331	**289**	**8.0%**	**72,526**

Total Network - DeMers Avenue/42nd Street

MOE	Daily Benefit (Weekday)				Annual Net Reduction
	Before	After	Net Reduction	Percent Improvement	
Stops (no. of veh)	89,025	67,524	**21,501**	**24.2%**	**5,396,626**
Delay (hr)	633	533	**101**	**15.9%**	**25,304**
Fuel Consumption (gal)	3,177	2,935	**242**	**7.6%**	**60,704**

Based on the study results, an annual benefit is estimated at approximately 4.0 million dollars, which includes an estimated annual savings of 228,000 gallons of gasoline. The benefit/cost ratio is computed based on the comparison between the annual net benefit and the total project cost. As shown in Table ES-4, the Signal Coordination Study resulted in a benefit/cost ratio of approximately 24:1 considering only one year of benefit.

Table ES - 4. Project Benefit to Cost Ratio

Segment	Number of Intersections	Total Cost / Intersection ($)	Benefit ($)	Benefit-Cost Ratio
Columbia Road - 32nd Avenue to 6th Avenue	8	$39,031	$1,217,110	**31**
Washington Street - 32nd Avenue to 5th Avenue	10	$45,918	$1,014,396	**22**
Gateway Drive - 47th Street to 3rd Street	10	$45,678	$973,645	**21**
42nd Street - 17th Avenue to 6th Avenue DeMers Avenue - 20th Street to 42nd Street	8	$37,142	$822,704	**22**
Total Project (All Zones)	**36**	**$167,769**	**$4,027,855**	**24**

Key Project Highlights

The project benefit analysis estimates the Signal Coordination Study resulted in a 24:1 benefit/cost ratio and an estimated annual economic savings of 4.0 million dollars, which includes an estimated annual savings of 228,000 gallons of gasoline. A number of factors contribute to the project benefit:

- Most routes and directions field measured were found to experience a travel time improvement during both the a.m. and p.m. peak hour and overall three-hour peak periods.
- Columbia Road experienced a significant travel time improvement during both the a.m. and p.m. peak periods (both directions). The largest improvement was found traveling southbound from 6th Avenue to 32nd Avenue (40 percent travel time improvement).
- Washington Street experienced a significant travel time improvement during both the a.m. and p.m. peak periods (both directions). The largest improvement was found traveling northbound from 32nd Avenue to 5th Avenue (26 percent travel time improvement).
- Gateway Drive experienced a significant travel time improvement during both the a.m. and p.m. peak periods (both directions). The largest improvement was found

traveling westbound from 3rd Street to 47th Street (24 percent travel time improvement).

- On a daily basis, the overall network delay is estimated to be reduced by over 11 percent.
- The project benefited from the development of several new off peak and mid-day timing plans, improving intersection efficiency and reducing motorist delay.
- Overall an estimated 18 percent reduction in total vehicle stops was found, saving time and fuel.
- The result of the Signal Coordination Study provided an improved balance between mainline progression and intersection delay, meeting the key objective of the project.

Potential Improvement Measures

As part of the Signal Coordination Study an operation review of each of the study corridors was completed. During the field implementation and signal timing review process, a few signal operation or roadway improvements were identified for further review and/or consideration. The purpose of the following sections is to document low cost signal operation or geometric modifications to improve intersection efficiency.

Programmed Future Improvements

The MPO has identified and programmed several future reconstruction projects within the study network that are expected to result in significant improvement at key intersections. Several of the items are currently programmed within the Long Range Transportation Plan (LRTP). These improvements include the following:

- Reconstruction of the Gateway Drive/Columbia Road intersection. Grand Forks is currently in the process of developing the preliminary intersection design layout.
- Reconstruction of the Washington Street/DeMers Avenue intersection. The Washington Street/DeMers Avenue intersection operates at capacity during both the a.m. and p.m. peak hours. The MPO recently awarded a planning study contract to determine the appropriate intersection and roadway improvements necessary to improve the intersection operations.
- Columbia Road at DeMers Avenue southbound entrance ramp – provide an exclusive auxiliary lane to 11th Avenue. The auxiliary lane would provide improved merging and weaving operations. This improvement is currently programmed for 2013.
- Columbia Road at 17th Avenue - construct an exclusive right turn lane on the northbound, southbound and eastbound approaches. Implementation should occur following the LRTP programmed 2013 improvements.
- Construct a secondary access to the Red River High School south of 17th Avenue, along the 20th Avenue alignment. The proposed access would extend 20th Avenue from 25th Street to Columbia Road and should be designed as a ¾ style intersection with Columbia Road (provide southbound left turn and northbound

right turn movements into the site, and prohibit the westbound left turn (outbound) movement). This access road is currently programmed for 2013.

Future Intersection Operation Improvements

The following lane use signing/signal modifications, operations or pavement markings are expected to result in improved intersection efficiency or safety.

- 42nd Street at 6th Avenue – install front loop detector between the stop bar and railroad tracks.
- Gateway Drive at Washington Street – consider installing protected/permissive left turn phasing for all four left turn movements.
- Gateway Drive at I-29 East Ramp – install protected/permissive left turn phasing for the eastbound left turn movement.
- Columbia Road at 32nd Avenue – construct a second northbound and westbound left turn lanes.
- Columbia Road at 13th Avenue – construct northbound and southbound right turn lanes.
- In future traffic signal modifications and design policies, the City of Grand Forks and NDDOT should consider the installation of far side pole mounted signal indications. With only the overhead signal indication, waiting left turn vehicles can block the view of the indication. This results in reduced capacity and could be contributing to left turn related crashes.
- Review the mast arm signing at each intersection to ensure a consistent use of the "Left Turn Yield on Green Ball" sign.
- Develop a program (and funding source) for regular retiming of the major signalized corridors. Signal optimization degrades linearly over time due to growth and changes in traffic patterns. Depending on the growth or changes in land use, fully re-optimizing the system should occur every three to five years.

Washington Street Left Turn Lane Improvements

The MPO has recently submitted an application to the North Dakota Department of Transportation (NDDOT) to receive federal transportation funding under the 2012 Highway Safety Improvement Program (HISP). If awarded funding, the proposed improvements could be constructed as soon as 2015. The project submittal includes the reconstruction of Washington Street between 17th Avenue and 28th Avenue to provide left turn lane improvements and traffic signal modifications to provide a northbound and southbound protected/permissive left turn phasing. This improvement will allow motorists to turn left on a "green ball" saving delay. In addition to the left turn arrow modification, the proposed improvement project will narrow the medians at the intersections to provide a positive left turn lane offset.

The primary beneficiaries of the proposed improvements are left turning motorists. It should be noted, the installation of protected/permissive left turn phasing will negate the ability for Washington Street to operate with lead/lag left turn operation (due to yellow ball trap safety issue). As a result, vehicle progression along the corridor will decrease. In

most cases, the overall delay along the corridor is expected to outweigh the progression impact. The exception is during the p.m. peak hour. The p.m. peak hour traffic conditions benefit significantly from lead/lag left turn operation. As part of the Washington Street improvement project, the following additional recommendations are made:

- Construct exclusive northbound and southbound right turn lanes on Washington Street at the 28th Avenue and Campbell Drive intersections.
- Washington Street/Campbell Drive should continue to operate with permissive only left turn phasing.
- The northbound and southbound left turn lanes should be lengthened to provide a minimum of 400 feet (storage plus deceleration) of length wherever feasible.

1.0 Introduction

The Grand Forks – East Grand Forks Metropolitan Planning Organization (MPO), working together with the North Dakota Department of Transportation (NDDOT) and City of Grand Forks, have been working towards improving the traffic signal timings along the arterial corridors of the community. The Grand Forks Traffic Signal Coordination Study (Signal Coordination Study) included five main corridor segments throughout the city of Grand Forks, North Dakota. The study corridors include:

- **Columbia Road.** Columbia Road between 28th Avenue and 6th Avenue. Columbia Road represents part of one signalized interconnect zone and consists of 8 signalized intersections.
- **Washington Street**: Washington Street between 32nd Avenue and 5th Avenue. Washington Street includes one interconnect zone with a total of 10 signalized intersections.
- **Gateway Drive**: Gateway Drive between 47th Street and 3rd Street. The Gateway Drive corridor includes one interconnect zone with a total of 10 signalized intersections.
- **DeMers Avenue**: DeMers Avenue between 20th Street and 42nd Street. DeMers Avenue is part of one interconnect zone and includes three signalized intersections.
- **42nd Street**: 42nd Street between 17th Avenue and 6th Avenue. The 42nd Street corridor is part of one interconnect zone and includes six signalized intersections.

The geographic extent of the Signal Coordination Study location with respect to the state of North Dakota is documented in Figure 1. Each of the five study corridors are primary arterials and carry regional significance to the transportation system. As such, the MPO has identified a need to maintain a high level of service for both motor vehicle and transit vehicles to ensure optimal performance. The location of each of the corridors is shown in Figure 2.

1.1 Study Goals and Process

The primary goal of the Signal Coordination Study is to provide improved traffic flow along each of the arterial corridors, reduce vehicle delays, vehicle stops, fuel consumption and improve safety. This was accomplished through installing optimized signal timing plans and upgrading traffic signal equipment. The Signal Coordination Study consisted of the following major components:

- Collecting traffic data (traffic volume counts, travel time studies, intersection average delay studies and crash history).
- Conducting a roadway and signal system inventory and evaluating the existing quality of traffic flow.

- Developing a traffic model to support preparing the new signal system timing coordination plans for each corridor.
- Installing new traffic signal controller equipment.
- Implementing the new timing plans to the street and fine-tuning them to real traffic conditions.
- Installing Transit Signal Priority (TSP) equipment on Cities Area Transit (CAT) buses and in the signal controller cabinets.
- Programming the controllers to accommodate TSP timing for transit vehicles.
- Developing timing plans at select intersections to help improve event entering and exiting at the Alerus and Ralph Englestad Arenas.
- Developing additional timing plans to better suit "adverse weather" driving conditions.
- Conducting a "before" and "after" analysis and documenting the project benefits.
- Conducting a comprehensive evaluation of each corridor and providing the MPO with low cost intersection improvements to further maximize operational efficiencies.

1.2 Study Review Committee

The study was guided by a Study Review Committee (SRC) including representatives from the City of Grand Forks (Engineering, CAT and Public Works) and the MPO. The role of the SRC was to administer and guide the technical aspects of the project, coordinate implementation of signal hardware components, provide input on the study process and final coordination timing plans.

1.3 Public Participation Plan

Public participation is an important element of any planning process. The Signal Coordination Study consisted largely of equipment installation and the installation of signal coordination timing plans. As such, the goal of the public participation plan was to provide a means to inform the public on the project status, detailed project information and opportunity to comment. The public participation plan included:

- **Project Website**
  A project website was maintained on the MPO Projects Page. The website provides project information documents, reports, schedule overview and an electronic comment form. http://www.theforksmpo.org/Pages/Projects.htm
- **Two Public Information Meetings**
  The first public information meeting was held on October 14, 2009 to engage interested citizens of the project, the project process, and schedule. A second public information meeting was held at the November 3, 2010 Planning and Zoning Commission Meeting. A formal presentation of the project components, study findings and TSP components was given to the committee and aired over cable television broadcast.

1.4 Elements of Study

An evaluation of the existing condition was completed. Key components of the existing conditions include collection of intersection and traffic volume characteristics, signal timing characteristics, development and calibration of the traffic model and collection/evaluation of current measures of effectiveness. The Synchro7.0 and SimTraffic7.0 models developed in evaluation of the existing conditions were used to create optimized signal timing plans. The traffic signal optimization included developing timing plans consisting of new cycle lengths, intersection splits and offsets for each of the signalized zones and intersections.

After implementation of the timing plans, Alliant Engineering conducted field reviews and fine-tuned the signal coordination plans during the months of October 2009 (Columbia Road) and October 2010 (Gateway Drive, 42nd Street, Washington Street and DeMers Avenue). During the field reviews, minor adjustments were made to the optimized timing plans to further improve traffic flow and minimize cross-street delays. Following the completed implementation of the signal timing plans, the event timing plans and TSP timing parameters were installed and fine-tuned. Field studies were conducted for the "after" condition and compared to the "before" conditions. A benefit/cost analysis was also completed to evaluate the overall cost-effectiveness of the implemented signal timing plans.

The purpose of this document is to present the results of the Signal Coordination Study as will be discussed in the following sections:

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- Project Benefit Analysis (Section 7.0)
- Potential Improvement Measures (Section 8.0)

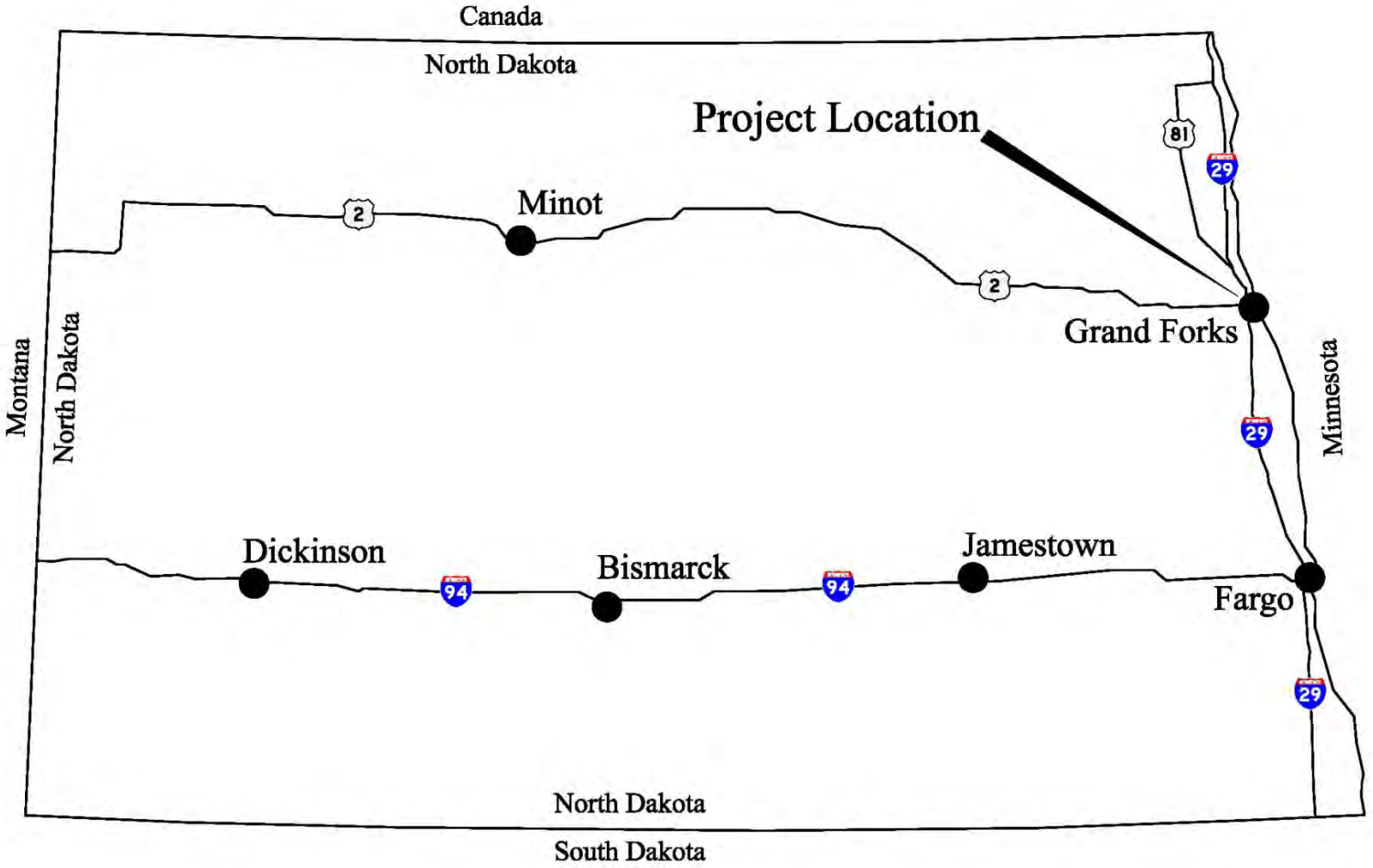


Figure 1. Project Vicinity Map

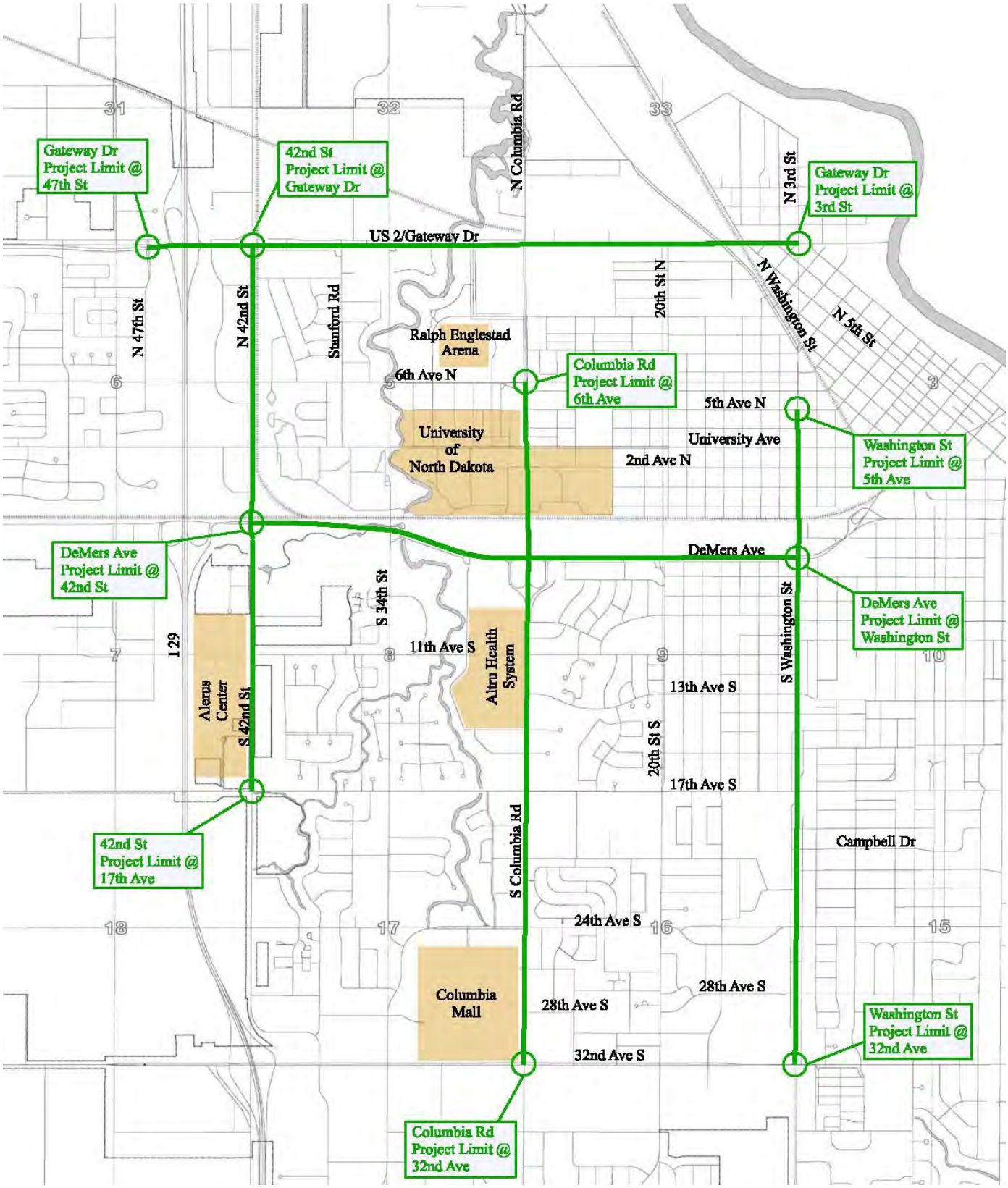


Figure 2. Project Location Map

2.0 Existing Conditions

An evaluation of the existing conditions was completed. Key components of the existing conditions include collection of corridor intersection and traffic volume characteristics, signal timing characteristics, development and calibration of the traffic model and collection/evaluation of current measures of effectiveness.

2.1 Existing Roadway, Traffic and Safety Characteristics

The following sections document the key characteristics of the existing conditions.

2.1.1 Interconnect Zones

The Signal Coordination Study included developing an existing condition traffic model for four separate networks and included 36 total intersections. Table 1 summarizes the study intersections. Figure 3 documents the location of each signalized intersection, critical intersection, critical event intersection, and coordination zones for the corridors included in this project.

The existing traffic signal equipment consists of either 170 or 2070 Oasis Software signal controllers managed by the Translink32 operations software. Under the 170/2070 and Translink system, the City of Grand Forks operates the network with five distinct zones:

- Zone 151 – 32nd Avenue between I-29 West Ramp and 20th Avenue (master controller located at 32nd Avenue/Columbia Road)
- Zone 400 – Columbia Road between 28th Avenue and 6th Avenue (shared master controller at 32nd Avenue/Columbia Road)
- Zone 222 – Washington Street between 5th Avenue and 47th Avenue
- Zone 60 – Gateway Drive between 47th Street and 3rd Street (master controller located at Gateway Drive/Columbia Road)
- Zone 10 – 42nd Street between 6th Avenue and 17th Avenue and DeMers Avenue between 34th Street and 20th Street.

The Signal Coordination Study includes the implementation of Transit Signal Priority (TSP), which is not supported by the 170 or 2070 Oasis Software. As such, the project will include the installation of new signal controller and master controller equipment. Further discussion will be provided in Section 3.1

Table 1. Signal Coordination Study Intersections

Existing Translink System Interconnect Zone	Synchro Node ID	Intersection	Phase	Responsible Agency	Existing Signal Controller	Existing Operation
400	420	Columbia Road at 6th Avenue N	5	City of Grand Forks	2070 (Oasis)	COORD (TOD)
	418	Columbia Road at University Avenue	8	City of Grand Forks	2070 (Oasis)	COORD (TOD)
	416	Columbia Road at 2nd Avenue N	6	City of Grand Forks	2070 (Oasis)	COORD (TOD)
	414	Columbia Road at 11th Avenue S	6	City of Grand Forks	2070 (Oasis)	COORD (TOD)
	412	Columbia Road at 13th Avenue S	8	City of Grand Forks	2070 (Oasis)	COORD (TOD)
	410	Columbia Road at 17th Avenue S	8	City of Grand Forks	2070 (Oasis)	COORD (TOD)
	408	Columbia Road at 24th Avenue S	8	City of Grand Forks	2070 (Oasis)	COORD (TOD)
	406	Columbia Road at 28th Avenue S	8	City of Grand Forks	2070 (Oasis)	COORD (TOD)
151	152**	Columbia Road at 32nd Avenue S	8	City of Grand Forks	2070 (Oasis)	COORD (TOD)
222	114	Washington Street at 5th Avenue N	2	City of Grand Forks	170	COORD (TOD)
	110	Washington Street at University Avenue N	8	City of Grand Forks	170	COORD (TOD)
	111	Washington Street at 2nd Avenue N	5	City of Grand Forks	170	COORD (TOD)
	10	Washington Street at DeMers Avenue S	8	City of Grand Forks	170	COORD (TOD)
	11	Washington Street at 13th Avenue S	8	City of Grand Forks	170	COORD (TOD)
	12	Washington Street at 17th Avenue S	8	City of Grand Forks	170	COORD (TOD)
	34	Washington Street at Campbell Drive	6	City of Grand Forks	170	COORD (TOD)
	13**	Washington Street at 24th Avenue S	8	City of Grand Forks	170	COORD (TOD)
	9	Washington Street at 28th Avenue S	6	City of Grand Forks	170	COORD (TOD)
	14	Washington Street at 32nd Avenue S	8	City of Grand Forks	170	COORD (TOD)
60	61	Gateway Drive at 3rd Street	2	City of Grand Forks	170	COORD (TOD)
	62	Gateway Drive at 5th Street	5	City of Grand Forks	170	COORD (TOD)
	63	Gateway Drive at Washington Street	8	City of Grand Forks	170	COORD (TOD)
	64	Gateway Drive at 20th Street	6	City of Grand Forks	170	COORD (TOD)
	65**	Gateway Drive at Columbia Road	6	City of Grand Forks	170	FREE
	66	Gateway Drive at Stanford Road	6	City of Grand Forks	170	FREE
	67	Gateway Drive at 42nd Street	6	City of Grand Forks	170	FREE
	68	Gateway Drive at I-29 East Ramp	3	City of Grand Forks	170	COORD (TOD)
	69	Gateway Drive at I-29 West Ramp	2	City of Grand Forks	170	COORD (TOD)
	70	Gateway Drive at 47th Street	6	City of Grand Forks	170	COORD (TOD)
10	16	DeMers Avenue at 20th Street	5	City of Grand Forks	170	FREE
	23	DeMers Avenue at 34th Street	2	City of Grand Forks	170	FREE
	41**	42nd Street at University Avenue	8	City of Grand Forks	170	FREE
	42	42nd Street at DeMers Avenue	8	City of Grand Forks	170	FREE
	43	42nd Street at 17th Avenue	5	City of Grand Forks	170	FREE
	44	42nd Street at 6th Avenue	2	City of Grand Forks	170	FREE
	45	42nd Street at 11th Avenue	6	City of Grand Forks	170	FREE
	100	DeMers Avenue at Columbia Road	5	City of Grand Forks	170	FREE

** Master Controller Location
S = Cross-Street Split-Phased

2.1.2 Lane Geometries, Signal Phasing, and Signal Timing

Traffic signal phasing layouts were acquired from the City of Grand Forks for each of the intersections mentioned previously (Table 1). Google Earth and field reviews of each of the intersections were conducted to confirm the intersection lane assignment, geometry, characteristics, as well as storage lengths for each of the turn bays.

Existing traffic signal timings and the Translink32 databases for each intersection and master controller were obtained from the City of Grand Forks. Key parameters include; minimum green times, clearance intervals, pedestrian intervals and coordination data (cycle length, offset, splits) and time of day settings. Table 2 provides a summary of the existing daily timing plans for each corridor.

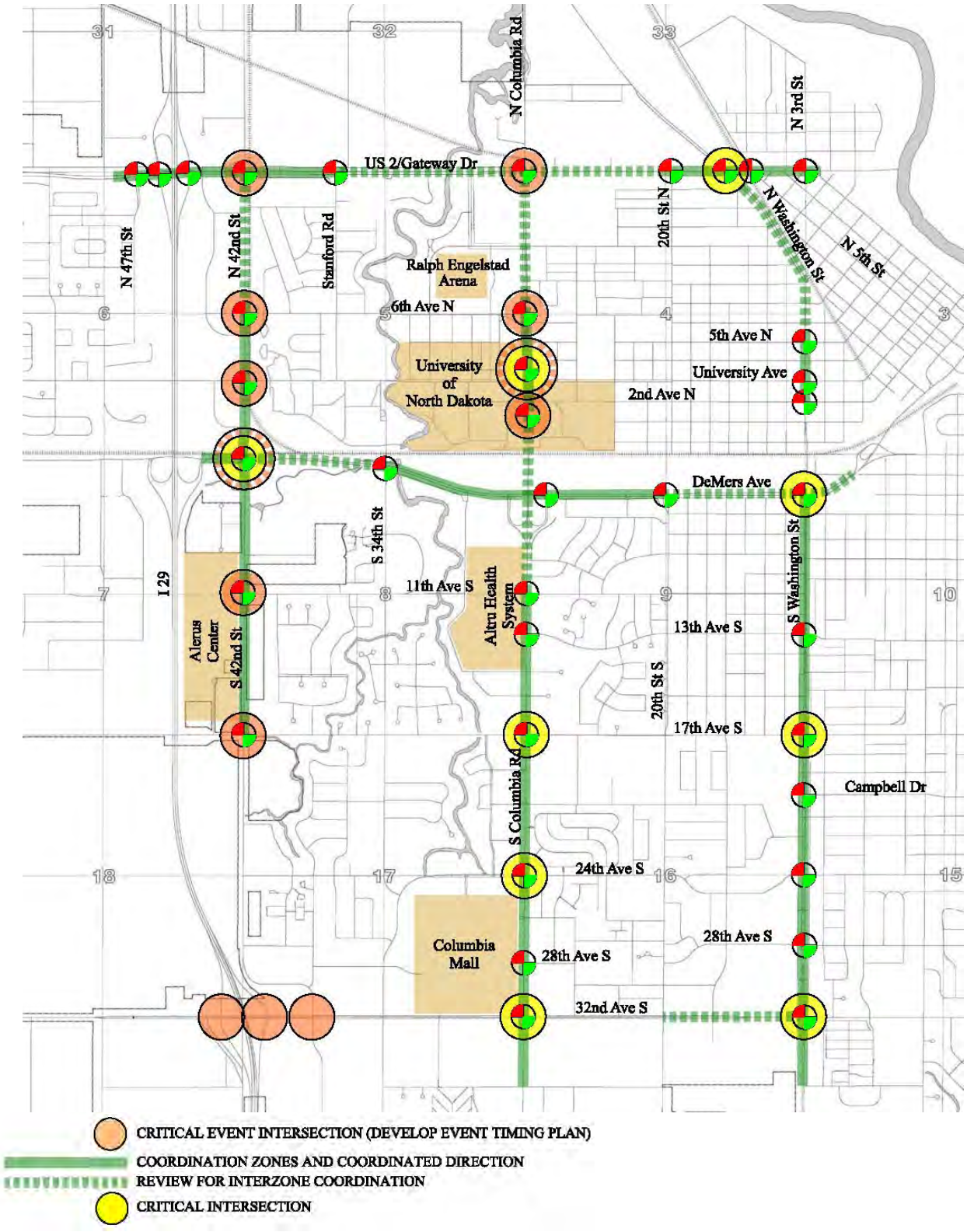


Figure 3. Key Study Intersections

Table 2. Existing Condition Signal Timing Plans

	Operation	Time	Plan	Cycle Length (s)
Zone 400 ***Columbia Road*** *- 32nd Avenue to 6th Avenue*	TOD	715 AM to 815 AM	2	90
		815 AM to 845 AM	1 [(1)]	90
		845 AM to 915 AM	4	100
		915 AM to 1130 AM	1 [(1)]	90
		1130 AM to 1215 PM	5	100
		1215 PM to 1245 PM	2	90
		1245 PM to 130 PM	5	100
		130 PM to 345 PM	2	90
		345 PM to 445 PM	6	100
		445 PM to 515 PM	5	100
		515 PM to 1000 PM	2	90
		1000 PM to 1130 PM	7	80

[(1)] Columbia Road/6th Avenue operates Manual Free

	Operation	Time	Plan (Cycle/Offset/Split)	Cycle Length (s)
Zone 10 ***DeMers Avenue*** *- 20th Street to 42nd Street* ***42nd Street*** *- 17th Avenue to 6th Avenue*	TOD	630 AM to 1000 PM	FREE [(1)]	FREE

(1) DeMers Avenue and 42nd Street operate free at all times of day.

Table 2. Existing Condition Signal Timing Plans Cont'd

	Operation	Time	Plan (Cycle/Offset/Split)	Cycle Length (s)
Zone 222 **Washington Street** - *32nd Avenue to 5th Avenue*	TOD	715 AM to 200 PM	8	105
		200 PM to 600 PM	9	115
		600 PM to 1045 PM	8	105
	Operation	**Time**	**Plan (Cycle/Offset/Split)**	**Cycle Length (s)**
Zone 60 ***Gateway Drive*** - *3rd Street to 47th Street*	TOD	715 AM to 1100 PM	3 [(1)]	100 / 70

[(1)] 100 s cycle length operates at 3rd, 5th, Washington, and 20th. Free operation at Columbia, Stanford, and 42nd. 70 s cycle length at I-29 East Ramp, I-29 West Ramp, and 47th.

2.1.3 Traffic Volumes

The MPO conducted turning movement volume counts at each of the 36 study intersections during the months of September and October, 2009. Turning movement counts were collected during the a.m. peak period (6:30 a.m. to 9:30 a.m.), mid-day period (10:30 a.m. to 1:30 p.m.) and p.m. peak period (2:30 p.m. to 6:30 p.m.) on weekdays. In addition to turning movement counts, the MPO conducted traffic volume tube counts (15-minute interval) at six locations: Columbia Road/24th Avenue, Columbia Road/University Avenue, Washington Street/17th Avenue, Washington Street/2nd Avenue, and Gateway Drive/42nd Street. Figure 4 documents the turning movement count and tube count data collection locations. Based on the turning movement counts and the daily volume profiles, six different volume cases were developed:

- a.m. peak
- a.m. off-peak
- mid-day low (balanced low)
- mid-day peak (balanced peak)
- p.m. off-peak
- p.m. peak

Figure 5 illustrates the daily traffic volume profiles existing at each of the six data collection locations. The volume profiles graphically show the volume case boundaries for the weekday conditions on each of the corridors.

The peak hour was identified for each of the three peak time periods (a.m., mid-day and p.m.). The a.m., mid-day and p.m. peak hour traffic volumes used in the Synchro7.0 model were developed by multiplying the highest 15-minute interval within the respective intersections peak hour, for each movement, by four. This method results in the maximum peak volume for each movement, necessary for developing the future optimized movement splits. To support the signal timing evaluation, a SimTraffic7.0 model was developed for the a.m. and p.m. peak hours. To more accurately replicate the corridor traffic conditions, a 15-minute interval traffic data set utilizing the raw and balanced intersection turning movement volumes was created for both the a.m. and p.m. peak hours. The turning movement volumes collected during the off peak periods were used to estimate representative volume levels (i.e., using either the average or the maximum multiplied by four for the volume scenario case).

The intersection turning movement counts were collected over a several week period. As such, the volumes between intersections were balanced to account for existing queuing, daily variation and to better estimate the actual volume demand. Balancing of intersection volumes is critical in developing a calibrated traffic model and making reasonable comparison to field observed conditions. The following supporting data was used to balance intersection turning movements:

- **Tube count data**. The tube count volumes provide a snapshot of traffic conditions on days of intersection observations and/or field studies (e.g., travel time runs or stopped delay studies) and provide indication of the upstream demand. Mainline volumes were balanced to match the peak 15-minute volume shown on the volume profiles.
- **Consideration of critical intersection or intersection movements**. In many instances, the turning count can be indicative of the intersections movement capacity.

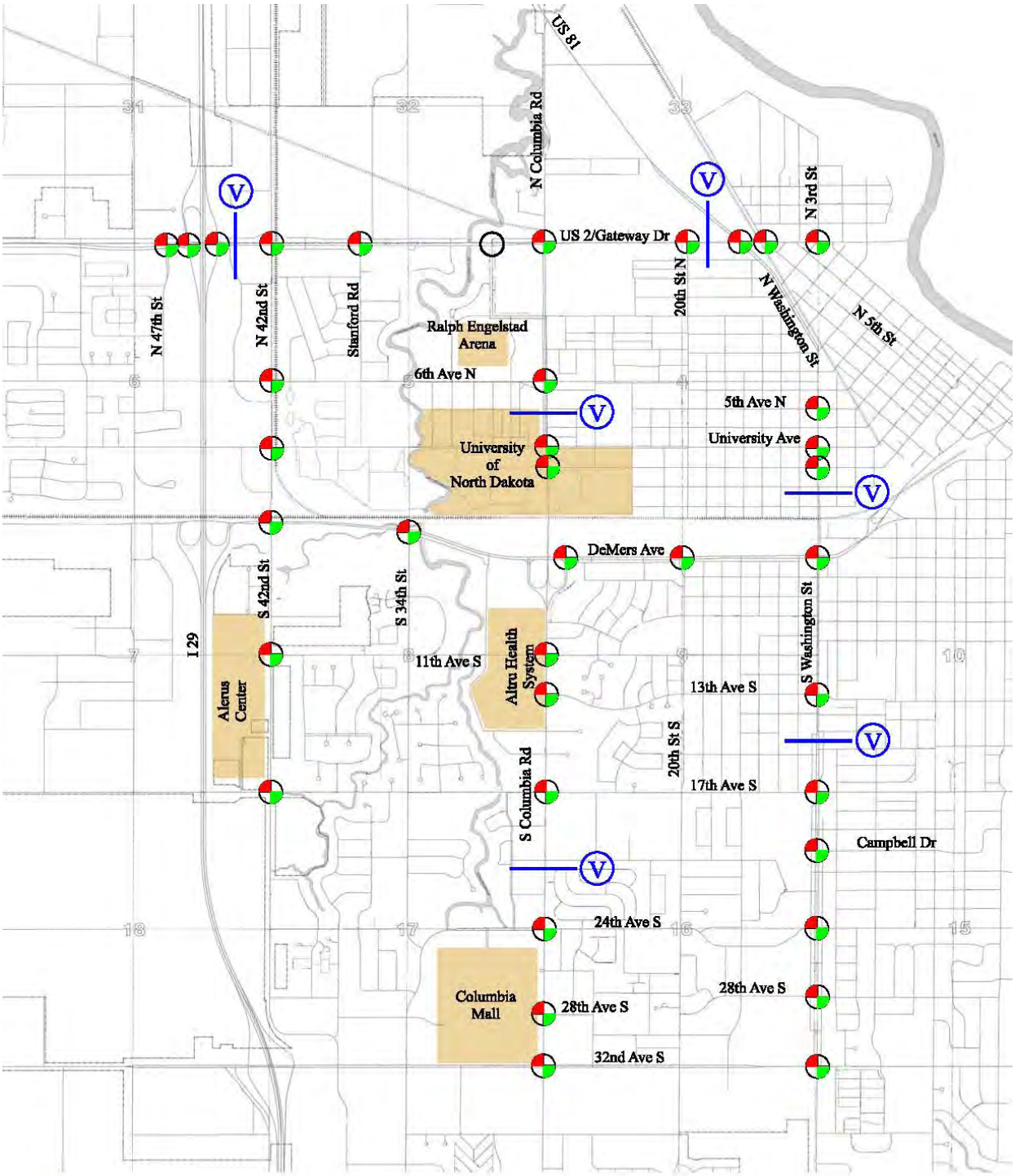
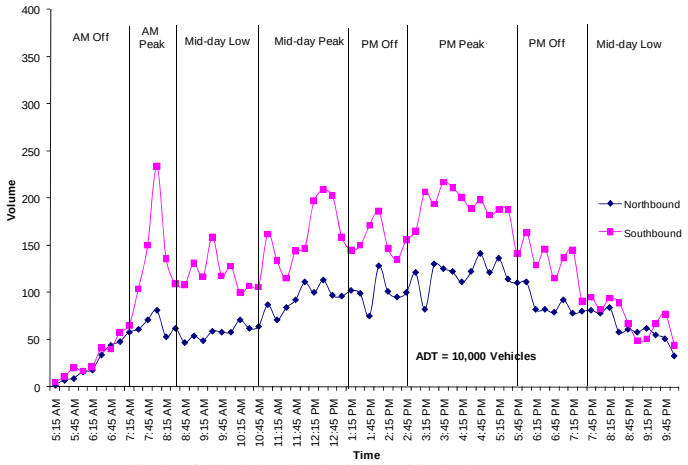


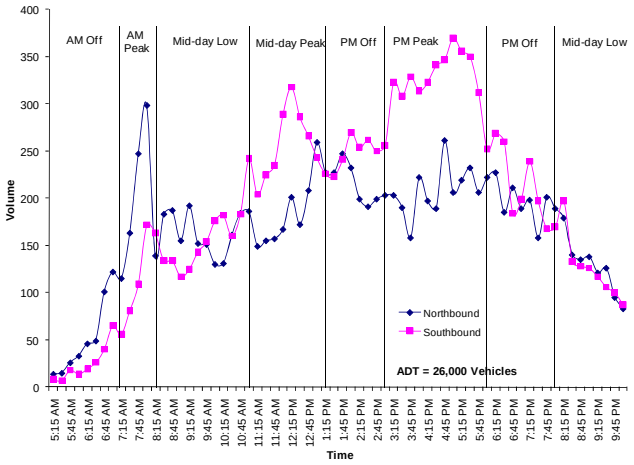
Figure 4. Data Collection Map

Zone 1 (Columbia Rd between University Ave and 6th Ave) on Thursday, 10/1/09



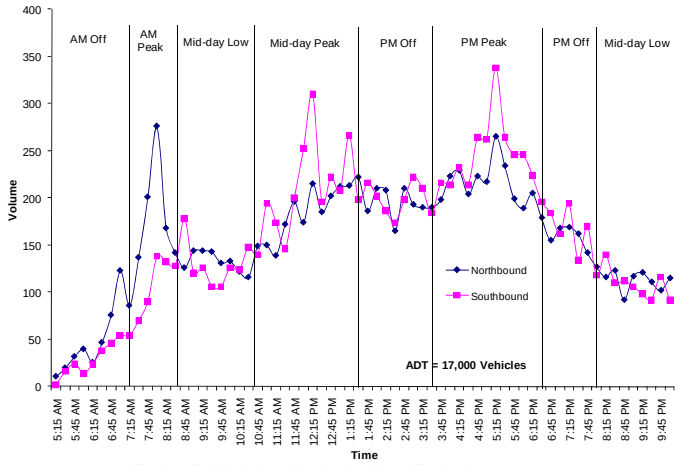
[1]ADT=Average 24-Hour traffic volume (includes both southbound and northbound directions)

Zone 1 (Columbia Rd between 24th Ave and 17th Ave) on Thursday, 9/24/09



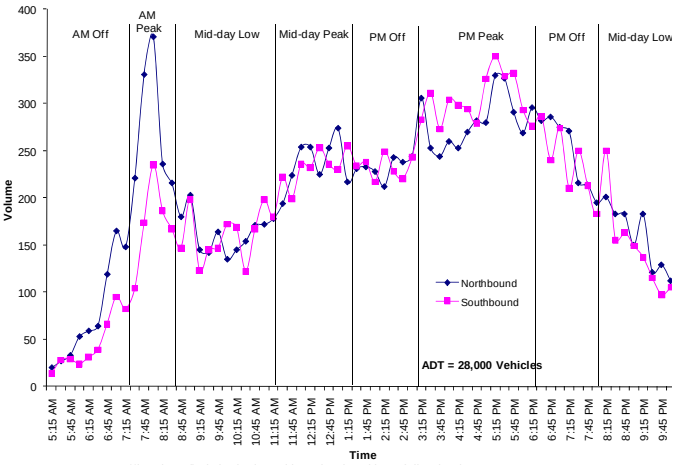
[1]ADT=Average 24-Hour traffic volume (includes both southbound and northbound directions)

Zone 2 (Washington Street between DeMers Avenue and 2nd Avenue) on Thursday, 10/22/09



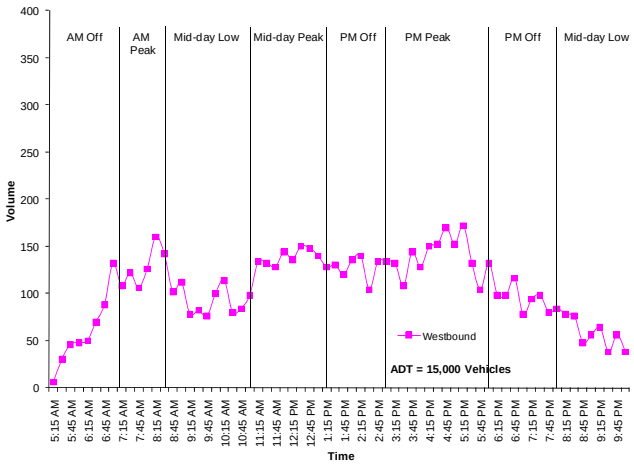
[1]ADT=Average 24-Hour traffic volume (includes both southbound and northbound directions)

Zone 2 (Washington Street between 13th Avenue and 17th Avenue) on Thursday, 10/8/09



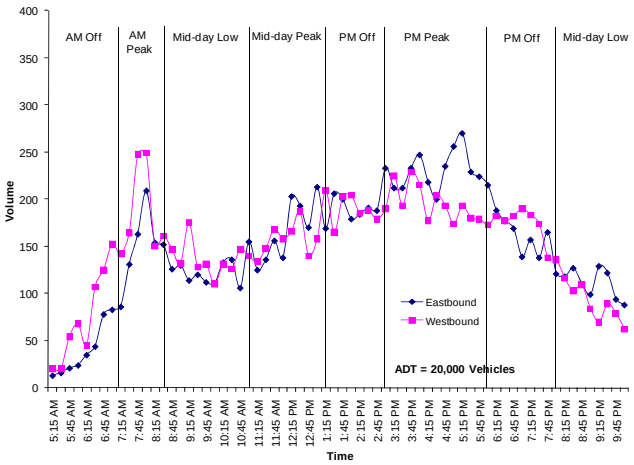
[1]ADT=Average 24-Hour traffic volume (includes both southbound and northbound directions)

Zone 4 (Gateway Drive between I-29 East Ramp and 42nd Street) on Thursday, 4/29/10



[1]ADT=Average 24-Hour traffic volume (includes both eastbound and westbound directions)

Zone 4 (Gateway Drive between 20th Avenue and Washington Street) on Tuesday, 4/27/10



[1]ADT=Average 24-Hour traffic volume (includes both eastbound and westbound directions)

Figure 5. Daily Volume Profiles

2.1.4 Vehicle Speed Characteristics

The MPO conducted a vehicle speed study on Columbia Road, Washington Street and Gateway Drive. The results of the speed study are summarized in the following:

- Columbia Road: The 85th percentile speed was found to be 40 mph (posted 40 mph) between 17th Avenue and 24th Avenue.
- Washington Street: The 85th percentile speed was found to be 40 mph (posted 35 mph) south of 13th Street and 40 mph (posted 30 mph) just north of DeMers Avenue.
- Gateway Drive: The 85th percentile speed was found to be 42 mph (posted 40 mph), west of Columbia Road and 36 mph (posted 35 mph) east of Columbia Road.

In general, the 85th percentile vehicle speeds closely represent the posted limits.

2.1.5 Heavy Commercial Vehicle Percentage

Existing heavy commercial vehicle volumes were field collected at each intersection as part of the intersection turning movement counts. The heavy vehicles were classified as single-unit or those consisting of more than three axles or being a truck and tractor trailer. The field collected data was utilized to estimate heavy vehicle percentages for the mainline and cross streets for a.m., off-peak and p.m. peak periods in the Synchro7.0 and SimTraffic7.0 models. In addition, the commercial truck percentages are used to estimate the time value of vehicle delay as part of the benefit/cost analysis. The corridor average truck percentages are summarized in Table 3.

Table 3. Heavy Truck Percentages

Volume Case	Weekday			
	Columbia Road	Washington Street	Gateway Drive	DeMers Avenue/ 42nd Street
AM PEAK	2.1%	2.7%	9.1%	2.4%
AM OFF	1.6%	4.0%	10.8%	2.7%
MID-DAY LOW	1.8%	4.1%	15.9%	4.0%
MID-DAY PEAK	1.2%	2.1%	10.6%	1.9%
PM OFF	1.2%	2.2%	13.2%	2.0%
PM PEAK	0.7%	1.4%	8.1%	1.2%

2.1.6 Crash Characteristics

The MPO provided intersection crash data for the years 2007 to 2009. Evaluation of current crash characteristics may identify certain patterns correctable by signal timing or signal phasing changes. The intersection crash types are tabulated in Table 4. Figure 6

documents the corridor crash type percentages and provides a comparison to the citywide average. Key observations include:

- The data indicates that about half of the intersection crashes are rear-ends, which is typical of signalized corridors. However, the rear-end crash type at four intersections were considerably higher than the average rate (highlighted in bold on Table 4). By improving traffic flow, and increased green time, the proportion of rear-end crashes may be expected to be minimally reduced.
- Right angle crashes, as a percentage of total crashes were found to be abnormally high at several intersections: Columbia Road/24th Avenue, Columbia Road/2nd Avenue, Washington Street/Campbell Drive, Gateway Drive/I-29 West Ramps, Gateway Drive/Stanford Road, Gateway Drive/3rd Street, DeMers Avenue/34th Street, 42nd Street/DeMers Avenue, 42nd Street/University Avenue, and 42nd Street/6th Avenue. Normally the primary contributing factors for right angle crashes are failure to yield right of way or disregarding the traffic control device.
- The Columbia Road/32nd Avenue, Columbia Road/17th Avenue, Columbia Road/2nd Avenue, Washington Street/17th Avenue, Washington Street/DeMers Avenue, and 42nd Street/DeMers Avenue intersections all experience crash rates greatly exceeding 0.8 (average rate for signalized intersection control). These intersections experience a high number of rear-end and right angle type crashes. The crash rate at Columbia Road/32nd Avenue has decreased from 1.26 to 0.93 since the implementation of new signal timing plans in 2008.
- Over the past three years there has not been any reported fatality crashes. Overall, injury related crashes were found to be approximately 28 percent, which is below the average rate (35 percent).

Continued monitoring of the noted intersections upon completion of the new signal timing plans should be considered.

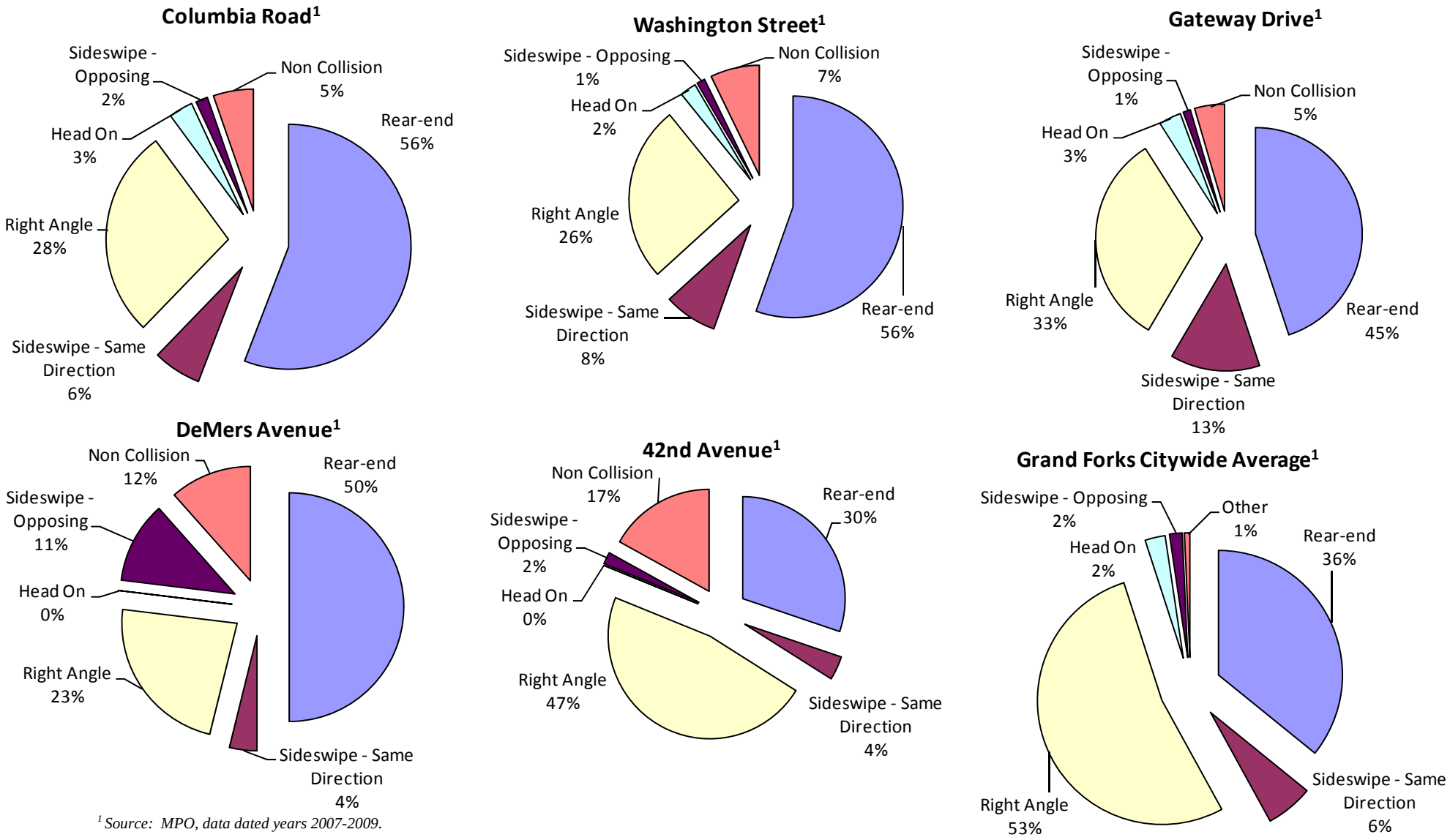
Table 4. Crash Type Summary

Intersection	Rear-end	Sideswipe - Same Direction	Left Turn into On-coming Traffic	Right Angle	Head On	Sideswipe - Opposing	Non Collision	TOTAL	CRASH RATE
Columbia Road @ 32nd Avenue	24	3	0	10	0	0	3	40	**1.14**
Columbia Road @ 28th Avenue	3	0	0	4	2	1	0	10	**0.44**
Columbia Road @ 24th Avenue	7	0	0	8	1	1	1	18	**0.58**
Columbia Road @ 17th Avenue	25	3	0	4	1	0	0	33	**1.08**
Columbia Road @ 13th Avenue	10	3	0	7	0	1	1	22	**0.79**
Columbia Road @ 11th Avenue	12	0	0	2	0	0	0	14	**0.47**
Columbia Road @ 2nd Avenue	12	1	0	10	1	0	3	27	**1.06**
Columbia Road @ University Avenue	10	2	0	7	1	0	1	21	**0.82**
Columbia Road @ 6th Avenue	2	0	0	0	0	0	1	3	**0.16**
Washington Street @ 32nd Avenue	13	0	0	3	0	0	1	17	**0.56**
Washington Street @ 28th Avenue	4	0	0	3	0	1	0	8	**0.31**
Washington Street @ 24th Avenue	10	3	0	3	0	0	3	19	**0.86**
Washington Street @ Campbell Drive	3	0	0	4	0	0	0	7	**0.31**
Washington Street @ 17th Avenue	15	1	0	8	1	0	0	25	**1.08**
Washington Street @ 13th Avenue	12	3	0	4	0	0	0	19	**0.76**
Washington Street @ DeMers Avenue	24	4	0	9	2	1	3	43	**1.37**
Washington Street @ 2nd Avenue	6	1	0	2	0	0	0	9	**0.48**
Washington Street @ University Avenue	5	1	0	6	1	0	2	15	**0.56**
Washington Street @ 5th Avenue	0	0	0	1	0	0	3	4	**0.23**
Gateway Drive @ 47th Street	6	4	0	2	0	0	1	13	**0.79**
Gateway Drive @ I-29 West Ramps	1	1	0	3	0	1	0	6	**0.25**
Gateway Drive @ I-29 East Ramps	3	0	0	1	0	0	0	4	**0.24**
Gateway Drive @ 42nd Street	2	1	0	4	1	0	1	9	**0.50**
Gateway Drive @ Stanford Rd	0	1	0	3	0	0	0	4	**0.16**
Gateway Drive @ Columbia Rd	1	0	0	2	1	0	1	5	**0.22**
Gateway Drive @ 20th Street	6	1	0	2	1	0	0	10	**0.52**
Gateway Drive @ Washington Street	12	2	0	5	0	0	1	20	**0.71**
Gateway Drive @ 5th Street	8	2	0	5	0	0	0	15	**0.69**
Gateway Drive @ 3rd Street	1	0	0	2	0	0	0	3	**0.17**
DeMers Avenue @ 34th Street	0	1	0	4	0	0	1	6	**0.19**
DeMers Avenue @ Columbia Road East Ramps	13	0	0	2	0	0	2	17	**0.84**
DeMers Avenue @ 20th Street	0	0	0	0	0	3	0	3	**0.14**
42nd Street @ 17th Avenue	2	0	0	1	0	1	5	9	**0.81**
42nd Street @ 11th Avenue	2	0	0	0	0	0	1	3	**0.15**
42nd Street @ DeMers Avenue	7	2	0	15	0	0	2	26	**1.03**
42nd Street @ University Avenue	5	0	0	4	0	0	0	9	**0.49**
42nd Street @ 6th Avenue	0	0	0	5	0	0	1	6	**0.59**
Columbia Road Total	**105**	**12**	**0**	**52**	**6**	**3**	**10**	**188**	**0.76**
Washington Street Total	**92**	**13**	**0**	**43**	**4**	**2**	**12**	**166**	**0.68**
Gateway Drive Total	**40**	**12**	**0**	**29**	**3**	**1**	**4**	**89**	**0.43**
DeMers Avenue Total	**13**	**1**	**0**	**6**	**0**	**3**	**3**	**26**	**0.36**
42nd Street Total	**16**	**2**	**0**	**25**	**0**	**1**	**9**	**53**	**0.62**
Total - All Corridors	**266**	**40**	**0**	**155**	**13**	**10**	**38**	**522**	**0.61**

Source: MPO, data dated years 2007-2009.

Crash Rate of 1.26 Before Re-timing in July 2008

Crash Rate = 0.93 After Re-timing in July 2008



[1] *Source: MPO, data dated years 2007-2009.*

Figure 6. Crash Type Percentages –vs- Citywide Average

2.2 Field Studies

Travel time runs, intersection approach delay studies, and saturation flow studies were conducted to assist in calibration of the Synchro7.0 and SimTraffic7.0 models and to provide data for the "before" conditions. Field Studies were conducted according to the methods described in the "Manual of Transportation Engineering Studies", ITE, 1994. Table 5 documents the location where saturation flow rate or approach delays were collected. Figure 7 illustrates the travel time study routes for all of the corridors. The results of the "before" travel time and intersection delay studies will be presented in Section 7.0 Project Benefit Analysis.

Table 5. Approach Delay and Saturation Flow Rate Study Locations

Delay Studies

Intersection	Approach	Time Period
AM		
Columbia Road at University Avenue	WB	7:30 to 8:00 AM
PM		
Columbia Road at 17th Avenue	EB	3:45 to 4:15 PM
Columbia Road at University Avenue	EB	4:30 to 5:00 PM
Washington Street at DeMers Avenue	WB	5:15 to 5:45 PM
Washington Street at 17th Avenue	EB	5:30 to 6:00 PM
Washington Street at Gateway Drive	NB	4:45 to 5:15 PM
Washington Street at Gateway Drive	SB	5:00 to 5:30 PM
Washington Street at 24th Avenue	EB	5:00 to 5:30 PM
42nd Street at University Avenue	WB	4:30 to 5:00 PM
42nd Street at University Avenue	EB	4:00 to 4:30 PM

Note: Delay studies selected based on v/c ratio at or exceeding 1.0 for one or more movements

Saturation Flow Studies

Intersection	Lane	Time Period
Columbia Road at 2nd Avenue	NB Left Turn	7:30 to 8:00 AM
Columbia Road at 17th Avenue	SB Thru Lane	4:45 to 5:15 PM
Columbia Road at University Avenue	SB Thru Lane	4:30 to 5:00 PM

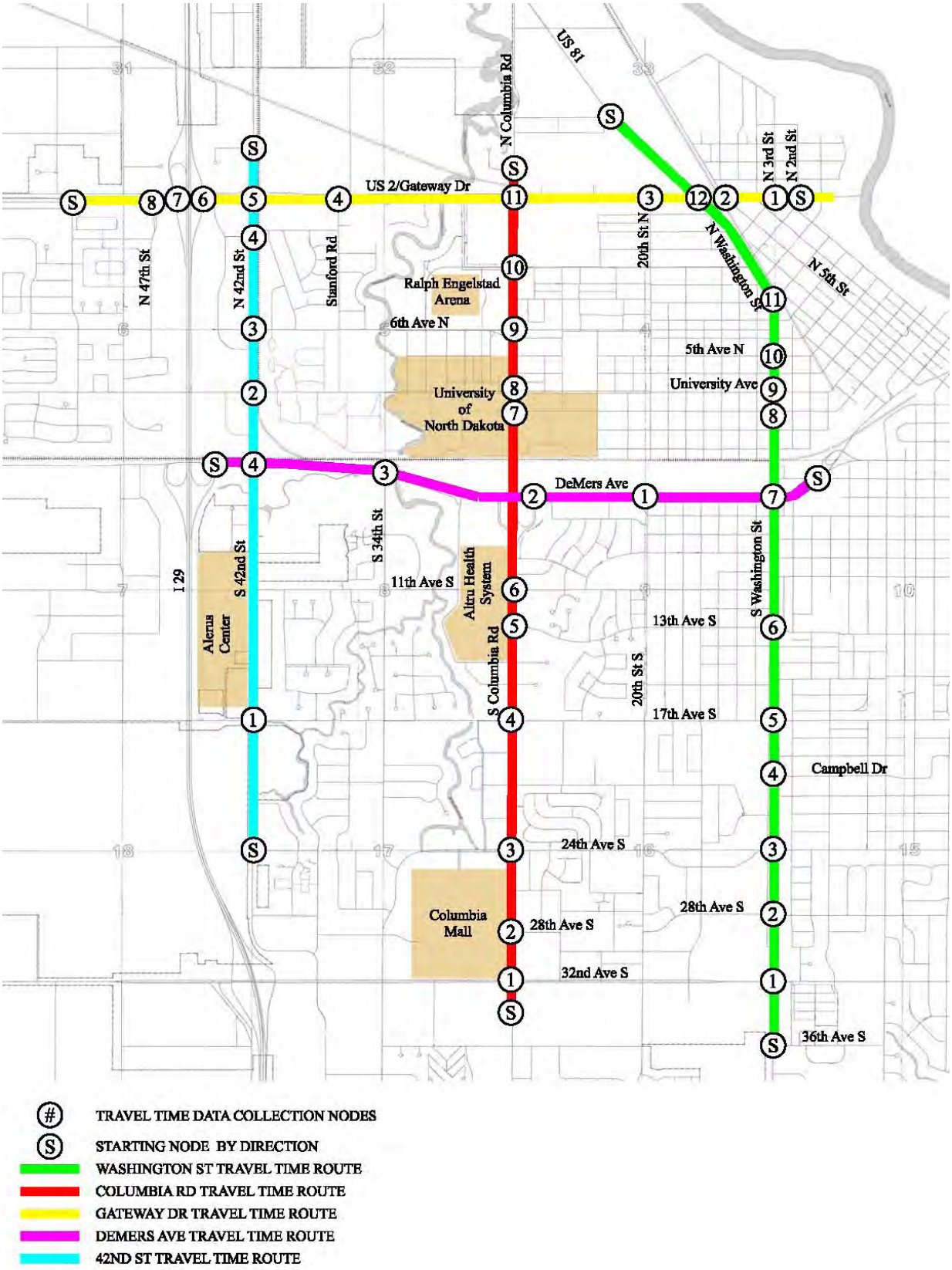


Figure 7. Travel Time Study Routes

2.3 Model Calibration

The roadway geometrics, traffic volume, and signal timing information were utilized to create a corridor model using the Synchro7.0 modeling software. A SimTraffic7.0 simulation model was created for the a.m. and p.m. peak hours.

The travel time and intersection delay data were used to support the model calibration. The model was calibrated by adjusting the saturation flow rates and headway factors (based on field collected data) to obtain values that accurately depict the approach capacities, travel time and intersection delays. In addition, lane utilization characteristics were replicated based upon field observed conditions.

2.3.1 Saturation Flow Rate

Saturation flow rate studies were conducted during both the a.m. and p.m. peak periods to assist in the traffic model calibration. The locations chosen contained representative lane geometrics with other intersections throughout Grand Forks and were measured to provide a ballpark lane capacity. The results of the saturation flow rate studies are documented in Table 6.

Table 6. Saturation Flow Rate Study

	Intersection	Movement	Saturation Flow Rate [1] (vplphg)	Maximum number of queued vehicles
AM	Columbia Road at 2nd Ave	NB Columbia Rd Left Turn	**1,650**	7
PM	Columbia Road at 17th Ave	SB Columbia Rd Thru Lane	**1,800**	20
	Columbia Road at University Ave	SB Columbia Rd Thru Lane	**1,750**	13

1. Field collected on September 23 & 24, 2009.
Source: Ulteig Engineers.

The raw saturation flow rates were adjusted slightly and applied throughout the model at approaches with similar characteristics. The headway factors were adjusted within the Synchro7.0 model to correspond with the above saturation flow rates for simulation within SimTraffic7.0.

2.3.2 Intersection Volumes

The SimTraffic7.0 simulation evaluated a 15-minute volume distribution over both the a.m. and p.m. peak hours. Raw intersection turning movement volumes, discussed previously, were balanced and read into the SimTraffic7.0 model. After the intersection approach saturation flow rates, signal timing information, coding of the model network characteristics, and critical approach capacities were validated, the sensitivity of the balanced turning movement volumes were further reviewed in attempt to better replicate actual volume demand and queuing behavior.

2.3.3 Travel Time Comparison

A comparison of field collected travel time data to the model output was performed to validate the model calibration. The comparison shows reasonable correlation between the model output and field collected travel times.

2.4 Existing Condition Traffic Operations

The following sections document the a.m. peak, mid-day peak and p.m. peak hour traffic operation analysis and the identified deficiencies under the existing conditions.

2.4.1. Traffic Operation Analysis

Using the calibrated models and the field collected data, an operations analysis was conducted. The analysis included an intersection capacity analysis as well as documentation of the arterial level of service for selected travel routes. The methods of the Highway Capacity Manual (HCM), 2000 Edition and the Synchro7.0/SimTraffic7.0 software model were used to conduct the analysis. LOS criteria as defined by the HCM for both signalized intersections and urban arterials are illustrated in Table 7.

The approach and overall intersection level of service analysis for the a.m., mid-day and p.m. peak hours for the Signal Coordination Study are documented in Table 8. In North Dakota, the LOS C/D boundary is typically considered the indicator of acceptable congestion. The arterial level of service for the travel time study routes is documented in Table 9. Based upon the overall corridor characteristics and 85th percentile vehicle speed, Columbia Road, Washington Street, Gateway Drive, DeMers Avenue and 42nd Street are all Class II urban arterials.

Table 7. LOS Criteria

LOS CRITERIA SIGNALIZED INTERSECTIONS

LOS	Control Delay per Vehicle (s/veh)
A	<=10
B	>10
C	>20
D	>35
E	>55
F	>80

Source: HCM, Chapter 16, Exhibit 16-2

URBAN STREET LOS

	CLASS I	CLASS II	CLASS III
Range of FFS	55 to 45 mph	45 to 35 mph	35 to 25 mph
LOS	Average Travel Speed (mph)	Average Travel Speed (mph)	Average Travel Speed (mph)
A	>42	>35	>25
B	>34	>28	>19
C	>27	>22	>13
D	>21	>17	>9
E	>16	>13	>7
F	<=16	<=13	<=7

Source: HCM, Chapter 15, Exhibit 15-2

Table 8. Existing Intersection Level of Service

Synchro Node ID	Intersection	AM Peak Hour						Mid-day Peak Hour						PM Peak Hour					
		EB Delay (s/v)	WB Delay (s/v)	NB Delay (s/v)	SB Delay (s/v)	Int. Delay (s/v)	LOS	EB Delay (s/v)	WB Delay (s/v)	NB Delay (s/v)	SB Delay (s/v)	Int. Delay (s/v)	LOS	EB Delay (s/v)	WB Delay (s/v)	NB Delay (s/v)	SB Delay (s/v)	Int. Delay (s/v)	LOS
407	Columbia Road at 28th Avenue	25.3	23.6	8.4	11.1	11.9	B	24.0	22.0	11.0	37.0	24.0	C	26.5	26.6	16.1	27.0	24.0	C
409	Columbia Road at 24th Avenue	39.5	26.8	14.0	11.4	19.1	B	34.0	22.0	32.0	16.0	24.0	C	34.3	28.7	25.8	22.8	26.0	C
411	Columbia Road at 17th Avenue	22.5	22.6	36.5	15.4	26.8	C	27.0	23.0	28.0	38.0	31.0	C	27.6	25.3	24.1	43.5	34.5	C
413	Columbia Road at 13th Avenue	26.2	27.7	10.2	5.8	12.0	B	27.0	24.0	25.0	25.0	25.0	C	32.3	27.6	20.1	18.0	21.4	C
415	Columbia Road at 11th Avenue	34.9	27.9	7.7	3.9	8.5	A	31.0	27.0	17.0	11.0	17.0	B	40.3	30.4	10.2	9.3	12.4	B
417	Columbia Road at 2nd Avenue	22.1	37.0	11.5	13.5	13.7	B	17.0	40.0	26.0	20.0	25.0	C	30.6	41.5	14.8	18.1	20.1	C
418	Columbia Road at University Avenue	25.1	37.3	9.7	16.9	18.8	B	31.0	31.0	14.0	16.0	21.0	C	35.4	33.7	15.1	44.5	31.5	C
420	Columbia Road at 6th Avenue	19.3	31.4	9.3	8.8	12.0	B	25.0	31.0	13.0	13.0	18.0	B	28.0	38.2	15.5	15.9	18.9	B
152	Columbia Road at 32nd Avenue	15.7	14.4	28.0	27.4	20.9	C	25.0	33.0	44.0	48.0	36.0	D	22.4	32.5	42.9	49.9	36.1	D
14	Washington Street at 32nd Avenue	24.3	30.0	27.1	16.2	24.3	C	35.0	37.0	33.0	13.0	27.0	C	28.6	34.4	35.1	21.6	28.2	C
9	Washington Street at 28th Avenue	36.6	26.5	16.0	8.7	15.3	B	31.0	29.0	25.0	15.0	22.0	C	54.7	31.4	19.3	12.6	21.4	C
13	Washington Street at 24th Avenue	36.2	34.1	11.5	9.8	15.7	B	32.0	30.0	26.0	17.0	24.0	C	32.2	42.6	32.7	11.6	24.0	C
34	Washington Street at Campbell Drive	40.6	32.6	5.3	3.5	5.8	A	44.0	48.0	4.0	1.0	8.0	A	39.9	45.2	13.4	4.9	10.8	B
12	Washington Street at 17th Avenue	33.9	32.7	24.6	22.0	27.2	C	34.0	30.0	30.0	21.0	27.0	C	25.6	42.2	34.7	32.0	33.3	C
11	Washington Street at 13th Avenue	34.6	35.0	14.7	10.7	16.6	B	35.0	47.0	14.0	10.0	17.0	B	36.0	37.9	28.1	14.2	22.3	C
10	Washington Street at DeMers Avenue	41.7	40.5	28.4	19.2	33.3	C	45.0	41.0	39.0	20.0	36.0	D	**56.1**	34.0	31.2	**72.8**	48.4	D
111	Washington Street at 2nd Avenue	26.0	39.9	8.3	4.0	8.3	A	33.0	43.0	3.0	3.0	8.0	A	27.6	47.7	5.8	3.9	7.2	A
110	Washington Street at University Avenue	36.9	36.9	7.4	13.6	18.7	B	35.0	28.0	3.0	19.0	17.0	B	31.8	37.2	5.9	19.1	18.7	B
114	Washington Street at 5th Avenue	36.7	33.0	1.6	1.6	3.5	A	33.0	45.0	1.0	2.0	4.0	A	37.2	40.1	7.7	4.0	8.9	A
61	Gateway Drive at 3rd Street	3.9	3.4	34.1	39.6	5.5	A	2.0	3.0	28.0	30.0	4.0	A	4.3	2.5	18.2	34.4	4.8	A
62	Gateway Drive at 5th Street	9.2	12.8	**65.6**	32.4	17.3	B	5.0	10.0	41.0	32.0	13.0	B	7.9	7.9	39.0	31.7	12.7	B
63	Gateway Drive at Washington Street	24.4	26.9	40.0	38.6	30.3	C	27.0	28.0	40.0	44.0	33.0	C	23.8	24.8	30.1	34.5	26.7	C
64	Gateway Drive at 20th Street	9.1	8.0	27.3	1.5	10.4	B	19.0	21.0	28.0	0.0	21.0	C	13.0	9.9	33.6	27.5	13.9	B
65	Gateway Drive at Columbia Road	14.0	16.5	12.6	28.7	15.5	B	21.0	19.0	22.0	26.0	21.0	C	12.6	13.8	12.9	28.7	14.7	B
66	Gateway Drive at Stanford Road	6.8	6.0	18.7	23.8	8.6	A	15.0	11.0	17.0	21.0	14.0	B	6.6	5.5	16.8	15.8	7.7	A
67	Gateway Drive at 42nd Street	5.9	5.8	16.2	21.2	8.0	A	7.0	7.0	11.0	15.0	9.0	A	6.2	6.7	14.1	19.6	8.8	A
68	Gateway Drive at I-29 East Ramp	4.7	7.8	19.9	0.0	8.8	A	6.0	10.0	21.0	0.0	10.0	A	4.3	6.9	24.0	0.0	8.1	A
69	Gateway Drive at I-29 West Ramp	2.8	3.1	0.0	23.7	4.5	A	2.0	3.0	0.0	22.0	5.0	A	2.8	2.9	0.0	20.3	3.8	A
70	Gateway Drive at 47th Street	8.0	7.5	14.4	32.9	9.7	A	12.0	9.0	11.0	29.0	12.0	B	12.1	9.3	12.8	33.6	12.8	B
16	DeMers Ave at 20th St	7.7	10.5	14.2	27.6	9.9	A	14.0	6.0	17.0	17.0	11.0	B	10.8	10.6	15.2	19.5	11.4	B
23	DeMers Ave at 34th St	10.2	6.8	16.1	0.0	10.4	B	5.0	9.0	12.0	0.0	8.0	A	7.6	8.3	17.0	0.0	9.0	A
41	42nd St at University Ave	15.4	17.7	11.7	10.9	13.1	B	19.0	16.0	20.0	25.0	20.0	B	18.9	15.7	15.9	18.7	17.1	B
42	42nd St at DeMers Ave	26.7	28.0	30.2	22.9	27.1	C	30.0	26.0	31.0	26.0	28.0	C	30.3	27.5	30.9	25.6	28.3	C
43	42nd St at 17th Ave	0.0	6.6	2.3	3.2	3.6	A	0.0	9.0	13.0	5.0	9.0	A	0.0	7.0	2.1	4.6	4.1	A
44	42nd St at 6th Ave	12.0	15.3	5.7	6.6	8.5	A	9.0	14.0	11.0	13.0	12.0	B	8.9	15.7	6.2	8.2	9.4	A
45	42nd St at 11th Ave	21.8	14.9	4.8	4.9	6.1	A	16.0	29.0	15.0	11.0	15.0	B	7.0	18.4	6.1	8.4	8.9	A
100	DeMers Ave at Columbia East Ramp	3.7	6.4	13.1	12.2	6.1	A	15.0	10.0	18.0	11.0	14.0	B	4.3	5.5	9.1	14.6	5.8	A

Note:

1. AM Peak and PM Peak delays computed using SimTraffic.

2. Intersection LOS based on delays computed for the benefit-cost analysis

Table 9. Existing Arterial Level of Service

Northbound / Eastbound

Zone	Cross-Street Intersection	Urban Street Class	AM Peak Hour		Mid-Day		PM Peak Hour	
			Average Travel Speed (mph)[1]	LOS	Average Travel Speed (mph)[1]	LOS	Average Travel Speed (mph)[1]	LOS
400	Columbia Road - 32nd Avenue to 6th Avenue	II	22.8	C	17.7	D	20.8	D
222	Washington Street - 32nd Avenue to 5th Avenue	II	23.4	C	18.6	D	19.6	D
60	Gateway Drive - 47th Street to 3rd Street	II	28.1	B	23.9	C	27.3	C
10	DeMers Avenue - 42nd Street to 20th Street	II	26.8	C	24.0	C	25.5	C
10	42nd Street - 17th Avenue to 6th Avenue	II	29.1	B	23.2	C	27.7	C

Southbound / Westbound

Zone	Cross-Street Intersection	Urban Street Class	AM Peak Hour		Mid-Day		PM Peak Hour	
			Average Travel Speed (mph)[1]	LOS	Average Travel Speed (mph)[1]	LOS	Average Travel Speed (mph)[1]	LOS
400	Columbia Road - 6th Avenue to 32nd Avenue	II	24.2	C	17.1	D	17.9	D
222	Washington Street - 5th Avenue to 32nd Avenue	II	26.0	C	21.1	D	20.5	D
60	Gateway Drive - 3rd Street to 47th Street	II	27.3	C	23.4	C	28.0	C
10	DeMers Avenue - 20th Street to 42nd Street	II	26.8	C	26.8	C	27.6	C
10	42nd Street - 6th Avenue to 17th Avenue	II	28.2	B	22.4	C	24.6	C

[1] SimTraffic model ouput for AM and PM peak hours. Synchro model output for Mid-day scenario.

2.4.2 Existing Network Performance Measures

In addition to intersection LOS and arterial LOS, the existing network zone performance was evaluated for the a.m. peak, mid-day peak, p.m. peak and remaining off peak periods. Key measures of effectiveness (MOE's) include overall delay (hours), vehicle stops and fuel consumption. Table 10 documents the existing condition network performance measures by corridor.

Table 10. Existing Network Performances Measures

	MOE	Existing ("Before")		
		AM Peak	Off Peak	PM Peak
Columbia Road	Stops (no. of veh)	14,009	104,928	54,872
	Delay (hr)	117	1,027	633
	Fuel Consumption (gal)	313	3,333	875

AM Peak: 630 to 830 AM
Off Peak: 830 AM to 230 PM, 600 to 1000 PM
PM Peak: 300 to 600 PM

	MOE	Existing ("Before")		
		AM Peak	Off Peak	PM Peak
Washington Street	Stops (no. of veh)	18,270	94,864	50,902
	Delay (hr)	198	1,086	680
	Fuel Consumption (gal)	520	3,478	1,071

AM Peak: 645 to 900 AM
Off Peak: 900 AM to 230 PM, 600 to 1000 PM
PM Peak: 230 to 600 PM

Table 10. Existing Network Performances Measures Cont'd

	MOE	Existing ("Before")		
		AM Peak	Off Peak	PM Peak
Gateway Drive	Stops (no. of veh)	11,757	85,952	22,688
	Delay (hr)	92	646	204
	Fuel Consumption (gal)	281	2,875	464

AM Peak: 630 to 815 AM
Off Peak: 815 AM to 245 PM, 600 to 1000 PM
PM Peak: 245 to 600 PM

	MOE	Existing ("Before")		
		AM Peak	Off Peak	PM Peak
DeMers Avenue/ 42nd Street	Stops (no. of veh)	10,920	69,685	8,420
	Delay (hr)	75	487	72
	Fuel Consumption (gal)	368	2,585	224

AM Peak: 630 to 900 AM
Off Peak: 900 AM to 415 PM, 545 to 1000 PM
PM Peak: 415 to 545 PM

2.4.3 Existing Traffic Operation Issues

The following discusses key operation issues and items requiring attention during the optimized timing plan development.

1. Columbia Road
   - During the a.m. peak hour, the primary operation deficiency occurs in the northbound direction at 2nd Avenue. Traffic backs up and over the bridge at 2nd Avenue. A short arrow for left turning vehicles decreases operational efficiency. Many pedestrians cross at 2nd Avenue and University Avenue. Due to the pedestrian activity and short green times, the traffic signals are operating out of sync during the peak periods (minimum split violations). The out of sync operation impacts vehicle progression resulting in congestion.
   - During the p.m. peak hour, southbound traffic becomes very congested at 11th Avenue, 13th Avenue and 17th Avenue. The congestion is the result of high cross-street volume demands and too short of green time along Columbia Road.

- During the p.m. peak hour, the southbound left turn lane at 13th Avenue was observed to back out of the turn lane storage bay which blocked through traffic.

2. Washington Street
   - During both the p.m. and a.m. peak hours, the critical intersections are DeMers Avenue, 17th Avenue and 32nd Avenue, which all serve very high mainline and cross-street traffic volumes.
   - During the p.m. peak hour a large queue builds in the southbound direction at DeMers Avenue that extends past the train overpass. This queue frequently did not clear the intersection. The existing cycle length appeared to be too short to handle the traffic volumes at the intersection.
   - The quality of vehicle progression along Washington Street was poor with many stops occurring in both directions. Progression is challenged by non-uniform signal spacing, lack of right turn lanes and inconsistent group vehicle speeds along the corridor.
3. Gateway Drive

   All intersections operate at an acceptable level of service during the peak periods. The following denotes specific areas requiring further attention during the optimized timing plan development.
   - The southbound left turn movement at the Washington Street/Gateway Drive intersection accommodates a high truck percentage. With the potential future closure of Bacon Road, the left turn movement is also expected to experience a slight increase.
   - The close traffic signal spacing between 5th Street and Washington Street will require progressing the turning traffic to best manage vehicle queues and stacking.

All intersections along 42nd Street and DeMers Avenue operate at an acceptable level of service during the peak periods. Both corridors currently operate in "free" mode (non-coordinated); therefore, a common cycle length along the corridors is not occurring. Operating in non-coordinated mode does provide a couple of advantages:

- Reduces cross-street motor vehicle delays
- Varies the cycle length to the traffic demand present during that particular cycle; and
- Generally results in few to no citizen complaints from the cross-streets.

However, at certain traffic volume levels the cross-street advantages of operating under non-coordinated mode, will come at the expense to mainline progression and delay. Although the motorist delay is acceptable, the vehicle platoons routinely stop at multiple traffic signals. The traffic volume and vehicle platoon sizes observed along each corridor are well within the range of providing efficient signal coordination.

3.0 Signal Timing Optimization

The Synchro7.0 and SimTraffic7.0 models developed for existing conditions were used to create optimized signal timing plans. The traffic signal optimization included installation of new signal equipment, evaluating coordination strategies and developing time of day (TOD) timing plans consisting of new cycle lengths, intersection splits and offsets for each corridor.

3.1 Signal Equipment/Software upgrades

As part of the Signal Coordination Study, the MPO installed new signal equipment, hardware and software in the existing signal cabinets. The signal equipment upgrades were made to accommodate the signal coordination and Transit Signal Priority (TSP) components. The following signal equipment/hardware/software upgrades were made:

- The existing 2070 Oasis controllers (16 controllers) on Columbia Road and 32nd Avenue were loaded with Econolite ASC3 software. The ASC3 software is operating on the existing rack mount 2070 controller processor unit.
- The existing 170 type controllers were replaced with Econolite ASC3 software operating on a rack mount 2070 processor controller to match Columbia Road and 32nd Avenue.
- Installation of four Econolite ASC2M master controllers.
- Installation of fiber optic communication cable along 32nd Avenue (31st Street to 34th Street).
- Replaced the existing Translink32 operating system with Aries Zone Monitoring software.
- Reconfigured the communication network to include four direct connect interconnect zones (Zone 1 to Zone 4) and individual system identification numbers. The direct connect interconnect between Grand Forks Public Works Maintenance Building (47th Street) and the master controller occurs via the city wireless network system.

Figure 8 illustrates the limits of the new interconnect zones, Aries system identification numbers and intersections receiving a signal controller upgrade.

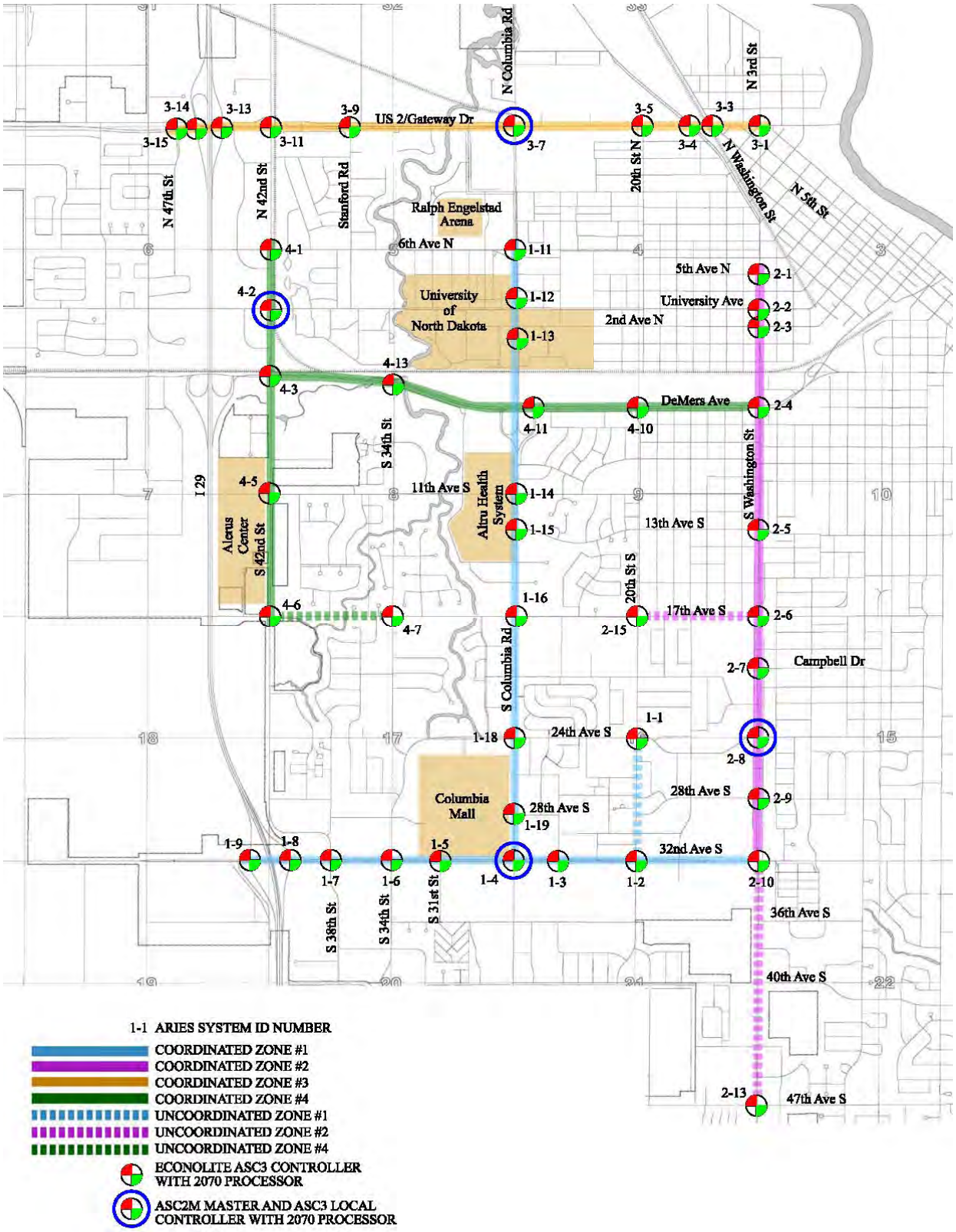


Figure 8. Signal Hardware and Interconnect Zone Map

3.2 Optimized Signal Operation Timing Plan Strategy

Signal coordination is the process to synchronize the start of the "green light" along the major roadway, so that vehicles can travel through a group of signals with minimal or no stopping. The cycle length is the most important parameter. In order for signal coordination to work, all intersections along the arterial must have the same cycle length (or be a multiple of each other). To best operate each corridor, the overall high level operation strategy for the signalized network was determined to be as described below:

- The Columbia Road corridor was optimized around the existing cycle lengths implemented on 32nd Avenue in 2008. This consideration is important because the 32nd Avenue/Columbia Road intersection requires two-way coordination (both north/south and east/west) to best service the traffic patterns of the two corridors.
- The 32nd Avenue Coordination Study[1] concluded the 32nd Avenue/Washington Street intersection is best operated with Washington Street being the coordinated direction. This intersection and the Washington Street/DeMers Avenue intersection govern the cycle length selection along the corridor. Washington Street (32nd Avenue to 5th Avenue) was evaluated for the most optimum cycle length. Inter-zone coordination with 32nd Avenue/20th Street or with DeMers Avenue/20th Street is a secondary priority and considered if the cycle lengths can be made common.
- Gateway Drive was determined to operate best as an isolated corridor. Cross-coordination with Columbia Road/6th Avenue, Washington Street/5th Avenue or 42nd Street/6th Avenue was not found beneficial and considered only if the optimum cycle lengths of each respective corridor happened to be common.
- 42nd Street and DeMers Avenue corridors will operate most efficiently on a common cycle length. In most cases, the coordinated direction at the 42nd Street/DeMers Avenue intersection should be the north/south through movements. During the a.m. peak and p.m. peak periods the Washington Street and DeMers Avenue corridors should operate on the same cycle or a half-cycle length.

There are three key timing parameters to optimize and are noticeable to the driver. These include the "cycle length", intersection "offset," or progression, and the individual traffic movement "green + yellow + red" phase (referred to as a movement "split") as will be highlighted in the following sections.

3.2.1 Cycle Length

Many alternative cycle length scenarios were evaluated to determine the overall most efficient corridor operation of Columbia Road, Washington Street, Gateway Drive, DeMers Avenue and 42nd Street to address existing operation concerns and improve traffic flow.

[1] 32nd Avenue Signal Coordination Study, Alliant Engineering, Inc., September 15, 2008.

SimTraffic7.0 was used to test the operation alternatives, and to iterate through different cycle length options. Table 11 highlights the cycle lengths selected and associated plan identification number. The cycle lengths were selected based on the following key considerations:

- Long enough to accommodate the mainline traffic volume demand.
- Maximizes directional flow during peak periods, but manage cross-street queue lengths and delays.
- Best maximizes two-way progression during off peak periods, given the existing signal spacing, signal phasing limitations, vehicle speeds and traffic volume relationship.
- Best addresses the traffic operation concerns identified in Section 2.4.3.
- Compatible with half-cycle or third-cycle operation at lower volume intersections.
- Compatible with cross-coordination progression for intersecting corridors.

Table 11. Cycle Length Summary

Columbia Road

Volume Case	Cycle Length (sec)	Plan ID	COS
AM PEAK	120 / 80 [1]	PLAN 1	111
MID-DAY LOW	80	PLAN 2	211
PM OFF PEAK	100	PLAN 3	311
PM PEAK	120	PLAN 4	411
MID-DAY PEAK/SAT	110	PLAN 5	511
EVENT OUTBOUND	140 [2]	PLAN 7	144
EVENT INBOUND	140 [2]	PLAN 8	444
OVERNIGHT	50 [3]	PLAN 11	133

[1] 24th Avenue and 28th Avenue operate on a 80 second cycle compatible with 32nd Avenue

[2] Applies to 2nd Avenue, University Avenue and 6th Avenue

[3] Applies to University Avenue, 2nd Avenue, 11th Avenue, and 13th Avenue. Remaining intersections operate free.

Table 11. Cycle Length Summary Cont'd

Washington Street

Volume Case	Cycle Length (sec)	Plan ID	COS
AM PEAK	110	PLAN 1	111
MID-DAY LOW	90	PLAN 2	211
PM OFF PEAK	100	PLAN 3	311
PM PEAK	130	PLAN 4	411
MID-DAY PEAK	120	PLAN 5	511
SATURDAY	110	PLAN 6	611

Gateway Drive

Volume Case	Cycle Length (sec)	Plan ID	COS
AM PEAK	100	PLAN 1	111
MID-DAY	90	PLAN 2	211
PM PEAK	120 / 100 (1)	PLAN 4	411
REA OUTBOUND	120 (2)	PLAN 7	144
ALERUS OUTBOUND	90 (3)	PLAN 9	244
OVERNIGHT	75 / 70 (4)	PLAN 11	133

(1) 47th Street to Columbia Road operate on a 100 second cycle

(2) Applies to I-29 East Ramp to 3rd Street.

(3) Applies only to 42nd Street.

(4) 47th Street to Stanford Road operate on a 70 second cycle, Columbia Road operates free, and 20th Street to 3rd Street operate on a 75 second cycle.

DeMers Avenue / 42nd Street

Volume Case	Cycle Length (sec)	Plan ID	COS
AM PEAK	110 / 80 (1)	PLAN 1	111
MID-DAY LOW	70	PLAN 2	211
BAL PEAK	80	PLAN 3	311
PM PEAK	130 / 65 (2)	PLAN 4	411
REA OUTBOUND	100 (3)	PLAN 7	144
ALERUS OUTBOUND	120 / 60 (4)	PLAN 9	244
ALERUS INBOUND	90	PLAN 10	344

(1) 42nd Street operates on a 80 second cycle. DeMers Avenue from 34th Street to 20th Street operates on a 110 second cycle.

(2) DeMers Avenue/42nd Street and 42nd Street/University Avenue operate on a 130 second cycle.

(3) 42nd Street at 6th Avenue, University Avenue, and DeMers Avenue operate on Plan 7.

(4) 42nd Street at 11th Avenue and 17th Avenue operate free. DeMers Avenue at 34th Street to 20th Street operate on a 60 second cycle.

3.2.2 Intersection Splits

Intersection splits were optimized to minimize delay along the mainline corridor, while providing adequate time to cross street traffic movements. Further refinement to the intersection splits was completed by determining the green time required to serve the expected vehicle queue per cycle. The refined split was calculated by multiplying the number of vehicles arriving per cycle by a factor 2.1; and adding a clearance factor (or start up time) of 3 seconds. Using the refined split calculation as a guideline, the overall cross street and left turn movement splits were adjusted accordingly. Once the offsets were finalized, left turn and cross-street splits were further inflated at locations where no impact to mainline vehicle platoons would occur.

3.2.3 Intersection Offsets

The primary objective of the offset optimization process is to maximize two-way vehicle progression. Offsets were manually manipulated using Synchro7.0. Lead/lead, lead/lag or lag/lag left turn phasing operation was considered where appropriate to improve the corridor green band. The lagging left turn (arrow comes up at the end instead of the start of the adjacent through movement green ball) can only be applied at intersections with protected only arrows. Several intersections along Washington Street, Gateway Drive and 32nd Avenue operate with a lagging left turn arrow. There are several advantages to this operation:

- Increases the green band along the corridor allowing motorists to proceed through more traffic signals without stopping.
- Reduces the delay for left turning motorists.
- Increases the green time for left turning motorists (can utilize unused green time from the opposite side through movement). This is not possible with lead/lead operation.
- Allows the left turn movements to be progressed through the green light at downstream intersections.

3.3 Signal Timing Implementation

The Synchro7.0 and SimTraffic7.0 models developed in evaluation of the existing and optimized conditions were used to support the field reviews and fine tuning of the signal systems. Alliant Engineering and City of Grand Forks staff implemented and conducted fine-tuning reviews during the week of October 12, 2009 (Columbia Road) and October 25, 2010 (Washington Street, Gateway Drive, 42nd Street and DeMers Avenue). During the field reviews, minor adjustments were made to the optimized timing plans to improve mainline progression, minimize stops and increase green time allotted to cross-street and left turn phases.

3.3.1 Controller Settings and Detector Programming

As part of the signal optimization and field implementation, Alliant Engineering also assisted the City of Grand Forks with reviewing and programming the controller option pages, detector settings and front page timing plan values. New minimum green, red clearance, yellow clearance and pedestrian intervals were developed. The timing values implemented are provided Appendix A. The pedestrian clearance intervals were developed in accordance with the *2009 Manual on Uniform Traffic Control Devices*. The sequence, recall and option pages were reviewed to ensure appropriate settings for dual entry, simultaneous gap, back up protection and other controller settings was completed. At the cabinet, the detection at each intersection was reviewed and the appropriate settings were adjusted based upon observations, detector setup and geometrics. The adjustments included adding delay for right turn detectors, adding lock or non-lock operation where appropriate and adding detector cross-switching for protected/permissive operation.

3.4 Implemented Signal Timing Plans

The final implemented TOD and signal timing plans for each zone are illustrated in Table 12. The final intersection splits and offsets, as of December 10, 2010 for each of the timing plans are attached in Appendix B.

Table 12. Implemented Signal Timing Plans – TOD Schedule

Columbia Road (28th Avenue to 6th Avenue)

Zone 1

Day	Operation	Time	Plan ID	COS	Cycle Length (s)
Weekday (Mon-Fri)	TOD	630 AM to 715 AM	PLAN 2	211	80
		715 AM to 815 AM	PLAN 1	111	120 / 80 [(1)]
		815 AM to 1100 AM	PLAN 2	211	80
		1100 AM to 230 PM	PLAN 5	511	110
		230 PM to 600 PM	PLAN 4	411	120
		600 PM to 800 PM	PLAN 3	311	100
		800 PM to 1100 PM	PLAN 2	211	80
		1100 PM to 630 AM	PLAN 11	133	50
Saturday	TOD	830 AM to 1030 AM	PLAN 2	211	80
		1030 AM to 600 PM	PLAN 5	511	110
		600 PM to 1030 PM	PLAN 2	211	80
		1030 PM to 830 AM	PLAN 11	133	50
Sunday	TOD	900 AM to 1100 AM	PLAN 2	211	80
		1100 AM to 500 PM	PLAN 5	511	110
		500 PM to 900 PM	PLAN 2	211	80
		900 PM to 900 AM	PLAN 11	133	50

[(1)] 630 to 1100 AM -- 80 s cycle Operates at 28th Avenue and 24th Avenue

Table 12. Implemented Signal Timing Plans – TOD Schedule Cont'd

Washington Street (32nd Avenue to 5th Avenue)
Zone 2

Day	Operation	Time	Plan ID	COS	Cycle Length (s)
Weekday (Mon-Fri)	TOD	1200 AM to 630 AM	PLAN 100	FREE	--
		630 AM to 715 AM	PLAN 2	211	90
		715 AM to 815 AM	PLAN 1	111	110
		815 AM to 1115 AM	PLAN 2	211	90
		1115 AM to 300 PM	PLAN 5	511	120
		300 PM to 615 PM	PLAN 4	411	130
		615 PM to 800 PM	PLAN 3	311	100
		800 PM to 1100 PM	PLAN 2	211	90
		1100 PM to 1200 AM	PLAN 100	FREE	--
Saturday	TOD	830 AM to 930 AM	PLAN 2	211	90
		930 AM to 1100 AM	PLAN 3	311	100
		1100 AM to 600 PM	PLAN 6	611	110
		600 PM to 730 PM	PLAN 3	311	100
		730 PM to 1030 PM	PLAN 2	211	90
Sunday	TOD	900 AM to 1100 AM	PLAN 2	211	90
		1100 AM to 500 PM	PLAN 6	611	110
		500 PM to 730 PM	PLAN 3	311	100
		730 PM to 1000 PM	PLAN 2	211	90

Gateway Drive (47th Street to 3rd Street)
Zone 3

Day	Operation	Time	Plan ID	COS	Cycle Length (s)
Weekday (Mon-Fri)	TOD	1200 AM to 630 AM	PLAN 100	FREE	--
		630 AM to 715 AM	PLAN 2	211	90
		715 AM to 815 AM	PLAN 1	111	100
		815 AM to 245 PM	PLAN 2	211	90
		245 PM to 600 PM	PLAN 4	411	120 / 100[(1)]
		600 PM to 1000 PM	PLAN 2	211	90
		1000 PM to 1200 AM	PLAN 11	133	75 / 70[(2)]
Saturday	TOD	700 AM to 800 AM	PLAN 11	133	75 / 70[(2)]
		800 AM to 1000 PM	PLAN 2	211	90
		1000 PM to 1200 AM	PLAN 11	133	75 / 70[(2)]
Sunday	TOD	730 AM to 900 AM	PLAN 11	133	75 / 70[(2)]
		900 AM to 800 PM	PLAN 2	211	90
		800 PM to 1200 AM	PLAN 11	133	75 / 70[(2)]

[(1)] 100 s cycle operates from 47th Street to Columbia Road

[(2)] 70 s cycle operates from 47th Street to Columbia Road

Table 12. Implemented Signal Timing Plans – TOD Schedule Cont'd

DeMers Avenue (20th Street to 42nd Street) and
42nd Street (17th Avenue to 6th Avenue)
Zone 4

Day	Operation	Time	Plan ID	COS	Cycle Length (s)
Weekday (Mon-Fri)	TOD	1200 AM to 630 AM	PLAN 100	FREE	--
		630 AM to 715 AM	PLAN 2	211	70[(1)]
		715 AM to 815 AM	PLAN 1	111	110 / 80[(2)]
		815 AM to 1130 AM	PLAN 2	211	70
		1130 AM to 415 PM	PLAN 3	311	80
		415 PM to 545 PM	PLAN 4	411	130 / 65[(3)]
		545 PM to 630 PM	PLAN 3	311	80
		630 PM to 1000 PM	PLAN 2	211	70[(1)]
		1000 PM to 1200 AM	PLAN 100	FREE	--
Saturday/Sunday	TOD	1200 AM to 800 AM	PLAN 100	FREE	--
		800 AM to 1000 AM	PLAN 2	211	70[(1)]
		1000 AM to 800 PM	PLAN 2	211	70
		800 PM to 900 PM	PLAN 2	211	70[(1)]
		900 PM to 1200 AM	PLAN 100	FREE	--

[(1)] 42nd Street at 11th Avenue and 17th Avenue operates free

[(2)] 80 s cycle operates at all intersections on 42nd Street

[(3)] 130 s cycle operates on 42nd Street at University Avenue and DeMers Avenue

3.5 Traffic Operation Analysis

The following section presents the traffic operation analysis results for the fine-tuned signal coordination plans.

3.5.1 Intersection and Arterial LOS

Using the final implemented timing plans and the Synchro7.0 and SimTraffic7.0 models, the overall intersection and arterial level of service (LOS) was documented. The overall intersection LOS for each of the intersections during the a.m., mid-day and p.m. peak hour is documented in Table 13. The arterial LOS for each vehicle travel time route is documented in Table 14.

Table 13. Implemented Overall Intersection Level of Service

Synchro Node ID	Intersection	"Before" Condition			"After" Condition																	
		AM Peak	Mid Peak	PM Peak	AM Peak Hour						Mid-day Peak Hour						PM Peak Hour					
		Int. Delay (s/v)	Int. Delay (s/v)	Int. Delay (s/v)	EB Delay (s/v)	WB Delay (s/v)	NB Delay (s/v)	SB Delay (s/v)	Int. Delay (s/v)	LOS	EB Delay (s/v)	WB Delay (s/v)	NB Delay (s/v)	SB Delay (s/v)	Int. Delay (s/v)	LOS	EB Delay (s/v)	WB Delay (s/v)	NB Delay (s/v)	SB Delay (s/v)	Int. Delay (s/v)	LOS
407	Columbia Road at 28th Avenue	11.9	24.0	24.0	22.3	21.2	5.0	5.7	8.0	A	38.0	32.0	6.0	8.0	15.0	B	36.9	36.5	7.7	9.5	14.5	B
409	Columbia Road at 24th Avenue	19.1	24.0	26.0	24.7	25.0	10.4	13.1	15.9	B	**58.0**	36.0	7.0	10.0	20.0	B	53.4	51.1	10.1	12.1	22.9	C
411	Columbia Road at 17th Avenue	26.8	31.0	34.5	41.4	34.1	16.7	13.3	21.7	C	**63.0**	51.0	18.0	17.0	30.0	C	48.0	36.6	14.8	15.9	21.5	C
413	Columbia Road at 13th Avenue	12.0	25.0	21.4	41.7	35.3	9.1	6.7	13.2	B	38.0	40.0	33.0	14.0	28.0	C	43.3	38.5	27.7	13.7	24.0	C
415	Columbia Road at 11th Avenue	8.5	17.0	12.4	45.3	37.7	5.0	4.2	8.1	A	36.0	32.0	7.0	8.0	13.0	B	47.9	33.4	8.2	7.9	11.6	B
417	Columbia Road at 2nd Avenue	13.7	25.0	20.1	28.2	51.8	12.8	10.3	14.1	B	24.0	**58.0**	17.0	23.0	26.0	C	40.1	**57.0**	11.6	10.1	17.5	B
418	Columbia Road at University Avenue	18.8	21.0	31.5	32.7	36.2	11.3	16.9	20.1	C	34.0	40.0	9.0	17.0	22.0	C	30.0	54.4	17.5	25.9	26.6	C
420	Columbia Road at 6th Avenue	12.0	18.0	18.9	21.7	50.4	6.7	7.1	11.7	B	25.0	33.0	7.0	15.0	16.0	B	32.6	42.7	13.7	12.3	18.0	B
152	Columbia Road at 32nd Avenue	20.9	36.0	36.1	15.6	15.6	15.6	15.6	15.6	B	24.0	32.0	51.0	49.0	37.0	D	22.8	35.5	47.1	49.8	37.5	D
14	Washington Street at 32nd Avenue	24.3	27.0	28.2	26.9	33.4	25.4	15.7	24.9	C	44.0	50.0	39.0	8.0	31.0	C	38.7	42.4	42.2	18.6	32.9	C
9	Washington Street at 28th Avenue	15.3	22.0	21.4	51.9	30.6	12.8	5.8	14.1	B	52.0	44.0	11.0	9.0	19.0	B	**86.0**	37.0	8.9	13.3	21.9	C
13	Washington Street at 24th Avenue	15.7	24.0	24.0	40.6	38.8	8.2	12.7	16.2	B	43.0	42.0	8.0	16.0	20.0	B	**59.2**	51.2	11.7	16.1	21.2	C
34	Washington Street at Campbell Drive	5.8	8.0	10.8	35.3	34.3	4.3	4.5	5.7	A	52.0	54.0	1.0	1.0	7.0	A	46.4	50.7	4.6	6.3	7.9	A
12	Washington Street at 17th Avenue	27.2	27.0	33.3	**67.1**	41.3	20.4	22.1	33.3	C	53.0	51.0	17.0	27.0	31.0	C	39.6	**72.6**	17.3	28.1	32.3	C
11	Washington Street at 13th Avenue	16.6	17.0	22.3	38.8	35.9	7.5	6.9	11.9	B	45.0	**58.0**	5.0	2.0	13.0	B	44.5	44.4	6.9	8.3	12.4	B
10	Washington Street at DeMers Avenue	33.3	36.0	48.4	41.0	47.0	15.5	18.4	30.7	C	52.0	49.0	28.0	24.0	37.0	D	**55.3**	53.5	34.0	36.9	44.4	D
111	Washington Street at 2nd Avenue	8.3	8.0	7.2	27.2	39.3	6.7	4.5	7.5	A	26.0	50.0	1.0	4.0	7.0	A	30.0	**57.1**	5.6	4.0	7.6	A
110	Washington Street at University Avenue	18.7	17.0	18.7	44.0	44.1	8.4	15.4	21.8	C	51.0	38.0	3.0	18.0	20.0	B	35.9	40.8	7.3	14.2	18.5	B
114	Washington Street at 5th Avenue	3.5	4.0	8.9	20.4	19.0	3.5	2.4	4.0	A	16.0	21.0	2.0	4.0	4.0	A	45.0	40.1	3.0	4.4	7.7	A
61	Gateway Drive at 3rd Street	5.5	4.0	4.8	2.0	3.5	39.6	39.3	4.9	A	1.0	4.0	25.0	26.0	4.0	A	2.1	2.6	24.1	37.7	3.9	A
62	Gateway Drive at 5th Street	17.3	13.0	12.7	6.9	8.3	46.9	34.0	13.3	B	3.0	9.0	40.0	30.0	11.0	B	4.4	6.8	46.7	35.0	11.6	B
63	Gateway Drive at Washington Street	30.3	33.0	26.7	18.8	23.2	32.1	37.8	25.6	C	21.0	35.0	40.0	41.0	33.0	C	27.2	21.8	47.3	44.8	32.0	C
64	Gateway Drive at 20th Street	10.4	21.0	13.9	6.8	3.5	28.1	4.2	7.5	A	7.0	2.0	39.0	0.0	11.0	B	9.4	5.8	46.5	26.2	11.6	B
65	Gateway Drive at Columbia Road	15.5	21.0	14.7	10.4	13.3	16.4	38.0	14.4	B	9.0	9.0	27.0	29.0	14.0	B	8.2	11.5	18.2	36.9	14.5	B
66	Gateway Drive at Stanford Road	8.6	14.0	7.7	5.5	5.2	24.2	36.9	8.9	A	9.0	6.0	26.0	33.0	11.0	B	5.5	5.6	22.3	27.6	8.4	A
67	Gateway Drive at 42nd Street	8.0	9.0	8.8	5.6	6.5	26.1	40.3	10.5	B	3.0	6.0	28.0	42.0	12.0	B	4.2	8.0	23.4	41.5	11.6	B
68	Gateway Drive at I-29 East Ramp	8.8	10.0	8.1	4.5	6.0	28.4	0.0	9.7	A	6.0	5.0	28.0	0.0	9.0	A	3.6	4.4	30.2	0.0	7.6	A
69	Gateway Drive at I-29 West Ramp	4.5	5.0	3.8	2.4	1.8	0.0	31.3	4.2	A	1.0	0.0	0.0	32.0	4.0	A	2.4	1.5	0.0	24.7	3.4	A
70	Gateway Drive at 47th Street	9.7	12.0	12.8	11.5	5.5	16.6	46.8	10.7	B	15.0	6.0	10.0	41.0	13.0	B	16.4	6.4	16.4	44.1	14.8	B
16	DeMers Ave at 20th St	9.9	11.0	11.4	5.5	9.1	22.5	6.5	9.3	A	6.0	5.0	22.0	20.0	8.0	A	11.3	11.7	17.4	20.0	12.3	B
23	DeMers Ave at 34th St	10.4	8.0	9.0	7.4	4.4	28.0	0.0	11.2	B	2.0	6.0	18.0	0.0	6.0	A	6.9	7.6	20.1	0.0	8.8	A
41	42nd St at University Ave	13.1	20.0	17.1	22.8	28.0	7.7	8.3	14.0	B	26.0	28.0	8.0	16.0	18.0	B	35.2	36.9	15.7	17.3	24.7	C
42	42nd St at DeMers Ave	27.1	28.0	28.3	22.2	22.2	19.8	14.8	20.1	C	17.0	9.0	21.0	27.0	19.0	B	30.7	28.0	22.9	18.3	24.6	C
43	42nd St at 17th Ave	3.6	9.0	4.1	0.0	8.7	2.2	2.5	3.8	A	0.0	17.0	7.0	2.0	6.0	A	0.0	9.2	2.0	4.0	3.9	A
44	42nd St at 6th Ave	8.5	12.0	9.4	24.3	52.6	6.0	7.8	18.3	B	18.0	37.0	7.0	10.0	16.0	B	15.7	29.9	4.3	7.8	12.6	B
45	42nd St at 11th Ave	6.1	15.0	8.9	30.4	23.7	3.4	3.6	5.9	A	20.0	38.0	4.0	4.0	9.0	A	11.1	19.0	3.8	5.8	6.8	A
100	DeMers Ave at Columbia East Ramp	6.1	14.0	5.8	4.5	4.1	23.1	39.1	9.0	A	5.0	6.0	31.0	32.0	13.0	B	4.8	5.6	20.9	40.6	11.0	B

Note:

1. AM Peak and PM Peak delays computed using SimTraffic.

2. Intersection LOS based on delays computed for the benefit-cost analysis

Table 14. Implemented Arterial Level of Service

Northbound / Eastbound

Zone	Cross-Street Intersection	Urban Street Class	"Before" Condition			"After" Condition					
			AM Peak	Mid Peak	PM Peak	AM Peak Hour		Mid-Day		PM Peak Hour	
			Average Travel Speed (mph) [(1)]	Average Travel Speed (mph) [(1)]	Average Travel Speed (mph) [(1)]	Average Travel Speed (mph)[1]	LOS	Average Travel Speed (mph)[1]	LOS	Average Travel Speed (mph)[1]	LOS
1	Columbia Road - 32nd Avenue to 6th Avenue	II	22.8	17.7	20.8	27.0	C	21.9	D	24.0	C
2	Washington Street - 32nd Avenue to 5th Avenue	II	23.4	18.6	19.6	28.5	B	23.9	C	26.1	C
3	Gateway Drive - 47th Street to 3rd Street	II	28.1	23.9	27.3	29.3	B	26.8	C	28.1	B
4	DeMers Avenue - 42nd Street to 20th Street	II	26.8	24.0	25.5	28.2	B	26.0	C	25.9	C
	42nd Street - 17th Avenue to 6th Avenue	II	29.1	23.2	27.7	30.8	B	25.5	C	31.7	B

Southbound / Westbound

Zone	Cross-Street Intersection	Urban Street Class	"Before" Condition			"After" Condition					
			AM Peak	Mid Peak	PM Peak	AM Peak Hour		Mid-Day		PM Peak Hour	
			Average Travel Speed (mph) [(1)]	Average Travel Speed (mph) [(1)]	Average Travel Speed (mph) [(1)]	Average Travel Speed (mph)[1]	LOS	Average Travel Speed (mph)[1]	LOS	Average Travel Speed (mph)[1]	LOS
1	Columbia Road - 6th Avenue to 32nd Avenue	II	24.2	17.1	17.9	27.0	C	21.4	D	23.4	C
2	Washington Street - 5th Avenue to 32nd Avenue	II	26.0	21.1	20.5	27.9	C	21.8	D	24.5	C
3	Gateway Drive - 3rd Street to 47th Street	II	27.3	23.4	28.0	28.9	B	26.7	C	29.3	B
4	DeMers Avenue - 20th Street to 42nd Street	II	26.8	26.8	27.6	27.9	C	28.9	B	27.1	C
	42nd Street - 6th Avenue to 17th Avenue	II	28.2	22.4	24.6	27.7	C	22.4	C	26.0	C

[1] SimTraffic model ouput for AM and PM peak hours. Synchro model output for Mid-day scenario.

3.5.2 Optimized Network Performance Measures

In addition to intersection LOS and arterial LOS, the optimized network zone performance was evaluated for the a.m. peak, mid-day peak, p.m. peak and remaining off peak periods. Key measures of effectiveness (MOE's) include overall delay (hours), vehicle stops and fuel consumption. Table 15 documents the optimized condition network performance measures by corridor.

Table 15. Optimized Network Performance Measures

	MOE	Existing ("Before")			Implemented ("After")			Percent Reduction		
		AM Peak	Off Peak	PM Peak	AM Peak	Off Peak	PM Peak	AM Peak	Off Peak	PM Peak
Columbia Road	Stops (no. of veh)	14,009	104,928	54,872	**11,427**	**91,908**	**42,415**	**18.4%**	**12.4%**	**22.7%**
	Delay (hr)	117	1,027	633	**103**	**937**	**526**	**11.7%**	**8.7%**	**17.0%**
	Fuel Consumption (gal)	313	3,333	875	**294**	**3,190**	**843**	**6.0%**	**4.3%**	**3.7%**

AM Peak: 630 to 830 AM
Off Peak: 830 AM to 230 PM, 600 to 1000 PM
PM Peak: 300 to 600 PM

	MOE	Existing ("Before")			Implemented ("After")			Percent Reduction		
		AM Peak	Off Peak	PM Peak	AM Peak	Off Peak	PM Peak	AM Peak	Off Peak	PM Peak
Washington Street	Stops (no. of veh)	18,270	94,864	50,902	**16,187**	**84,351**	**42,878**	**11.4%**	**11.1%**	**15.8%**
	Delay (hr)	198	1,086	680	**185**	**970**	**635**	**6.6%**	**10.7%**	**6.6%**
	Fuel Consumption (gal)	520	3,478	1,071	**496**	**3,304**	**1,056**	**4.7%**	**5.0%**	**1.4%**

AM Peak: 645 to 900 AM
Off Peak: 900 AM to 230 PM, 600 to 1000 PM
PM Peak: 230 to 600 PM

	MOE	Existing ("Before")			Implemented ("After")			Percent Reduction		
		AM Peak	Off Peak	PM Peak	AM Peak	Off Peak	PM Peak	AM Peak	Off Peak	PM Peak
Gateway Drive	Stops (no. of veh)	11,757	85,952	22,688	**8,447**	**61,633**	**19,468**	**28.2%**	**28.3%**	**14.2%**
	Delay (hr)	92	646	204	**81**	**534**	**219**	**12.3%**	**17.4%**	**-7.5%**
	Fuel Consumption (gal)	281	2,875	464	**260**	**2,602**	**469**	**7.3%**	**9.5%**	**-1.0%**

AM Peak: 630 to 815 AM
Off Peak: 815 AM to 245 PM, 600 to 1000 PM
PM Peak: 245 to 600 PM

	MOE	Existing ("Before")			Implemented ("After")			Percent Reduction		
		AM Peak	Off Peak	PM Peak	AM Peak	Off Peak	PM Peak	AM Peak	Off Peak	PM Peak
DeMers Avenue/ 42nd Street	Stops (no. of veh)	10,920	69,685	8,420	**8,335**	**51,005**	**8,184**	**23.7%**	**26.8%**	**2.8%**
	Delay (hr)	75	487	72	**63**	**394**	**76**	**15.7%**	**19.2%**	**-6.5%**
	Fuel Consumption (gal)	368	2,585	224	**339**	**2,369**	**228**	**8.0%**	**8.4%**	**-1.7%**

AM Peak: 630 to 900 AM
Off Peak: 900 AM to 415 PM, 545 to 1000 PM
PM Peak: 415 to 545 PM

3.5.3 Results Discussion

The results of the traffic operation analysis found the overall intersection LOS to be acceptable at all intersections included in the Signal Coordination Study during each of the a.m., mid-day and p.m. peak hours. Although some cross-street approaches are reported to operate at a LOS D or E, in almost all cases the longer delay is a function of the cycle length and is not an operational concern. Two intersections were reported to operate at an overall LOS D during the before conditions and were found to maintain the LOS D grade after the new timing plans. These include:

- Washington Street at DeMers Avenue
- Columbia Road at 32nd Avenue

At all intersections, the cross-street delay is managed to service all (or nearly all each cycle) waiting motorists, minimize queue lengths and provide a balance with the mainline progression. Based on the traffic operation analysis and comparison of the before and after intersection signal timing, the overall intersection or approach delays were significantly improved at several intersections:

- Columbia Road/28th Avenue
- Columbia Road/17th Avenue
- Washington Street/13th Avenue
- Gateway Drive/Columbia Road
- 42nd Street/DeMers Avenue

Although there are always some trade-offs and there may be some individual cross-street movements (e.g., left turn movements) experiencing a slight increase in wait time, significant performance improvements are generally made. Especially when considering the entire length of an arterial and all the intersections within the system. A comparison of the overall intersection delay between the before and after the signal coordination plans found 29 intersections operating at a LOS A or B (30 in before condition) during the a.m. peak hour, 28 intersections operating at a LOS A or B (21 in before condition) during the mid-day peak period, and 24 intersections operating at a LOS A or B (22 in before condition) during the p.m. peak hour. In general, most intersection delays were found improved.

The key arterial corridor findings are summarized below:

- The average corridor operating speed was improved for nearly all directions and route patterns.
- Columbia Road resulted in the greatest corridor improvement. The average corridor operating speed increased by approximately 3 to 6 mph depending upon direction and time period.
- The Washington Street corridor operating speed increased by approximately 1 to 7 mph depending upon direction and time period.

The optimized timings found an improved balance between intersection delay and progression. Overall the travel times are reduced (i.e., improved), while also improving many of the overall intersection delays.

4.0 Event Timing Plans

The City of Grand Forks hosts two major entertainment/convention facilities, the Alerus Center with a seating capacity over 20,000 persons and the Ralph Engelstad Arena (REA) having a seating capacity of approximately 11,000 persons. Prior to and after a large event at either of the facilities, traffic volumes at adjacent intersections are considerably higher than normal and require special consideration. As part of the Signal Coordination Study, event traffic patterns at both facilities were reviewed and inbound and outbound traffic signal timing plans were developed to help improve the traffic flow at key intersections surrounding the arenas.

4.1 Field Observations

An event at each of the Alerus Center and REA were field reviewed in October 2009 to observe inbound and outbound traffic patterns. The observations included identifying the location of traffic control officers, restricted turning movements, traffic circulation patterns, event duration, identifying the impacted intersections and identifying locations of high volume turning movements.

4.2 REA Event Timing Plans

Inbound and outbound timing plans were developed to best accommodate an event at the REA. The inbound event timing plan includes Columbia Road and is designed to facilitate northbound traffic with long green times provided for motorists making a left turn at 2nd Avenue, University Avenue and 6th Avenue. The outbound timing plan includes key intersections along three corridors; Columbia Road, Gateway Drive and 42nd Street. The outbound timing plan is designed to be compatible with the location/operation of traffic control officers and best progresses traffic away from the REA, with long green times at Columbia Road/6th Avenue (eastbound), Columbia Road/Gateway Drive (northbound), 42nd Street/6th Avenue (westbound) and 42nd Street/University Avenue (westbound).

Figure 9 illustrates the intersections included in the inbound and outbound event timing plans implemented for the REA. Table 16 summarizes the detailed timing plan matrix for the REA. In general, the event timing plans should be activated anytime the REA sets up event traffic control devices and uses traffic control officers.

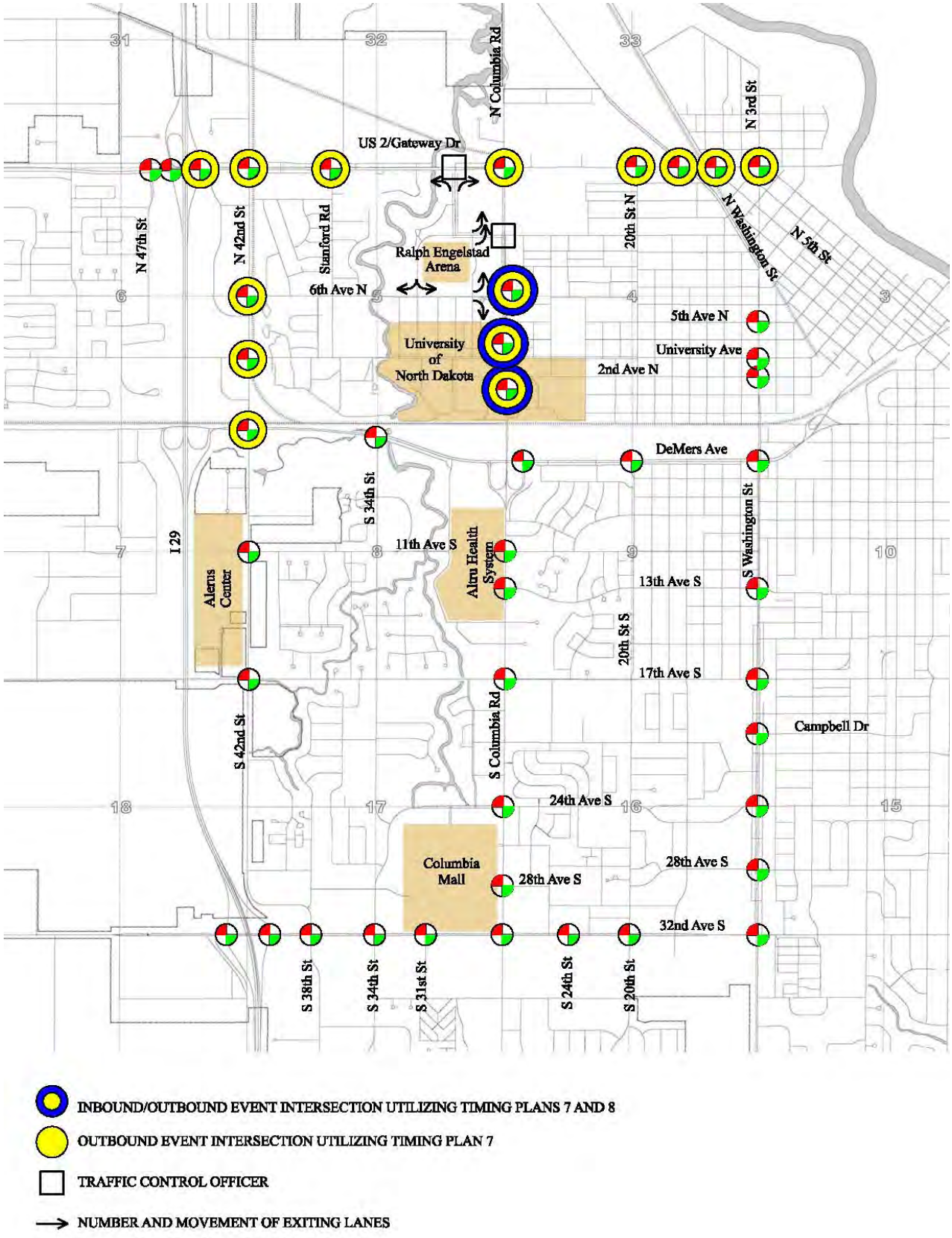


Figure 9. REA Event Timing Plan Map

Table 16. REA Event Timing Plan Matrix

Event Scenario	Event Attendance	Inbound / Outbound	Intersection	Timing Plan	Cycle Length	Time Base Day Plan	Duration	Notes
Friday Evening (7:35 PM)	Any	Inbound	Columbia Road/2nd Avenue	PLAN 8	140s	4 or 11	1 Hour Before Game	
		Inbound	Columbia Road/University Avenue	PLAN 8	140s	4 or 11	1 Hour Before Game	
		Inbound	Columbia Road/6th Avenue	PLAN 8	140s	4 or 11	1 Hour Before Game	
		Inbound	Gateway Drive/I-29 East Ramp	-- [1]		4 or 11		Operate Normal TOD Coord
		Inbound	Gateway Drive/42nd Street	-- [1]		4 or 11		Operate Normal TOD Coord
		Inbound	Gateway Drive/Stanford Road	-- [1]		4 or 11		Operate Normal TOD Coord
		Inbound	Gateway Drive/Columbia Road	-- [1]		4 or 11		Operate Normal TOD Coord
		Outbound	Columbia Road/2nd Avenue	PLAN 7	140s	4 or 11	1 Hour After Game	
		Outbound	Columbia Road/University Avenue	PLAN 7	140s	4 or 11	1 Hour After Game	
		Outbound	Columbia Road/6th Avenue	PLAN 7	140s	4 or 11	1 Hour After Game	
		Outbound	Gateway Drive/I-29 East Ramp	PLAN 7	120s	4 or 11	1 Hour After Game	
		Outbound	Gateway Drive/42nd Street	PLAN 7	120s	4 or 11	1 Hour After Game	
		Outbound	Gateway Drive/Stanford Road	PLAN 7	120s	4 or 11	1 Hour After Game	
		Outbound	Gateway Drive/Columbia Road	PLAN 7	120s	4 or 11	1 Hour After Game	
		Outbound	Gateway Drive/20th Street	PLAN 7	120s	4 or 11	1 Hour After Game	
		Outbound	Gateway Drive/Washington Street	PLAN 7	120s	4 or 11	1 Hour After Game	
		Outbound	Gateway Drive/5th Street	PLAN 7	120s	4 or 11	1 Hour After Game	
		Outbound	Gateway Drive/3rd Avenue	PLAN 7	120s	4 or 11	1 Hour After Game	
		Outbound	42nd Street/6th Avenue	PLAN 7	100s	4 or 11	1 Hour After Game	
		Outbound	42nd Street/University Avenue	PLAN 7	100s	4 or 11	1 Hour After Game	
		Outbound	42nd Street/DeMers Avenue	PLAN 7	100s	4 or 11	1 Hour After Game	
Saturday / Sunday Day (3:35 PM)	Any	Inbound	Columbia Road/2nd Avenue	PLAN 8	140s	7	1 Hour Before Game	
		Inbound	Columbia Road/University Avenue	PLAN 8	140s	7	1 Hour Before Game	
		Inbound	Columbia Road/6th Avenue	PLAN 8	140s	7	1 Hour Before Game	
		Inbound	Gateway Drive/I-29 East Ramp	-- [1]		7		Operate Normal TOD Coord
		Inbound	Gateway Drive/42nd Street	-- [1]		7		Operate Normal TOD Coord
		Inbound	Gateway Drive/Stanford Road	-- [1]		7		Operate Normal TOD Coord
		Inbound	Gateway Drive/Columbia Road	-- [1]		7		Operate Normal TOD Coord
		Outbound	Columbia Road/2nd Avenue	PLAN 7	140s	7	1 Hour After Game	
		Outbound	Columbia Road/University Avenue	PLAN 7	140s	7	1 Hour After Game	
		Outbound	Columbia Road/6th Avenue	PLAN 7	140s	7	1 Hour After Game	
		Outbound	Gateway Drive/I-29 East Ramp	PLAN 7	120s	7	1 Hour After Game	
		Outbound	Gateway Drive/42nd Street	PLAN 7	120s	7	1 Hour After Game	
		Outbound	Gateway Drive/Stanford Road	PLAN 7	120s	7	1 Hour After Game	
		Outbound	Gateway Drive/Columbia Road	PLAN 7	120s	7	1 Hour After Game	
		Outbound	Gateway Drive/20th Street	PLAN 7	120s	7	1 Hour After Game	
		Outbound	Gateway Drive/Washington Street	PLAN 7	120s	7	1 Hour After Game	
		Outbound	Gateway Drive/5th Street	PLAN 7	120s	7	1 Hour After Game	
		Outbound	Gateway Drive/3rd Avenue	PLAN 7	120s	7	1 Hour After Game	
		Outbound	42nd Street/6th Avenue	PLAN 7	100s	7	1 Hour After Game	
		Outbound	42nd Street/University Avenue	PLAN 7	100s	7	1 Hour After Game	
		Outbound	42nd Street/DeMers Avenue	PLAN 7	100s	7	1 Hour After Game	
Saturday Evening (7:05 PM / 7:35 PM)	Any	Inbound	Columbia Road/2nd Avenue	PLAN 8	140s	5 or 6	1 Hour Before Game	
		Inbound	Columbia Road/University Avenue	PLAN 8	140s	5 or 6	1 Hour Before Game	
		Inbound	Columbia Road/6th Avenue	PLAN 8	140s	5 or 6	1 Hour Before Game	
		Inbound	Gateway Drive/I-29 East Ramp	-- [1]		5 or 6		Operate Normal TOD Coord
		Inbound	Gateway Drive/42nd Street	-- [1]		5 or 6		Operate Normal TOD Coord
		Inbound	Gateway Drive/Stanford Road	-- [1]		5 or 6		Operate Normal TOD Coord
		Inbound	Gateway Drive/Columbia Road	-- [1]		5 or 6		Operate Normal TOD Coord
		Outbound	Columbia Road/2nd Avenue	PLAN 7	140s	5 or 6	1 Hour After Game	
		Outbound	Columbia Road/University Avenue	PLAN 7	140s	5 or 6	1 Hour After Game	
		Outbound	Columbia Road/6th Avenue	PLAN 7	140s	5 or 6	1 Hour After Game	
		Outbound	Gateway Drive/I-29 East Ramp	PLAN 7	120s	5 or 6	1 Hour After Game	
		Outbound	Gateway Drive/42nd Street	PLAN 7	120s	5 or 6 or 8	1 Hour After Game	
		Outbound	Gateway Drive/Stanford Road	PLAN 7	120s	5 or 6	1 Hour After Game	
		Outbound	Gateway Drive/Columbia Road	PLAN 7	120s	5 or 6	1 Hour After Game	
		Outbound	Gateway Drive/20th Street	PLAN 7	120s	5 or 6	1 Hour After Game	
		Outbound	Gateway Drive/Washington Street	PLAN 7	120s	5 or 6	1 Hour After Game	
		Outbound	Gateway Drive/5th Street	PLAN 7	120s	5 or 6	1 Hour After Game	
		Outbound	Gateway Drive/3rd Avenue	PLAN 7	120s	5 or 6	1 Hour After Game	
		Outbound	42nd Street/6th Avenue	PLAN 7	100s	5 or 6 or 8	1 Hour After Game	
		Outbound	42nd Street/University Avenue	PLAN 7	100s	5 or 6 or 8	1 Hour After Game	
		Outbound	42nd Street/DeMers Avenue	PLAN 7	100s	5 or 6 or 8	1 Hour After Game	

[1] Where an inbound timing plan is not specificied, the key intersection left turn movements have been inflated under normal timing operation to account for variable traffic demand. Therefore, a special event timing plan is not expected to be necessary.

2010-2011 Schedule

Time Base Day Plans
- Day Plan 4: Friday 7:35 PM Game (REA)
- Day Plan 5: Saturday 7:05 PM Game (REA)
- Day Plan 6: Saturday 7:35 PM Game (REA)
- Day Plan 7: Saturday or Sunday 3:35 PM Game (REA)
- Day Plan 8: Saturday 12:00 PM UND Football (ALERUS) and 7:05 UND Hockey Game (REA)
- Day Plan 9: Saturday 12:00 PM UND Football (ALERUS)
- Day Plan 11: Weekday Evening Special Event (Modify Event Start/Exit As Necessary)

Note: Gateway Drive/42nd Street, 42nd Street/6th Avenue, 42nd Street/University Avenue, 42nd Street/DeMers Avenue will have both Alerus and REA event timing plans

4.3 Alerus Center Event Timing Plans

Inbound and outbound timing plans were developed to best accommodate an event at the Alerus Center. The inbound event timing plan includes 42nd Street and DeMers Avenue and is designed to provide two-way vehicle progression. The inbound traffic patterns at the Alerus are largely spread out and most left turns occur at unsignalized access points. The outbound timing plan includes key intersections along three corridors; 42nd Street, DeMers Avenue and 32nd Avenue. The outbound timing plan is designed to be compatible with the location/operation of traffic control officers along 42nd Street and best progresses traffic away from the Alerus, with the primary northbound exiting traffic patterns destined to Gateway Drive, to I-29 via DeMers, or into town via DeMers Avenue. The south half of the Alerus Center is directed southbound out of the parking lots, with most motorists destined to eastbound 17th Avenue, to I-29 or southeast Grand Forks via 32nd Avenue.

Table 17 summarizes the detailed timing plan matrix for the Alerus Center. Figure 10 illustrates the intersections included in the inbound and outbound event timing plans. In general, the event timing plans should be activated anytime the Alerus Center sets up event traffic control devices and uses traffic control officers.

Table 17. Alerus Center Event Timing Plan Matrix

Event Scenario	Event Attendance	Inbound / Outbound	Intersection	Timing Plan	Cycle Length	Time Base Day Plan	Duration	Notes
Weekday Evening -- Or -- Saturday/Sunday	Any Where Traffic Control Devices and Traffic Control Officers Deployed	Inbound	Gateway Drive/42nd Street	-- (1)		8 or 9		Operate Normal TOD Coord
		Inbound	42nd Street/6th Avenue	PLAN 10	90s	9	2 Hour Before Game	
		Inbound	42nd Street/University Avenue	PLAN 10	90s	9	2 Hour Before Game	
		Inbound	42nd Street/DeMers Avenue	PLAN 10	90s	9	2 Hour Before Game	
		Inbound	42nd Street/11th Avenue	PLAN 10	90s	9	2 Hour Before Game	
		Inbound	42nd Street/17th Avenue	PLAN 10	90s	9	2 Hour Before Game	
		Inbound	DeMers Avenue/34th Street	PLAN 10	90s	9	2 Hour Before Game	
		Inbound	DeMers Avenue/Columbia Road	PLAN 10	90s	9	2 Hour Before Game	
		Inbound	DeMers Avenue/20th Street	PLAN 10	90s	9	2 Hour Before Game	
		Inbound	32nd Avenue/29 West Ramp	-- (1)		9		Operate Normal TOD Coord
		Inbound	32nd Avenue/29 East Ramp	-- (1)		9		Operate Normal TOD Coord
		Inbound	32nd Avenue/38th Street	-- (1)		9		Operate Normal TOD Coord
		Outbound	Gateway Drive/42nd Street	PLAN 9	90s	8 or 9	1 Hour After Game	
		Outbound	42nd Street/6th Avenue	PLAN 9	120s	8 or 9	1 Hour After Game	
		Outbound	42nd Street/University Avenue	PLAN 9	120s	8 or 9	1 Hour After Game	
		Outbound	42nd Street/DeMers Avenue	PLAN 9	120s	8 or 9	1 Hour After Game	
		Outbound	42nd Street/11th Avenue	PLAN 9	Free	9	1 Hour After Game	
		Outbound	42nd Street/17th Avenue	PLAN 9	Free	9	1 Hour After Game	
		Outbound	DeMers Avenue/34th Street	PLAN 9	60s	9	1 Hour After Game	
		Outbound	DeMers Avenue/Columbia Road	PLAN 9	60s	9	1 Hour After Game	
		Outbound	DeMers Avenue/20th Street	PLAN 9	60s	9	1 Hour After Game	
		Outbound	32nd Avenue/29 West Ramp	PLAN 9	110s	9	1 Hour After Game	
		Outbound	32nd Avenue/29 East Ramp	PLAN 9	110s	9	1 Hour After Game	
		Outbound	32nd Avenue/38th Street	PLAN 9	110s	9	1 Hour After Game	
		Outbound	32nd Avenue/34th Street	PLAN 9	110s	9	1 Hour After Game	
		Outbound	32nd Avenue/31st Street	PLAN 9	110s	9	1 Hour After Game	
		Outbound	32nd Avenue/Columbia Road	PLAN 9	110s	9	1 Hour After Game	
		Outbound	32nd Avenue/24th Street	PLAN 9	110s	9	1 Hour After Game	
		Outbound	32nd Avenue/20th Street	PLAN 9	110s	9	1 Hour After Game	

(1) Where an inbound timing plan is not specificied, the key intersection left turn movements have been inflated under normal timing operation to account for variable traffic demand. Therefore, a special event timing plan is not expected to be necessary.

2010-2011 Schedule

Time Base Day Plans
- Day Plan 4: Friday 7:35 PM Game (REA)
- Day Plan 5: Saturday 7:05 PM Game (REA)
- Day Plan 6: Saturday 7:35 PM Game (REA)
- Day Plan 7: Saturday or Sunday 3:35 PM Game (REA)
- Day Plan 8: Saturday 12:00 PM UND Football (ALERUS) and 7:05 UND Hockey Game (REA)
- Day Plan 9: Saturday 12:00 PM UND Football (ALERUS)

Note: Gateway Drive at 42nd Street will have both Alerus and REA event timing plans

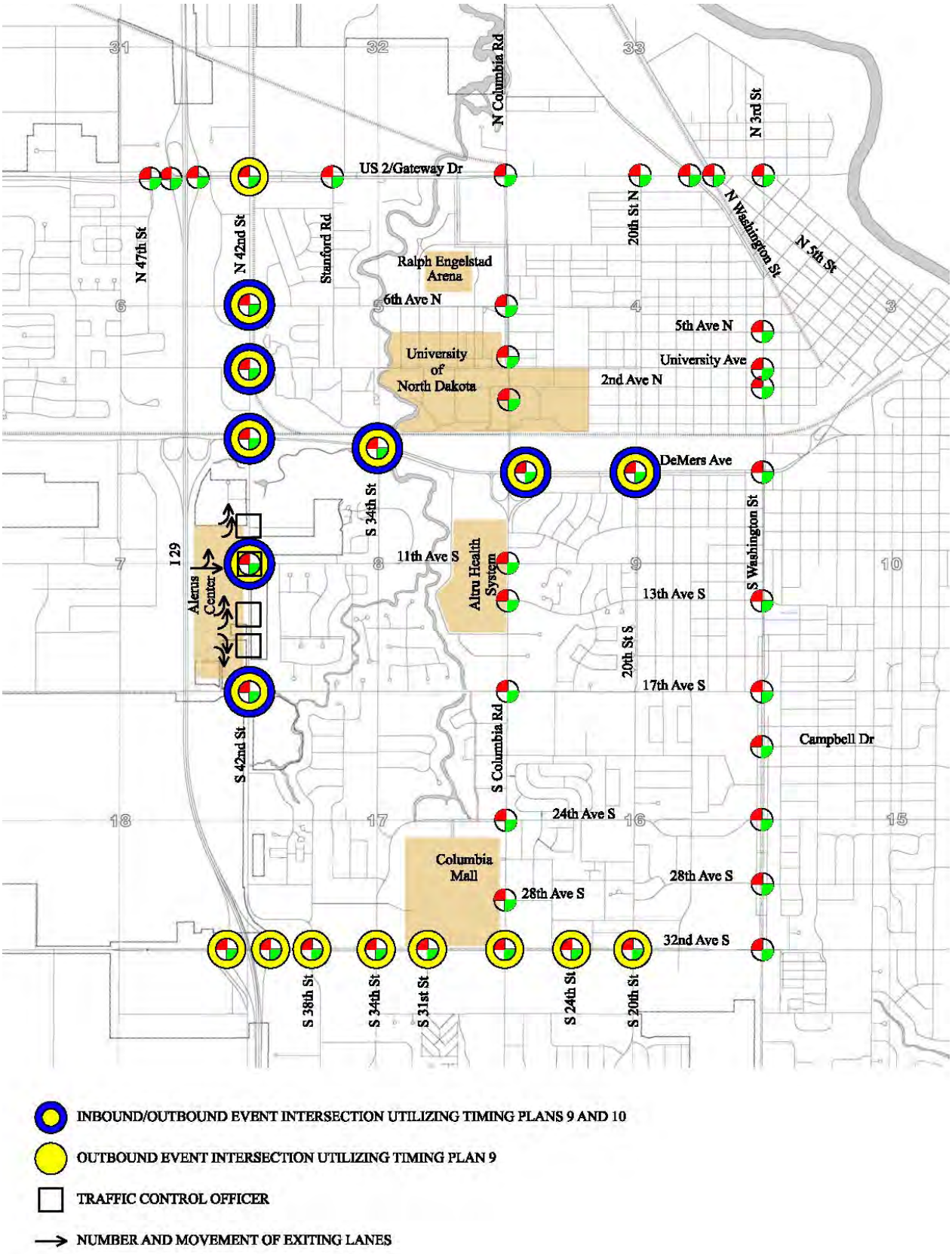


Figure 10. Alerus Center Event Timing Plan Map

5.0 Transit Signal Priority

Transit Signal Priority (TSP) is the operation strategy used to provide advantage to buses at signalized intersections. The transit vehicle benefits from TSP by automatically adjusting the signal timing through green extension and red truncation. Green extension grants extra green time for a transit vehicle so the vehicle can safely pass through a traffic signal that is about to turn red. Red Truncation shortens other signal phases so that a transit vehicle receives a green light sooner than it normally would. The two main objectives of TSP are to help improve the bus schedule reliability and to help reduce the bus running time. The TSP component of the project included the installation of bus and signal cabinet equipment and implementation of timing parameters as will be discussed in the following sections.

5.1 TSP Equipment

The TSP system uses GPS technology to determine the location and speed of transit vehicles. This information is broadcast to traffic signals equipped with special equipment. The traffic signal uses this information to determine how to adjust green and red times to better service the transit vehicle. TSP equipment was acquired by the MPO and installed by Strata Corporation in the spring of 2010. The signal controllers were supplied by Econolite and installed by Traffic Control Corporation in October 2010. Alliant Engineering mapped the GTT phase selector channels and programmed the ASC3 controllers in November and December 2010 to make the system operational. The TSP equipment included:

- GTT (Global Traffic Technologies) phase selector installed in each signal cabinet.
- GPS receiver and radio installed on the traffic signal mast arm.
- GPS transmitter and vehicle computer unit (VCU) installed on the CAT buses and wired to the bus turn signal.
- Econolite ASC3 signal controller with Econolite TSP logic data key (illustrated previously in Figure 8).

In order for the TSP system to work properly the traffic signal system and all buses using the system need to have the correct equipment installed.

5.2 City of Grand Forks Bus Routes

The City of Grand Forks operates 11 color coded bus routes. Bus service is offered Monday through Saturday, excluding holidays. TSP is able to benefit buses on these routes when it is installed at traffic signals that the buses pass through. Figure 11 illustrates the City of Grand Forks bus route system.

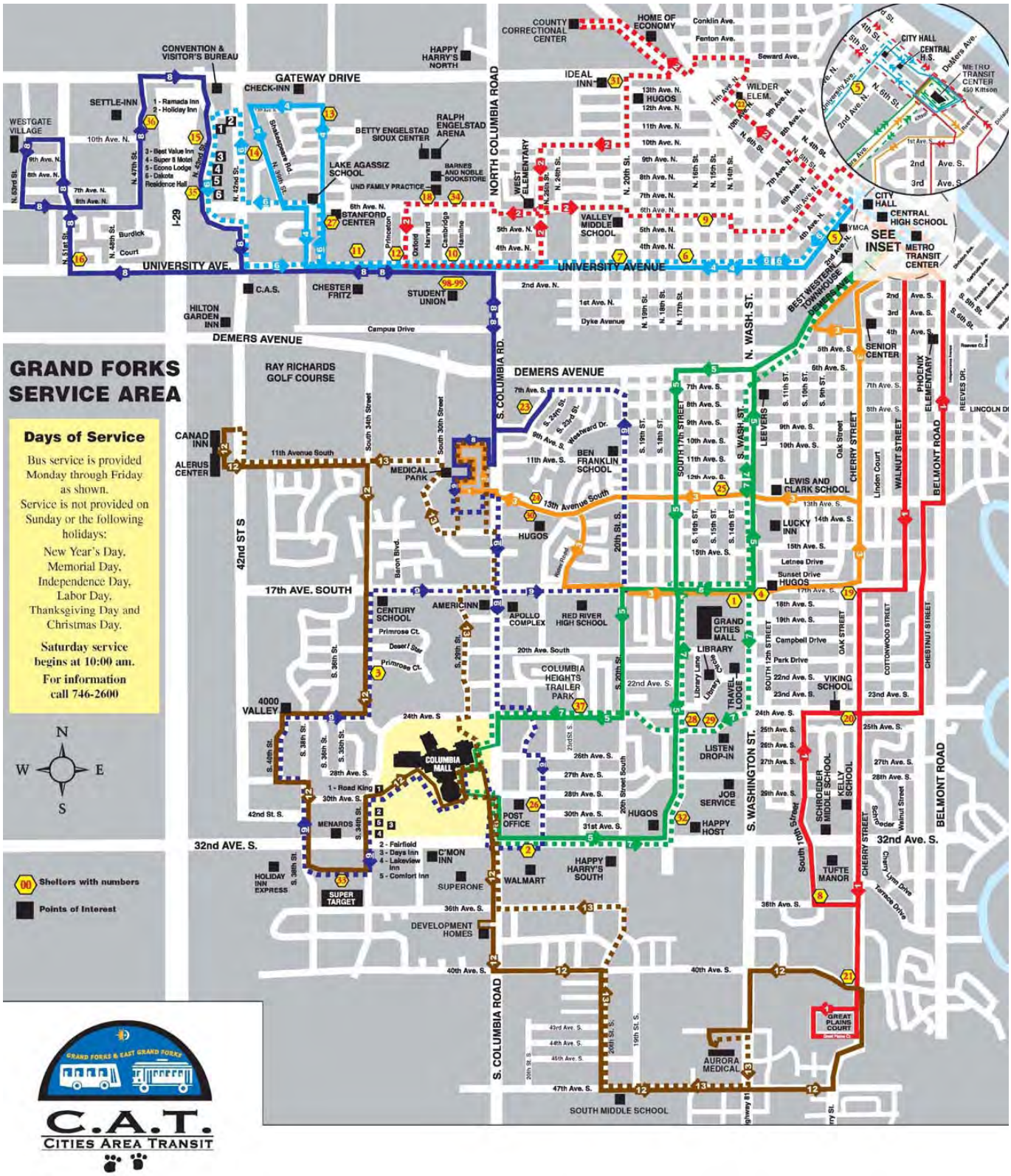


Figure 11. City of Grand Forks Bus Route Map

5.3 TSP Equipped Intersections

The MPO and the City of Grand Forks identified 28 intersections to receive TSP equipment. Figure 12 and the following list highlight the intersections where TSP equipment is installed.

- 32nd Avenue and 38th Street
- 32nd Avenue and 34th Street
- 32nd Avenue and Columbia Road
- 32nd Avenue and 24th Street
- 32nd Avenue and 20th Street
- Columbia Road and 28th Avenue
- Columbia Road and 24th Avenue
- Columbia Road and 17th Avenue
- Columbia Road and 13th Avenue
- Columbia Road and 11th Avenue
- Columbia Road and 2nd Avenue
- Columbia Road and University Avenue
- Columbia Road and 6th Avenue
- Washington Street and 47th Avenue
- Washington Street and Campbell Drive
- Washington Street and 17th Avenue
- Washington Street and 13th Avenue
- Washington Street and DeMers Avenue
- Washington Street and University Avenue
- Washington Street and 5th Avenue
- Gateway Drive and I-29 East Ramp
- Gateway Drive and I-29 West Ramp
- Gateway Drive and 20th Street
- Gateway Drive and 3rd Street
- 42nd Street and University Avenue
- 17th Avenue and 20th Street
- 17th Avenue and 34th Street
- 24th Avenue and 20th Street

Each intersection was reviewed against the City of Grand Forks bus route map and the TSP channels and ASC3 controller inputs/signal phases were mapped to the specific bus route movement. Because the TSP system is GPS based, only the specific movements having a bus route were enabled. Figure 12 illustrates the bus movement (TSP enabled movement) cross-referenced with the corresponding route color.

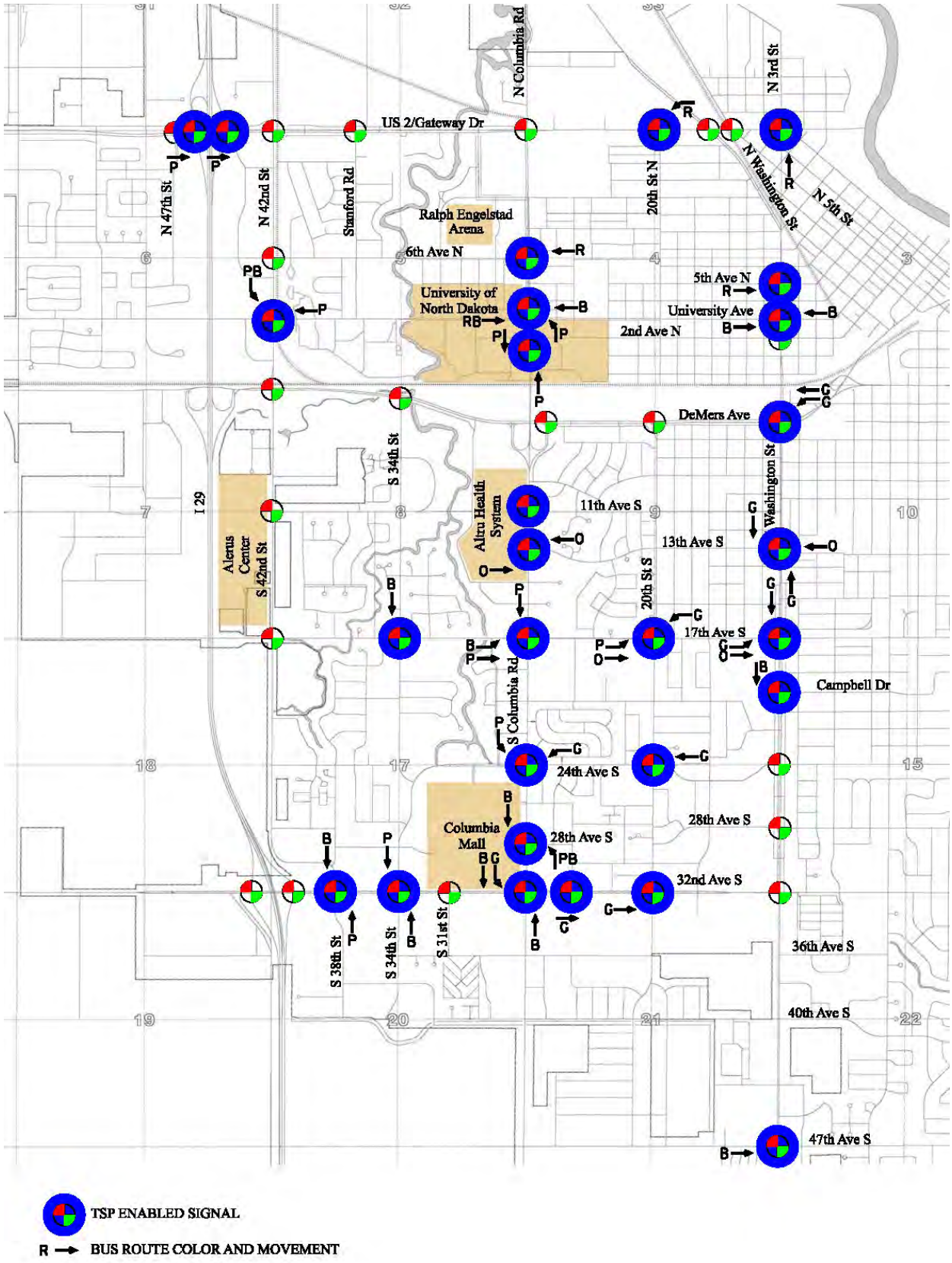


Figure 12. TSP Intersection Map

5.4 TSP Timing Parameters

The TSP timing parameters were developed in accordance with the Econolite ASC3 signal controller logic for TSP operations. In developing the timing parameters there are several fundamental constraints adhered to and standards followed:

- The cycle length cannot change and the signal controller cannot lose its cycle sync in order to service a TSP request.
- The signal phase order cannot change and all signal phases at the intersection must be served. Omitting signal phases is possible; however, the City of Grand Forks has elected to not operate TSP in this manner.
- All phase minimum times must be served (minimum green, yellow/red and pedestrian clearance intervals). In other words, the TSP timing parameters cannot reduce the green time or clearance interval of any movement (e.g., left turn arrow) less than the controller minimum.
- A TSP request can only borrow time from a movement in the same cycle. The cycle always begins with the start of the mainline green. (e.g., at Washington Street/17th Avenue the start of northbound Washington is time zero. In this example, a TSP call for the eastbound 17th Avenue movement can only take time from shortening northbound/southbound Washington Street coordinated phases and the opposing westbound left turn arrow).

The following summarizes the global TSP parameters programmed in the ASC3 controller:

- TSP delay time set to zero. No delay between the check-in time of a transit vehicle and the start of the TSP routine.
- TSP maximum presence set to 210 seconds. Ensures a bus picking up passengers at the intersection will not drop a TSP request.
- TSP reservice set to zero. Allows back to back TSP requests to be granted.

The TSP timing parameters consist of two key parameters – maximum green time reduction and the approach detection zone length. The maximum green time reduction time is the maximum amount of time that a phase is allowed to reduce when a TSP call is granted. Detection zone length is the distance from the intersection where a transit vehicle can be granted a TSP request by the signal controller. A summary of the maximum green time reduction values and detection zone lengths are provided in Appendix C. The following sections summarize the general approach to determining the respective values.

5.4.1 Maximum Green Time Reduction

In general, the TSP timing parameters programmed were as aggressive as the controller logic allows for, while also balancing the traffic demands at the intersection. The maximum reduction time for all non-coordinated movements was calculated by using the difference between the green-time programmed for each timing plan versus the minimum

allowable green time for that movement. In other words, the maximum allowable reduction was programmed for each plan. This allows the TSP request to maximize the time savings. This rule applied to all intersections except Washington Street/DeMers Avenue, Washington Street/17th Avenue and Columbia Road/17th Avenue. These three intersections during the a.m. and p.m. peak hours operate at capacity. Therefore, the maximum green time reduction for the non-coordinated movements was determined based on the volume to capacity ratio to ensure a congestion problem does not result from the TSP request.

Several of the TSP enabled movements at intersections along Columbia Road, Washington Street and 32nd Avenue are non-coordinated phases. In this regard, the benefit of TSP can be greatly reduced. In order for TSP to benefit the bus routes in these situations, the coordinated phase must be allowed to be reduced; thereby, having a potential to impact vehicle progression on the corridor mainline. In all these instances, the maximum reduction was based upon when the vehicle platoons passed through the intersection (on average). The maximum reduction was then programmed for the greatest time allowable without cutting off the approaching vehicle platoon.

For purpose of illustration, the intersection of Columbia Road at 13th Avenue is highlighted to summarize how the TSP parameters work. Table 18 shows the normal and TSP timing parameters in operation from 8:30 a.m. to 10:45 a.m.

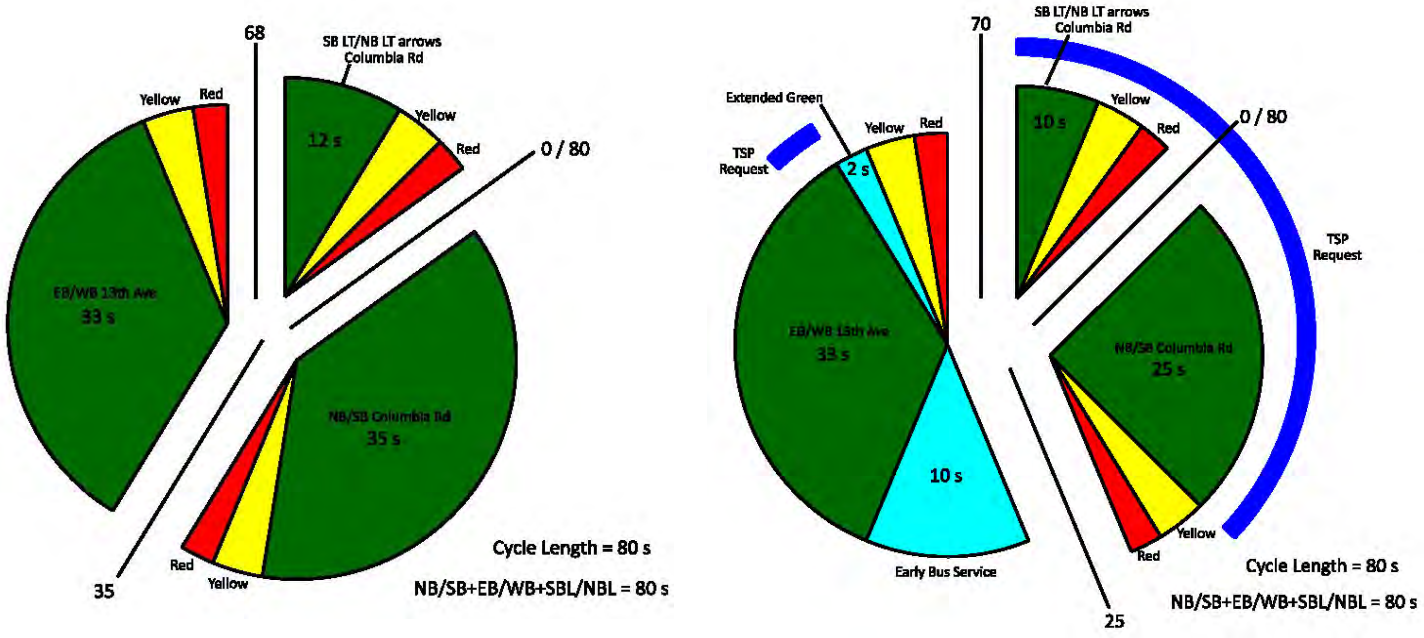
Table 18. TSP Timing Parameters - Columbia Road at 13th Avenue

	Cycle Legnth (s)	Southbound / Northbound Left Turn Arrows (s)	Northbound / Southbound Through Movements (s)	Eastbound / Westbound Left and Through Movements (s)	TSP Detection Zone (ft)
Programmed Split Time	80	12	35	33	
Controller Minimum Split	--	10	21	NA	
Maximum Green Reduction	--	2	10	NA	350
New Split Time		10	25	45	

= TSP Enabled Movements

Figure 13 on the following page illustrates how the signal operation is modified to grant a TSP request and compares the intersection of Columbia Road at 13th Avenue under normal conditions versus responding to a TSP request. As shown in the pie charts, a new cycle begins at time zero, which is always the start of green for the mainline through movement. The numbers located in the green slices of the pie chart represent the maximum amount of time the corresponding movement has (this includes the yellow and red slices). Under normal operation the northbound/southbound Columbia Road (coordinated phases) have 35 seconds. Because the TSP movements are on the non-coordinated approaches, the TSP benefit comes from reducing the coordinated

movements green time and must consider vehicle platoons approaching the intersection. In this case 10 seconds is reduced. A bus traveling along 13th Avenue and approaching Columbia Road while the signal is red will receive the TSP request by reducing the Columbia Road green time by 10 seconds, equaling a 10 second time savings. A bus traveling along 13th Avenue and approaching Columbia Road while the signal is green, will either pass through the intersection, or be given an extended green. The extended green can only occur by reducing the northbound/southbound left turn arrow time. In this case, the green can only be extended by 2 seconds due to the minimum green time requirements.



Normal Operation *TSP Modified Operation*

Figure 13. TSP Operation Illustration – Columbia Road at 13th Avenue

5.4.2 TSP Detection Zone Length

For each TSP movement enabled at an intersection, the GTT phase selectors were programmed for the appropriate detection zone length. The detection zone applies to only buses and is the distance in advance of the intersection a TSP call can be placed into the controller. The detection zone lengths were calculated by using the total maximum reduction time for non-TSP phases to determine the amount of time that could be given to the TSP movements. Once this amount of time (maximum extension time of all timing plans) was determined the detection zone length could be calculated by multiplying the maximum extension time by the bus approach speed. The bus approach speed is assumed to be the posted speed limit minus five miles per hour. Engineering judgment was then used to adjust the detection zone where necessary, such as locations where the zone

would extend beyond an upstream traffic signal. The detection zone lengths for each intersection are tabulated in Appendix C.

5.5 TSP Timing Parameters Fine-Tuning

The TSP system was integrated, tested and made operational in December 2010. As the bus routes continue to operate through these intersections, it is expected that the MPO and City of Grand Forks will need to or want to make fine-tuning adjustments to best maximize the benefit. As mentioned previously, most of the timing parameters have already been programmed to maximize the TSP benefit, but two remaining adjustments could be further considered at select locations:

- Increasing the maximum green reduction of the coordinated phases, and
- Lengthening the detection zone length.

These adjustments would only be made at intersections where the bus TSP movement is on the non-coordinated cross-street (e.g., Columbia Road/13th Avenue or 32nd Avenue/34th Street). There are pros and cons to both adjustments, which would need to be considered on a case-by-case basis for each intersection. Increasing the detection zone will allow the TSP request to engage the traffic signal earlier and depending on where in the signal cycle the bus makes the request, there is a small window of opportunity to increase the benefit to approaching buses. The downside to this option is the bus could also make the request too early, and not get to the intersection in time to receive the TSP call. This would result in a back to back TSP event at the intersection with no additional benefit to buses. Further reducing the coordinated phase is a feasible option; however, this would most likely impact traffic operations and could lead to a safety concern with the signal phase terminating while the platoon is approaching or in the intersection. This adjustment will need to be considered carefully.

6.0 Adverse Weather Timing Plans

The presence or aftermath of heavy rain storms, snow storms or ice storms can result in motorists traveling and accelerating much more cautiously and slower than under normal conditions. As the vehicle travel and acceleration speeds reduce, the normal dry weather timing plans can become unsuitable in providing vehicle progression along the corridor. To help manage traffic conditions and provide the best operation possible under adverse weather conditions, special timing plans were developed. The following sections document previous research in this regard, assumptions and approach to developing the timing plan parameters and a summary of the timing plans placed into operation.

6.1 Literature Research

Adverse weather timing plans are not commonly used by agencies to manage traffic. This is primarily due to the fact that enabling the timing plans automatically cannot be done reliably (requires staff time to manually enable) and the most important variable, motorist travel speed, can vary from storm to storm or by roadway condition. There have been several studies completed that research the motorist driving parameters during adverse weather and the expected effectiveness of implementing special timing plans. Research studies reviewed in developing the adverse weather timing plans as part of the Signal Coordination Study include:

- Inclement Weather Timing Plans, Dr. Peter T Martin, Associate Professor of Civil Engineering, UTAH Department of Transportation, July 2000
- Modifying Signal Timing During Inclement Weather, Joseph Parrin Jr, Peter T. Martin, TRB Research Paper 01-3233, January 2001.
- Adverse Weather Signal Timing, Minnesota Department of Transportation, 1999.

A variety of traffic and weather data was collected as part of these research projects. Traffic data such as signal timing plans, geometrics, turning movement counts, travel time runs, volume and occupancy, start up delay and saturation flow rate are documented. Based on an analysis of the research documents a couple of key conclusions were made:

- The cycle length should remain the same. Only the intersection splits and offsets are refined to accommodate the slower start up and vehicle travel speeds.
- Adverse weather timing plan can reduce congestion, reduce stops and improve travel times if implemented during the appropriate roadway conditions.
- Motorist driving parameters and behaviors under adverse weather conditions are well documented.

6.2 Adverse Weather Timing Plan Assumptions

The previous research studies documented the motorists driving behavior and traffic characteristics under various adverse weather conditions. Based on this data and field

observations made in Grand Forks, the following assumptions were made when designing adverse weather signal timing plans:

- Motorist travel speed is approximately 25 mph throughout Grand Forks. Approximately a 30 percent decrease from dry conditions.
- 20 percent reduction in saturation flow rate (1,500 vehicles per hour per lane).
- 15 percent reduction in traffic volume.
- One additional second per movement of intersection lost time.

The above traffic characteristics were applied to the fine-tuned coordinated timing plans and the adverse weather timings were developed for each corridor. Key strategies in developing the timing plans included:

- Operating each corridor with less timing plans than normal conditions. Only an a.m. peak, mid-day and p.m. peak plan were developed for the weekdays.
- A Saturday adverse weather timing plan was developed for 32nd Avenue, Columbia Road and Washington Street.
- The same cycle length was used as the dry weather timing plans and common cycle lengths with inter-zone coordination between each of the corridors was maximized when appropriate.
- Left turn arrow and cross-street green times were increased wherever feasible.

6.3 Adverse Weather Timing Plan Summary

Table 19 highlights the adverse weather timing plan cycle lengths and associated plan identification number for each corridor.

Table 19. Adverse Weather Cycle Length and Plan Identification Summary

32nd Avenue

Volume Case	Cycle Length (sec)	Plan ID	COS
AM PEAK	80	PLAN 21	221
MID-DAY LOW	100	PLAN 23	223
MID-DAY / PM PEAK	120	PLAN 24	224
SATURDAY	120 / 60 (1)	PLAN 25	232

(1) I-29 West Ramp and I-29 East Ramp operate on a 60 second cycle.

Table 19. Adverse Weather Cycle Length and Plan Identification Summary Cont'd

Columbia Road

Volume Case	Cycle Length (sec)	Plan ID	COS
AM PEAK	120 / 80 (1)	PLAN 21	221
MID-DAY LOW	100	PLAN 23	223
MID-DAY / PM PEAK	120	PLAN 24	224
SATURDAY	120	PLAN 25	232
OVERNIGHT	50 (2)	PLAN 31	231

(1) 28th Avenue operates on a 80 second cycle compatible with 32nd Avenue

(2) Applies to 13th Avenue, 11th Avenue, 2nd Avenue and University Avenue. Remaining intersections operate free.

Washington Street

Volume Case	Cycle Length (sec)	Plan ID	COS
AM PEAK	110	PLAN 21	221
MID-DAY LOW	100	PLAN 23	223
MID-DAY / PM PEAK	130	PLAN 24	224
SATURDAY	120 (1)	PLAN 25	232

(1) 5th Avenue operates on a 60 second cycle

Gateway Drive

Volume Case	Cycle Length (sec)	Plan ID	COS
AM PEAK	110	PLAN 21	221
MID-DAY PEAK	90	PLAN 22	222
PM PEAK	120 / 100 (1)	PLAN 24	224
OVERNIGHT	75 / 70 (2)	PLAN 31	231

(1) 47th Street to Columbia Road operate on a 100 second cycle

(2) 47th Street to Stanford Road operate on a 70 second cycle, Columbia Road operates free and 20th Street to 3rd Street operate on a 75 second cycle.

DeMers Avenue / 42nd Street

Volume Case	Cycle Length (sec)	Plan ID	COS
AM PEAK	110 / 80 (1)	PLAN 21	221
MID-DAY PEAK	80	PLAN 23	223
PM PEAK	130 / 65 (2)	PLAN 24	224

(1) 42nd Street operates on a 80 second cycle. DeMers Avenue from 34th Street to 20th Street operates on a 110 second cycle.

(2) DeMers Avenue/42nd Street and 42nd Street/University Avenue operate on a 130 second cycle.

Table 20 highlights the adverse weather timing plan time of day program for each corridor.

Table 20. Adverse Weather TOD Summary

Columbia Road (28th Avenue to 6th Avenue)

Zone 1

Day	Operation	Time	Plan ID	COS	Cycle Length (s)
Weekday	TOD	630 AM to 815 AM	PLAN 21	221	120 / 80[(1)]
		815 AM to 1030 AM	PLAN 23	223	100
		1030 AM to 630 PM	PLAN 24	224	120
		630 PM to 1100 PM	PLAN 23	223	100
		1100 PM to 630 AM	PLAN 31	231	50
Saturday/Sunday	TOD	800 AM to 1000 AM	PLAN 23	223	100
		1000 AM to 600 PM	PLAN 25	232	120
		600 PM to 1030 PM	PLAN 23	223	100
		1030 PM to 800 AM	PLAN 31	231	50

(1) 80 s cycle operates on Columbia Road at 28th Avenue

Washington Street (32nd Avenue to 5th Avenue)

Zone 2

Day	Operation	Time	Plan ID	COS	Cycle Length (s)
Weekday	TOD	1200 AM to 630 AM	PLAN 100	FREE	--
		630 AM to 715 AM	PLAN 23	223	100
		715 AM to 815 AM	PLAN 21	221	110
		815 AM to 1115 AM	PLAN 23	223	100
		1115 AM to 615 PM	PLAN 24	224	130
		615 PM to 1100 PM	PLAN 23	223	100
		1100 PM to 1200 AM	PLAN 100	FREE	--
Saturday/Sunday	TOD	830 AM to 1100 AM	PLAN 23	223	100
		1100 AM to 600 PM	PLAN 25	232	120
		600 PM to 1030 PM	PLAN 23	223	100

Gateway Drive (47th Street to 3rd Street)

Zone 3

Day	Operation	Time	Plan ID	COS	Cycle Length (s)
Weekday	TOD	1200 AM to 630 AM	PLAN 100	FREE	--
		630 AM to 715 AM	PLAN 22	222	90
		715 AM to 815 AM	PLAN 21	221	110
		815 AM to 245 PM	PLAN 22	222	90
		245 PM to 600 PM	PLAN 24	224	120 / 100[(1)]
		600 PM to 1000 PM	PLAN 22	222	90
		1000 PM to 1200 AM	PLAN 31	231	70
Saturday/Sunday	TOD	700 AM to 800 AM	PLAN 31	231	70
		800 AM to 2200 PM	PLAN 22	222	90
		2200 PM to 2400 PM	PLAN 31	231	70

(1) 100 s cycle operates on Gateway Drive from 47th Street to Columbia Road

Table 20. Adverse Weather TOD Summary Cont'd

DeMers Avenue (20th Street to 42nd Street) and 42nd Street (17th Avenue to 6th Avenue)
Zone 4

Day	Operation	Time	Plan ID	COS	Cycle Length (s)
Weekday	TOD	1200 AM to 630 AM	PLAN 100	FREE	--
		630 AM to 715 AM	PLAN 23 [1]	223	80
		715 AM to 815 AM	PLAN 21	221	110 / 80 [2]
		815 AM to 415 PM	PLAN 23	223	80
		415 PM to 545 PM	PLAN 24	224	130 / 65 [3]
		545 PM to 630 PM	PLAN 23	223	80
		630 PM to 1000 PM	PLAN 23 [1]	223	80
		1000 PM to 1200 AM	PLAN 100	FREE	--
Saturday/Sunday	TOD	1200 AM to 800 AM	PLAN 100	FREE	--
		800 AM to 1000 AM	PLAN 23 [1]	223	80
		1000 AM to 800 PM	PLAN 23	223	80
		800 PM to 900 PM	PLAN 23 [1]	223	80
		900 PM to 1200 AM	PLAN 100	FREE	--

[1] 42nd Street/11th Avenue and 42nd Street/17th Avenue operate free

[2] 80 s cycle operates on 42nd Street from 17th Avenue to 6th Avenue

[3] 130 s cycle operates at 42nd Street/DeMers Avenue and 42nd Street/University Avenue

6.4 Network Performance Comparison

The estimated network performance was evaluated for the a.m. peak, mid-day peak and p.m. peak periods. Key measures of effectiveness (MOE's) include overall delay (hours), vehicle stops and fuel consumption. Table 21 compares the network performance between the adverse weather and the normal dry weather timing plans to provide an estimate of the operational value. Based on the analysis, the adverse weather timing plans are expected to improve motorist delay by 5 to 10 percent. It should be noted, the largest variable is the motorist travel speed. The analysis and premise of the adverse weather timing plans is they are enabled when the network travel speed reduce to approximately 25 mph. Outside of this travel speed, the operational benefit would be much less.

6.5 Implementation Guidelines

The adverse weather timing plans are designed for short durations and are not meant to operate for extended periods of time. Observations in early December 2010 during a very cold (-4 degree) day with a slight fog and a dusting of snow on the road found the vehicle travel speeds within 5 mph of the posted speed limit. Considering these observed conditions and driver behavior, enabling the adverse weather timing plans should be predicated upon more severe roadway conditions. The following guidelines provide general parameters to assist in deciding if and when to turn on the adverse weather timing plans:

- The platoon travel speed along the major roadways is observed to be 25 mph or less.
- A measurable amount of snow has fallen within an hour.

- The roadways are snow or ice packed resulting in significantly reduced vehicle travel speeds.
- Ice storm resulting in ice covered roadways
- Blowing snow resulting in less than 500 feet of visibility.

Table 21. Adverse Weather Timing Plans Network Operation Performance

	MOE	Normal Plan Operation			Winter Plan Operation			Winter Plan Improvement		
		AM Peak	Mid-day Peak	PM Peak	AM Peak	Mid-day Peak	PM Peak	AM Peak	Mid-day Peak	PM Peak
32nd Avenue	Stops (no. of veh)	4,953	3,626	8,103	**4,664**	**3,063**	**7,472**	**5.8%**	**15.5%**	**7.8%**
	Delay (hr)	57	30	103	**40**	**30**	**99**	**29.8%**	**0.0%**	**3.9%**
	Fuel Consumption (gal)	151	106	269	**137**	**103**	**263**	**9.3%**	**2.8%**	**2.2%**
Columbia Road	Stops (no. of veh)	9,795	5,511	11,076	**8,919**	**4,372**	**10,595**	**8.9%**	**20.7%**	**4.3%**
	Delay (hr)	117	47	146	**100**	**43**	**126**	**14.5%**	**8.5%**	**13.7%**
	Fuel Consumption (gal)	330	181	395	**314**	**173**	**379**	**4.8%**	**4.4%**	**4.1%**
Washington Street	Stops (no. of veh)	11,781	5,865	13,935	**11,233**	**5,374**	**14,651**	**4.7%**	**8.4%**	**-5.1%**
	Delay (hr)	178	63	240	**163**	**57**	**222**	**8.4%**	**9.5%**	**7.5%**
	Fuel Consumption (gal)	459	225	558	**446**	**219**	**548**	**2.8%**	**2.7%**	**1.8%**
Gateway Drive	Stops (no. of veh)	8,085	7,203	9,098	**7,321**	**7,218**	**9,559**	**9.4%**	**-0.2%**	**-5.1%**
	Delay (hr)	95	86	122	**90**	**74**	**109**	**5.3%**	**14.0%**	**10.7%**
	Fuel Consumption (gal)	323	280	357	**317**	**272**	**349**	**1.9%**	**2.9%**	**2.2%**
DeMers Avenue / 42nd Street	Stops (no. of veh)	5,603	5,870	8,230	**5,059**	**5,720**	**7,350**	**9.7%**	**2.6%**	**10.7%**
	Delay (hr)	56	56	83	**48**	**49**	**78**	**14.3%**	**12.5%**	**6.0%**
	Fuel Consumption (gal)	264	256	322	**255**	**250**	**314**	**3.4%**	**2.3%**	**2.5%**

7.0 Project Benefit Analysis

The purpose of this section is to document the benefit of the Signal Coordination Study. To help assess the benefit, field studies were completed for the "after" condition and compared to the "before" conditions. In addition, a benefit/cost analysis was completed to evaluate the overall cost-effectiveness of the implemented signal timing plans. It should be noted the project benefit is based upon weekday traffic conditions and a comparison between the "before" condition previous signal timing versus the "after" condition optimized timing plans. The project benefit analysis does not include the operational benefit to the transit system or the Alerus Center/REA event management plans. Traffic data to make these specific before versus after comparison analyses is unavailable.

7.1 Before/After Travel Time Comparison

Travel time studies were conducted by Ulteig Engineers (project partner) during both the "before" and "after" conditions along each of the study corridors. The travel time study limits were previously illustrated in Figure 7.

The "before" travel time study was conducted during the a.m. peak period (6:00 to 9:00 a.m.) and p.m. peak period (3:00 to 6:00 p.m.) in September 2009, March 2010 and April 2010 and the "after" travel time study was conducted in December 2009, November 2010 and December 2010. The travel time studies represent an average of several days and include a minimum of 12 runs each direction (five runs during the peak hour). Data points were collected at each signalized intersection within the study limits.

A comparison of the "before" and "after" travel time field studies was made. Table 22 and Table 23 provide an overall summary of the travel time runs and percent improvement for the a.m. peak and p.m. peak periods, respectively. Figure 14 to Figure 18 illustrate the travel time improvement in a graphical format comparing the before and after travel times and benchmarking the peak direction of the a.m. and p.m. peak periods against the ideal free flow travel time of the corridor.

The comparison of the "before" and "after" field collected travel times found the following:

- All routes and directions field measured were found to experience a travel time improvement during both the a.m. and p.m. peak hour and overall three-hour peak periods.
- Columbia Road experienced a significant travel time improvement during both the a.m. and p.m. peak periods (both directions), ranging from 21 percent to 40 percent. The largest improvement was found traveling southbound from 6th Avenue to 32nd Avenue during the p.m. peak hour.
- Washington Street experienced a significant travel time improvement during both the a.m. and p.m. peak periods (both directions), ranging from 6 percent to 27

percent. The largest improvement was found traveling northbound from 32nd Avenue to 5th Avenue during the p.m. peak hour.

- Gateway Drive experienced a significant travel time improvement during both the a.m. and p.m. peak periods (both directions), ranging from 15 percent to 24 percent. The largest improvement was found traveling eastbound from 47th Street to 3rd Street during the p.m. peak hour.
- DeMers Avenue experienced a travel time improvement during both peak periods in both directions. An improvement of two percent was achieved traveling westbound from Washington Street to 42nd Street. However, once a vehicle is given a green at Washington Street the improvement increases to 12 percent. The largest improvement of 19 percent was found traveling eastbound from 42nd Street to Washington Street.
- 42nd Street experienced a travel time improvement during all peak periods. Peak hour improvements ranged from six to 16 percent. The largest improvement was found traveling southbound during the p.m. peak hour.

Table 22. Before/After Travel Time Comparison – A.M. Peak Period

Northbound/Eastbound

	Free Flow	AM Peak Hour (730 - 830)			AM Overall (700 - 900)			Peak Hour Average Speed (mph)	
		Before	After	Percent Improvement	Before	After	Percent Improvement	Before	After
	Min Sec	Min Sec	Min Sec		Min Sec	Min Sec			
Columbia Road - 32nd Avenue to 6th Avenue	4 33	8 7	5 44	**30%**	7 45	5 52	**24%**	19.3	27.3
Washington Street - 32nd Avenue to 5th Avenue	4 50	7 33	5 54	**22%**	7 9	5 28	**24%**	20.0	25.5
Gateway Drive - 47th Street to 3rd Street	4 24	6 22	4 53	**23%**	5 58	4 51	**19%**	25.4	33.1
DeMers Avenue - 42nd Street to Washington Street	3 21	4 36	4 10	**9%**	4 21	4 8	**5%**	29.1	32.1
42nd Street - 17th Avenue to 6th Avenue	3 8	4 10	3 49	**8%**	3 57	3 43	**6%**	29.0	31.6

Southbound/Westbound

	Free Flow	AM Peak Hour (730 - 830)			AM Overall (700 - 900)			Peak Hour Average Speed (mph)	
		Before	After	Percent Improvement	Before	After	Percent Improvement	Before	After
	Min Sec	Min Sec	Min Sec		Min Sec	Min Sec			
Columbia Road - 6th Avenue to 32nd Avenue	4 48	7 18	5 30	**25%**	6 48	5 24	**21%**	22.6	30.0
Washington Street - 5th Avenue to 32nd Avenue	4 54	5 44	5 23	**6%**	5 41	5 18	**7%**	22.4	23.8
Gateway Drive - 3rd Street to 47th Street	4 17	6 2	4 52	**19%**	5 35	4 45	**15%**	25.5	31.6
DeMers Avenue - Washington Street to 42nd Street	3 31	4 45	4 2	**15%**	4 35	4 8	**10%**	29.6	34.8
42nd Street - 6th Avenue to 17th Avenue	3 5	4 19	3 37	**16%**	4 7	3 27	**16%**	25.8	30.8

1. Ulteig Engineers field collected data in September of 2009, March of 2010, and April of 2010 (Before) and October of 2009, November of 2010, and December of 2010 (After)

Table 23. Before/After Travel Time Comparison – P.M. Peak Period

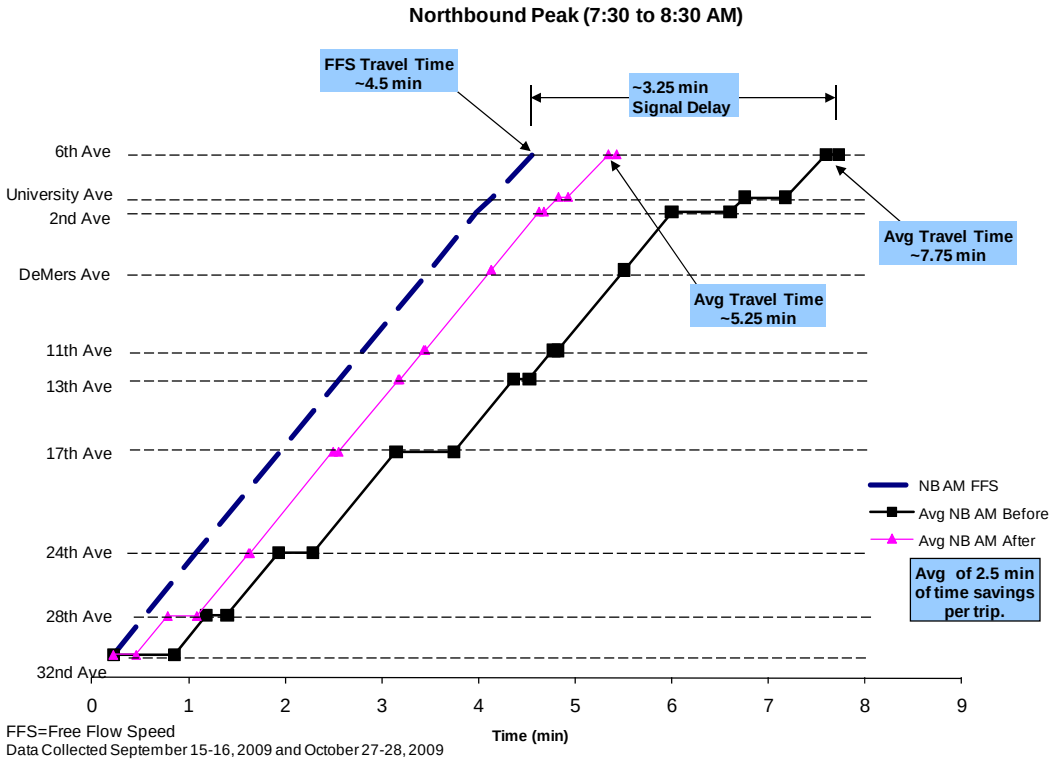
Northbound/Eastbound

	Free Flow	PM Peak Hour (430 - 530)			PM Overall (300 - 600)			Peak Hour Average Speed (mph)	
		Before	After	Percent Improvement	Before	After	Percent Improvement	Before	After
	Min Sec	Min Sec	Min Sec		Min Sec	Min Sec			
Columbia Road - 32nd Avenue to 6th Avenue	4 33	8 7	5 44	**30%**	7 45	5 52	**24%**	19.3	27.3
Washington Street - 32nd Avenue to 5th Avenue	4 50	8 42	6 28	**26%**	8 36	6 16	**27%**	17.3	23.3
Gateway Drive - 47th Street to 3rd Street	4 24	6 45	5 8	**24%**	6 14	5 3	**19%**	24.0	31.5
DeMers Avenue - 42nd Street to Washington Street	3 21	5 25	4 23	**19%**	5 11	4 22	**16%**	24.7	30.5
42nd Street - 17th Avenue to 6th Avenue	3 8	4 34	3 59	**13%**	4 33	3 51	**15%**	26.4	30.3

Southbound/Westbound

	Free Flow	PM Peak Hour (430 - 530)			PM Overall (300 - 600)			Peak Hour Average Speed (mph)	
		Before	After	Percent Improvement	Before	After	Percent Improvement	Before	After
	Min Sec	Min Sec	Min Sec		Min Sec	Min Sec			
Columbia Road - 6th Avenue to 32nd Avenue	4 48	10 16	6 11	**40%**	9 59	6 8	**38%**	16.1	26.7
Washington Street - 5th Avenue to 32nd Avenue	4 54	7 20	5 58	**19%**	7 8	5 50	**18%**	17.5	21.5
Gateway Drive - 3rd Street to 47th Street	4 17	5 47	4 25	**24%**	5 47	4 27	**23%**	26.6	34.9
DeMers Avenue - Washington Street to 42nd Street	3 31	4 38	4 31	**2%**	4 40	4 22	**6%**	30.3	31.1
42nd Street - 6th Avenue to 17th Avenue	3 5	4 29	3 46	**16%**	4 35	3 37	**21%**	24.9	29.7

1. Ulteig Engineers field collected data in September of 2009, March of 2010, and April of 2010 (Before) and October of 2009, November of 2010, and December of 2010 (After)



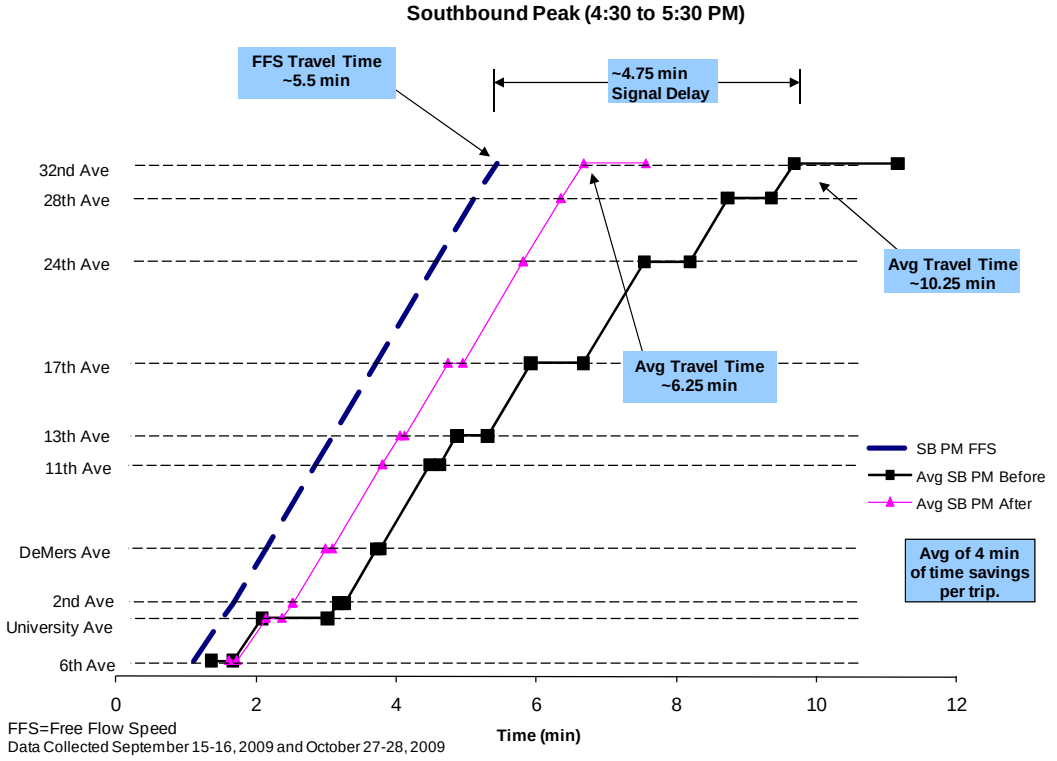
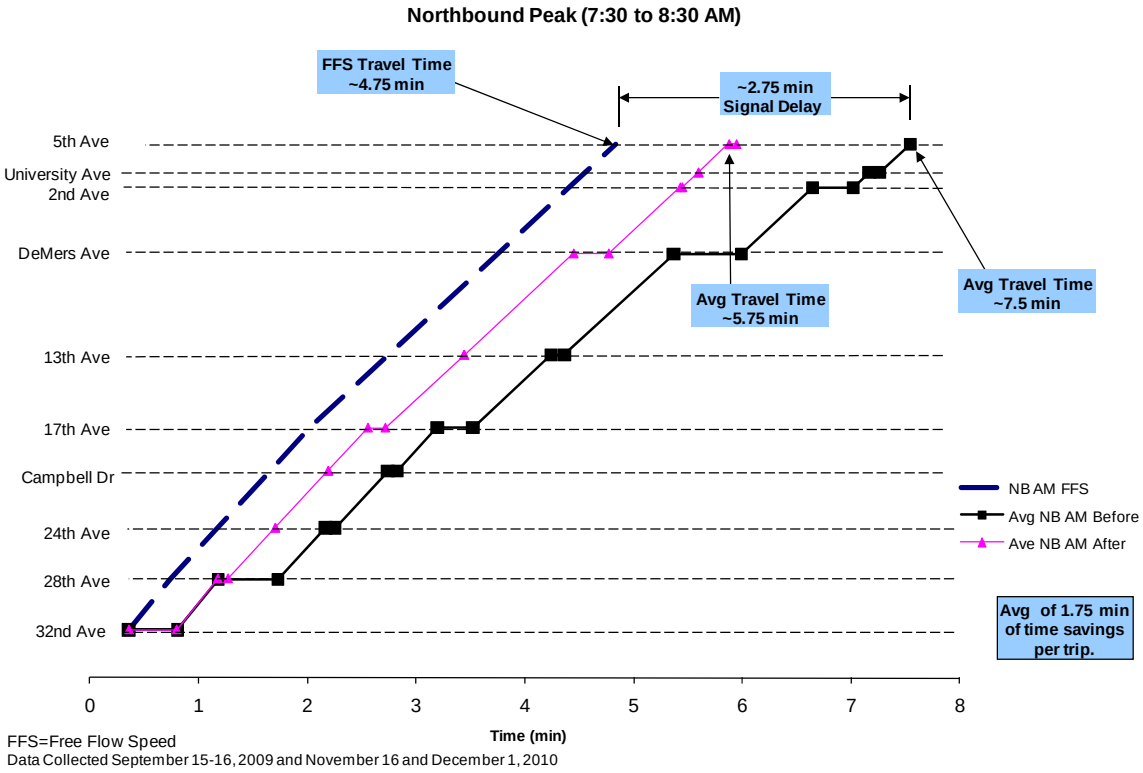
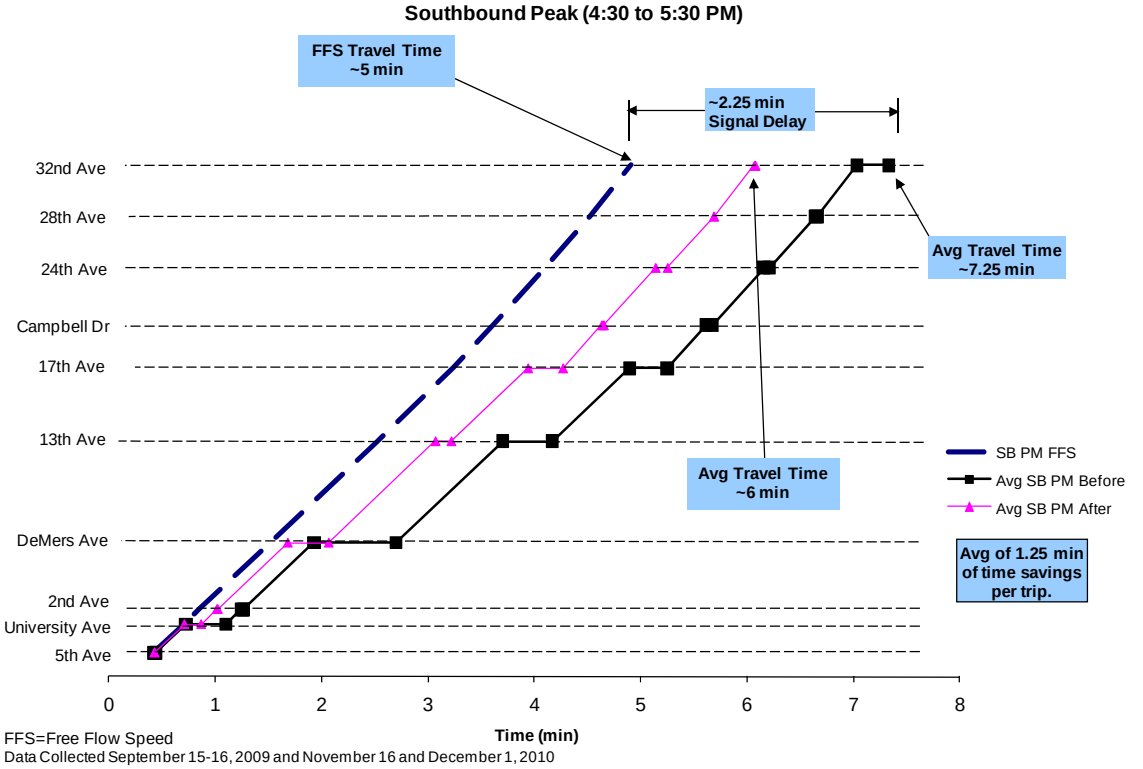


Figure 14. Columbia Road Before/After Travel Time Comparison Graphs

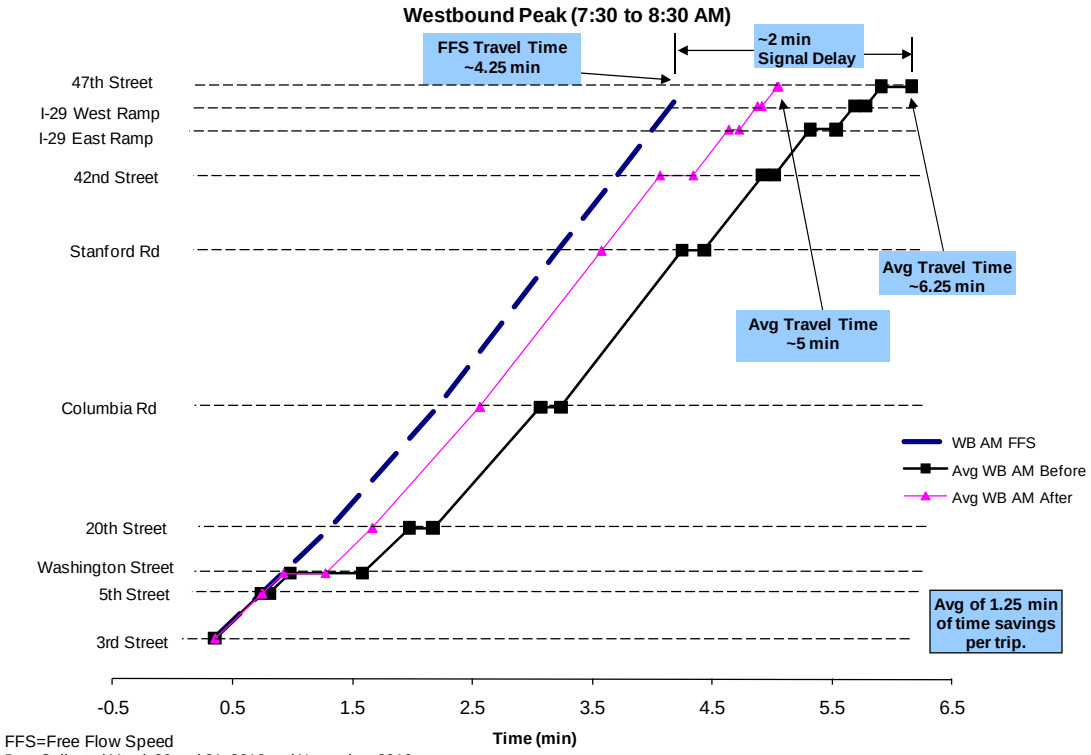


FFS=Free Flow Speed
Data Collected September 15-16, 2009 and November 16 and December 1, 2010

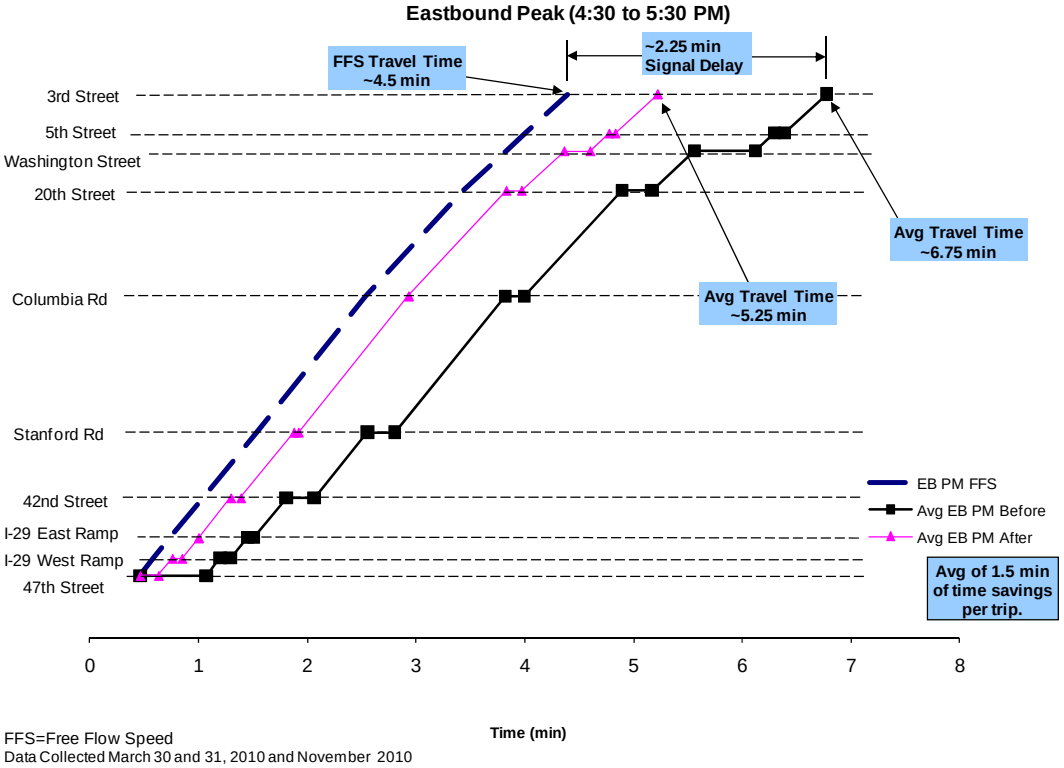


FFS=Free Flow Speed
Data Collected September 15-16, 2009 and November 16 and December 1, 2010

Figure 15. Washington Street Before/After Travel Time Comparison Graphs

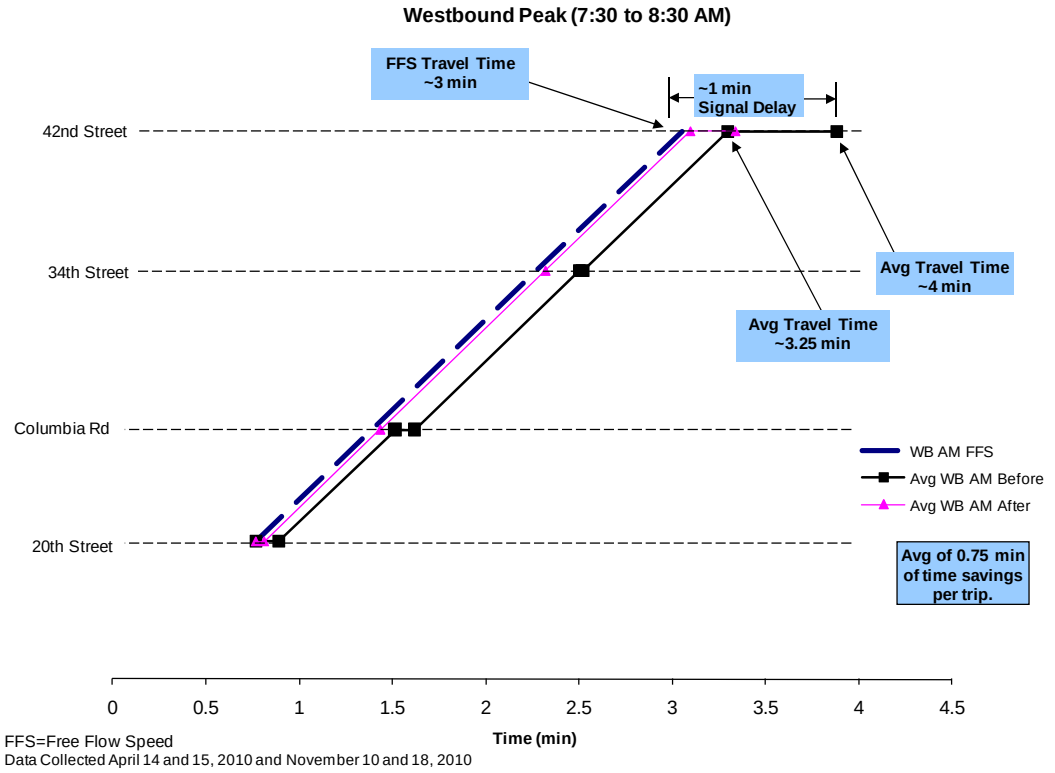


FFS=Free Flow Speed
Data Collected March 30 and 31, 2010 and November 2010

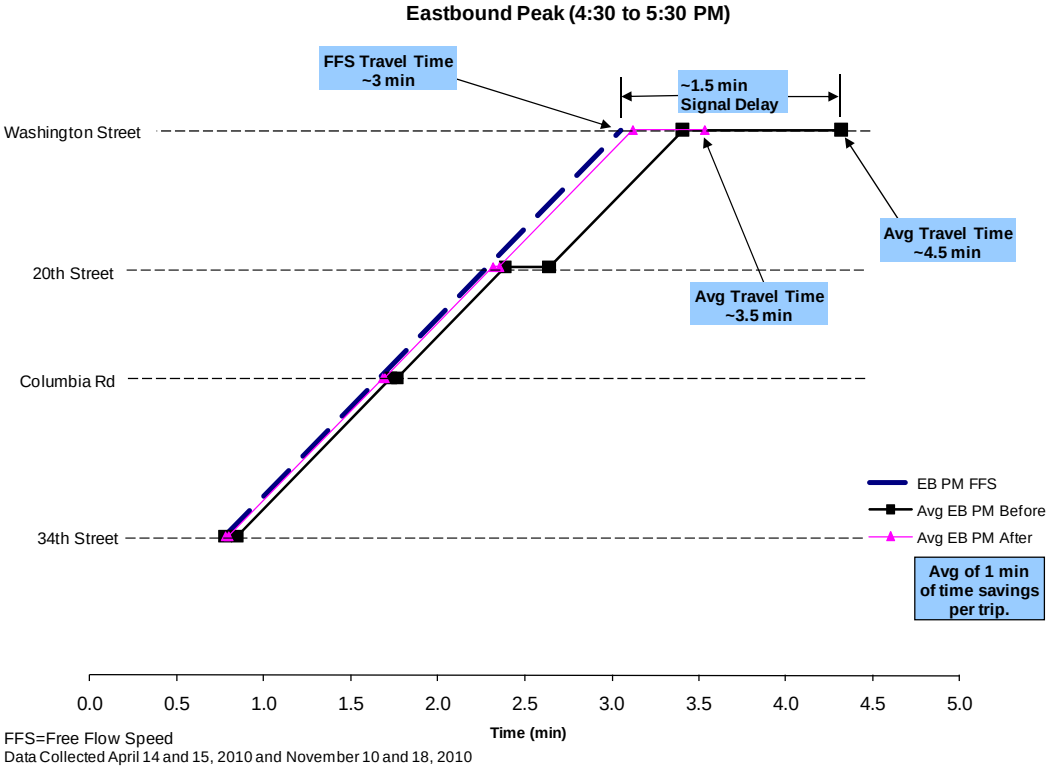


FFS=Free Flow Speed
Data Collected March 30 and 31, 2010 and November 2010

Figure 16. Gateway Drive Before/After Travel Time Comparison Graphs

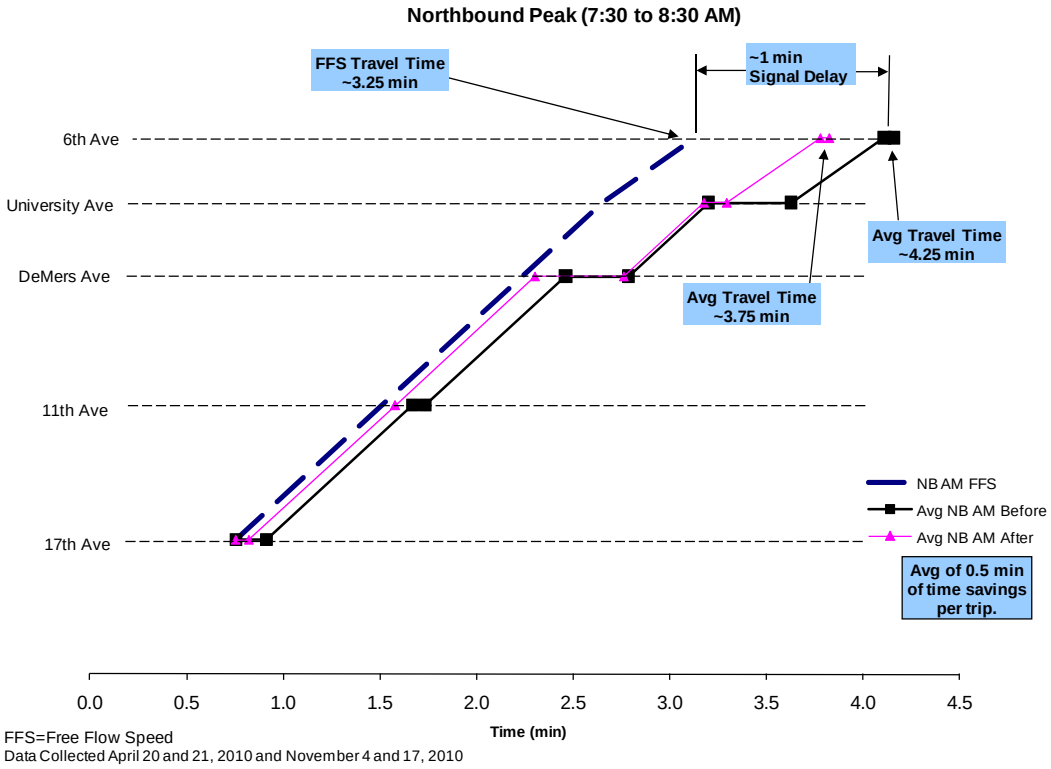


FFS=Free Flow Speed
Data Collected April 14 and 15, 2010 and November 10 and 18, 2010



FFS=Free Flow Speed
Data Collected April 14 and 15, 2010 and November 10 and 18, 2010

Figure 17. DeMers Avenue Before/After Travel Time Comparison Graphs



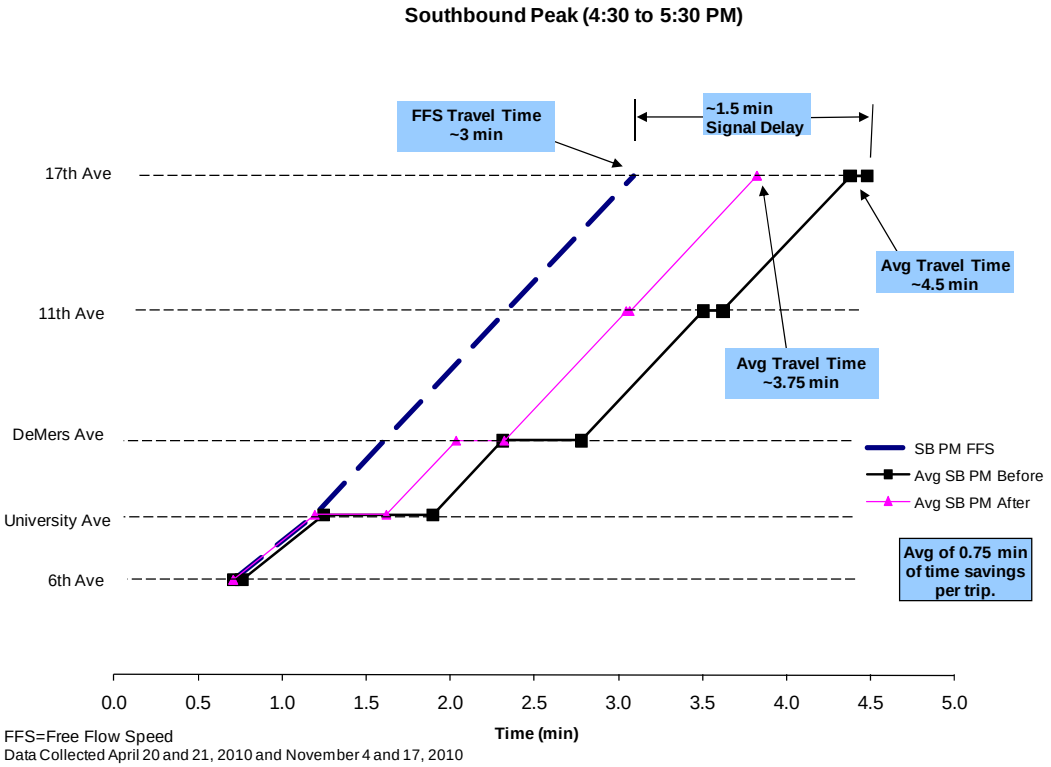


Figure 18. 42nd Street Before/After Travel Time Comparison Graphs

7.2 Before/After Average Approach Delay Comparison

Cross-street approach delays were conducted for several minor street approaches (peak half hour). The approaches selected are those locations at critical intersections, having unique characteristics or those observed to have excessive vehicle queues.

The cross-street approach delays are conducted for several reasons. The first is to support the building of the existing traffic models, the second is to use as a measure or benchmark during coordination and the third reason is to support the measures of effectiveness calculations conducted for the benefit/cost analysis. A comparison of the "before" and "after" intersection average approach delay field studies was made. Table 24 provides a summary of the average approach delay percent improvement accomplished or percent impact incurred as a result of the Signal Coordination Study. The intersections studied represent the critical intersections that required the greatest attention in balancing progression and delay to address mainline congestion issues. Delays that increased were due to longer cycle lengths and splits that were reduced to better accommodate mainline traffic.

7.3 Benefit/Cost Analysis

A cost benefit analysis was completed to establish the annual economic savings incurred as a result of the Signal Coordination Study. Typical measures of effectiveness (MOE) used in estimating the benefit of signal optimization projects include approach vehicle delay, vehicle stops and fuel consumption.

7.3.1 Traffic Volume Cases

In order to compute the daily "before" and "after" MOE's for the Signal Coordination Study, general traffic volume cases were developed. It is not feasible or practical to develop hourly traffic volumes for every hour of the day. Instead, the traffic volume cases were developed in consideration of the particular corridors general daily hourly volume trend. The tube count traffic volumes collected along Columbia Road, Washington Street, Gateway Drive, DeMers Avenue and 42nd Street found relatively consistent volume levels on a weekday. The benefit/cost analysis includes the daily volume cases for a Monday to Friday, excluding Holidays. The benefit/cost analysis does not take into account the overnight plan (plan 11).

Each volume case is assigned and assumed to be applicable for a certain number of hours of the day as previously discussed in Section 2.1.3. In general, the traffic volume cases include an a.m. off peak, a.m. peak, mid-day low, mid-day peak, p.m. off peak (before peak), p.m. peak and p.m. off peak (late evening) and were developed specifically for the corridor. In order to make an accurate "apple-to-apple" comparison, the traffic volumes used in the "before" condition (and number of hours) has to equal the volumes used in the "after" condition (and number of hours) analysis. With the traffic volume cases constant between the "before"/"after" conditions, the only variable is the signal timing plans and duration each timing plan is in operation.

Table 24. Before/After Average Approach Delay Comparison – A.M. and P.M. Peak Hour

	Intersection	Zone	Time Period	Approach	Before			After		
					Cycle Length	Traffic Volume (vehicle)	Field Measured Average Delay (seconds)	Cycle Length	Traffic Volume (vehicle)	Field Measured Average Delay (seconds)
AM	Columbia Road at University Avenue	1	7:30-8:00	Westbound	90	338	**37.3**	120	307	**36.2**
PM	Columbia Road at 17th Avenue	1	3:45-4:15	Eastbound	100	220	**26.7**	120	206	**46.7**
	Columbia Road at University Avenue	1	4:30-5:00	Eastbound	100	322	**16.2**	120	319	**30.0**
	Washington Street at DeMers Avenue	2	5:15-5:45	Westbound	115	327	**34.0**	130	394	**53.5**
	Washington Street at 17th Avenue	2	5:30-6:00	Eastbound	115	259	**25.6**	130	197	**39.6**
	Washington Street at 24th Avenue	2	5:00-5:30	Eastbound	115	197	**32.2**	130	174	**59.2**
	Washington Street at Gateway Drive	3	4:45-5:15	Northbound	100	182	**30.1**	120	136	**47.3**
	Washington Street at Gateway Drive	3	5:00-5:30	Southbound	100	190	**34.5**	120	192	**44.8**
	42nd Street at University Avenue	4	4:30-5:00	Westbound	FREE	236	**15.7**	130	229	**36.9**
	42nd Street at University Avenue	4	4:00-4:30	Eastbound	FREE	104	**18.9**	130[(1)]	25	**35.2**

Note: Delay studies conducted during the months of September 2009, March 2010 and September 2010 (Before Study) and the months of October, November and December 2010 (After Study)

[(1)] 80 s cycle operates from 4:00 to 4:15 PM. After numbers only use data from 4:15 to 4:30 PM.

7.3.2 Project Benefit

The project benefit measures of effectiveness are measured through the reduction in mainline travel time, reduction in vehicle stops and reduction in fuel consumption. Table 25 provides a summary of unit dollar values for each measure of effectiveness.

To determine the annual economic benefit of the Signal Coordination Study, the daily estimated reductions (or increases) in MOE's are calculated and are then applied to the unit benefit.

Table 25. Unit Benefit

MOE	Unit Price
Value of Time - Truck[1]	$17.08
Value of Time - Auto[1]	$13.59
Vehicle Stop[2]	$0.057
Fuel Cost[3]	$2.33

[1] Mn/DOT Office of Investment Management Benefit-Cost Analysis for Transportation Projects, Appendix A, Table A.1, SFY2010 Recommended Standard Values

[2] Life-Cycle Cost Analysis in Pavement Design, US Dept of Transportation, FHWA, Table 2.3 (Vehicle Cost per Stop), September 1998 (Refer to Appendix D for calculations) (Adjusted to include an estimated 2% per year rate of inflation).
The vehicle stop value is $0.046 for Columbia Road and $0.047 for Washington Street
The vehicle stop value is $0.051 for Gateway Drive and $0.057 for DeMers Avenue/42nd Street

[3] US Department of Energy, Energy Information Administration, Average Fuel Prices 9/01/09 to 8/31/10 (latest 12-month period)
The fuel cost value is $2.63 for Columbia Road and $2.33 for Washington, Gateway, and DeMers/42nd

Net Average Daily MOE

The daily savings for each MOE was determined by multiplying the number of hours each implemented plan is in effect and comparing against the corresponding existing timing plan and traffic volume conditions. It should also be noted, the overall net benefit of these measures accounts for any impacts (i.e., typically an increase in vehicle delay) to cross-street or mainline MOE's. Output used in determining each MOE was computed using Synchro7.0 (off peak and mid-day or balanced plans) and SimTraffic7.0 (a.m. and p.m. peak hours). Where collected, the field obtained average approach delays were used in lieu of the model results. Table 26 illustrates the overall daily and annual "before" and "after" network performance comparison and percent improvement. Table 27 provides a detailed summary of the daily MOE's and documents the net reduction in vehicle delay, vehicle stops and fuel consumption. A positive value shown in Table 27 is a benefit (i.e., reduction) and a negative value shown is an impact (i.e., increase).

Table 26. Measures of Effectiveness – Network Performance Comparison

Total Network - Columbia Road

MOE	Daily Benefit (Weekday)				Annual Net Reduction
	Before	After	Net Reduction	Percent Improvement	
Stops (no. of veh)	173,808	145,749	**28,059**	**16.1%**	**7,042,684**
Delay (hr)	1,777	1,566	**211**	**11.9%**	**52,871**
Fuel Consumption (gal)	4,520	4,327	**193**	**4.3%**	**48,456**

Total Network - Washington Street

MOE	Daily Benefit (Weekday)				Annual Net Reduction
	Before	After	Net Reduction	Percent Improvement	
Stops (no. of veh)	164,036	143,415	**20,622**	**12.6%**	**5,175,997**
Delay (hr)	1,964	1,790	**174**	**8.9%**	**43,794**
Fuel Consumption (gal)	5,069	4,855	**214**	**4.2%**	**53,676**

Total Network - Gateway Drive

MOE	Daily Benefit (Weekday)				Annual Net Reduction
	Before	After	Net Reduction	Percent Improvement	
Stops (no. of veh)	120,398	89,547	**30,850**	**25.6%**	**7,743,413**
Delay (hr)	942	833	**109**	**11.5%**	**27,238**
Fuel Consumption (gal)	3,620	3,331	**289**	**8.0%**	**72,526**

Total Network - DeMers Avenue/42nd Street

MOE	Daily Benefit (Weekday)				Annual Net Reduction
	Before	After	Net Reduction	Percent Improvement	
Stops (no. of veh)	89,025	67,524	**21,501**	**24.2%**	**5,396,626**
Delay (hr)	633	533	**101**	**15.9%**	**25,304**
Fuel Consumption (gal)	3,177	2,935	**242**	**7.6%**	**60,704**

Table 27. Measures of Effectiveness – Net Average Daily MOE Reductions

		MOE - Net Reduction from Existing to Proposed Condition[1]			
	Aggregate Timing Plans[2]	Stops (no. of veh) (All Approaches)	Delay (veh-hr) (Mainline)	Delay (veh-hr) (Cross Street)[3]	Fuel Consumption (gal) (All Approaches)
Columbia Road (*32nd Avenue to 6th Avenue*) Weekday	AM Period (630 to 830 AM)	2,582	22.8	-9.1	19
	Off Period (830 AM to 230 PM, 600 to 1000 PM)	13,020	175.6	-86.2	142
	PM Period (300 to 600 PM)	12,457	145.8	-38.3	32
		28,059	**344.2**	**-133.6**	**193**
		MOE - Net Reduction from Existing to Proposed Condition[1]			
	Aggregate Timing Plans[2]	Stops (no. of veh) (All Approaches)	Delay (veh-hr) (Mainline)	Delay (veh-hr) (Cross Street)[3]	Fuel Consumption (gal) (All Approaches)
Washington Street (*32nd Avenue to 5th Avenue*) Weekday	AM Period (645 to 900 AM)	2,083	26.8	-13.7	25
	Off Period (900 AM to 230 PM, 600 to 1000 PM)	10,514	154.1	-37.7	175
	PM Period (230 to 600 PM)	8,025	127.2	-82.2	15
		20,622	**308.1**	**-133.6**	**214**
		MOE - Net Reduction from Existing to Proposed Condition[1]			
	Aggregate Timing Plans[2]	Stops (no. of veh) (All Approaches)	Delay (veh-hr) (Mainline)	Delay (veh-hr) (Cross Street)[3]	Fuel Consumption (gal) (All Approaches)
Gateway Drive (*47th Street to 3rd Street*) Weekday	AM Period (630 to 815 AM)	3,310	19.6	-8.3	21
	Off Period (815 AM to 245 PM, 600 to 1000 PM)	24,320	153.2	-40.7	273
	PM Period (245 to 600 PM)	3,221	17.6	-32.8	-5
		30,850	**190.3**	**-81.8**	**289**
		MOE - Net Reduction from Existing to Proposed Condition[1]			
	Aggregate Timing Plans[2]	Stops (no. of veh) (All Approaches)	Delay (veh-hr) (Mainline)	Delay (veh-hr) (Cross Street)[3]	Fuel Consumption (gal) (All Approaches)
42nd Street (*17th Avenue to 6th Avenue*) DeMers Avenue (*20th Street to 42nd Street*) Weekday	AM Period (630 to 900 AM)	2,585	14.4	-2.7	30
	Off Period (900 AM to 415 PM, 545 to 1000 PM)	18,680	121.0	-27.3	216
	PM Period (415 to 545 PM)	236	4.1	-8.7	-4
		21,501	**139.5**	**-38.7**	**242**
	Total Project (Average Daily Total)	**101,031**	**982.1**	**-387.6**	**938**

[1] A positive value equals the net reduction (i.e., benefit) and a negative value equals a net increase (i.e., impact)

[2] AM period includes the AM OFF and AM PEAK Plans. The OFF period includes the BALANCED Plans and the PM period includes the PM OFF and PM PEAK Plans.

[3] Where obtained, AM and PM peak hour cross-street field collected approach delays (before and after) were used in lieu of model output.

Annual Economic Benefit

The net annual economic benefit is based upon 251 Monday to Fridays (10 holiday days were excluded). Applying the number of day and the unit savings to each computed daily MOE, the annual net benefit (or economic savings) can be estimated. Table 28 documents the overall annual net benefit estimated as a result of the Signal Coordination Study. Based on the results, the total estimated annual benefit is estimated at approximately 4.0 million dollars.

Table 28. Annual Net Benefit (dollar)

	Aggregate Timing Plans[3]	Truck Percent (Mainline)	Truck Percent (Cross-Street)	Occupancy[1]	Days/ Year[2]	Value of Time Benefit ($) (Mainline)	Value of Time Impact ($) (Cross-Street)	Stops Reduction Benefit ($)	Fuel Reduction Benefit ($)	Total Benefit ($)
Columbia Road *(32nd Avenue to 6th Avenue)* **Weekday**	AM Period (630 to 830 AM)	1.4%	2.4%	1.08	251	$83,336.03	-$33,575.38	$29,579.78	$12,344.43	$91,684.86
	Off Period (830 AM to 230 PM, 600 to 1000 PM)	1.2%	2.2%	1.08	251	$642,662.49	-$316,862.43	$149,187.95	$93,903.49	$568,891.50
	PM Period (300 to 600 PM)	0.9%	1.5%	1.08	251	$532,952.65	-$140,345.69	$142,736.89	$21,190.17	$556,534.02
	Subtotal (Weekday Annual Total Benefit)					**$1,258,951.17**	**-$490,783.49**	**$321,504.61**	**$127,438.10**	**$1,217,110.38**
Washington Street *(32nd Avenue to 5th Avenue)* **Weekday**	AM Period (645 to 900 AM)	3.0%	3.3%	1.08	251	$99,293.29	-$50,768.76	$24,580.85	$14,357.58	$87,462.95
	Off Period (900 AM to 230 PM, 600 to 1000 PM)	3.0%	2.1%	1.08	251	$570,355.69	-$139,542.10	$124,054.66	$102,052.84	$656,921.09
	PM Period (230 to 600 PM)	1.7%	1.1%	1.08	251	$469,866.41	-$303,193.70	$94,683.31	$8,655.48	$270,011.50
	Subtotal (Weekday Annual Total Benefit)					**$1,139,515.39**	**-$493,504.56**	**$243,318.82**	**$125,065.90**	**$1,014,395.54**
Gateway Drive *(47th Street to 3rd Street)* **Weekday**	AM Period (630 to 815 AM)	8.5%	8.7%	1.08	251	$73,076.76	-$30,904.92	$42,446.82	$11,989.02	$96,607.68
	Off Period (815 AM to 245 PM, 600 to 1000 PM)	13.0%	11.8%	1.08	251	$576,424.37	-$152,765.21	$311,895.50	$159,658.59	$895,213.26
	PM Period (245 to 600 PM)	9.0%	7.3%	1.08	251	$65,608.29	-$122,428.92	$41,305.42	-$2,660.98	-$18,176.19
	Subtotal (Weekday Annual Total Benefit)					**$715,109.42**	**-$306,099.05**	**$395,647.74**	**$168,986.63**	**$973,644.74**
42nd Street (17th Avenue to 6th Avenue) **DeMers Avenue** (20th Street to 42nd Street) **Weekday**	AM Period (630 to 900 AM)	3.2%	2.3%	1.08	251	$53,446.73	-$9,955.93	$37,081.16	$17,252.49	$97,824.45
	Off Period (900 AM to 415 PM, 545 to 1000 PM)	2.0%	1.6%	1.08	251	$447,239.38	-$100,716.36	$267,959.82	$126,469.49	$740,952.33
	PM Period (415 to 545 PM)	1.0%	0.4%	1.08	251	$14,944.74	-$32,114.65	$3,378.19	-$2,280.84	-$16,072.56
	Subtotal (Weekday Annual Total Benefit)					**$515,630.84**	**-$142,786.94**	**$308,419.18**	**$141,441.14**	**$822,704.22**
Total Project - Columbia, Washington, Gateway, DeMers, and 42nd (Average Annual Benefit)						**$3,629,206.82**	**-$1,433,174.04**	**$1,268,890.35**	**$562,931.76**	**$4,027,854.88**

[1] Mn/DOT Metro Traffic Office

[2] Total weekday days were reduced by 10 to account for Holidays. Sundays were not included as part of the Benefit/Cost Analysis.

[3] AM period includes the AM OFF and AM PEAK Plans. The OFF period includes the BALANCED Plans and the PM period includes the PM OFF and PM PEAK Plans.

7.3.3 Project Cost

Costs for most roadway improvement projects are associated with capital costs, future costs, and operations and maintenance costs. At the end of the analysis period, there would also be a remaining capital value. For this Signal Coordination Study, there is not a capital or future cost. The cost also does not include signal equipment or agency staff labor time associated with or required to provide the TSP operations. The only cost is an "operations" cost and includes the labor required to develop and implement the new signal timing plans, since the optimized timing plans could be implemented on the original signal equipment. Therefore the estimated project cost was $167,000 and includes consulting fees and agency staff time. Governing agency staff labor costs for the project management, steering committee meetings, implementation/fine-tuning of the new timing plans and general project involvement assumed a labor rate of $60 per hour.

7.3.4 Project Benefit/Cost Ratio

The benefit/cost ratio is computed based on the comparison between the annual net benefit and the total project cost. Table 29 documents the estimated benefit/cost ratio for each zone and the total project.

Table 29. Project Benefit to Cost Ratio

Segment	Number of Intersections	Total Cost / Intersection ($)	Benefit ($)	Benefit-Cost Ratio
Columbia Road - 32nd Avenue to 6th Avenue	8	$39,031	$1,217,110	**31**
Washington Street - 32nd Avenue to 5th Avenue	10	$45,918	$1,014,396	**22**
Gateway Drive - 47th Street to 3rd Street	10	$45,678	$973,645	**21**
42nd Street - 17th Avenue to 6th Avenue DeMers Avenue - 20th Street to 42nd Street	8	$37,142	$822,704	**22**
Total Project (All Zones)	**36**	**$167,769**	**$4,027,855**	**24**

As shown, the Signal Coordination Study resulted in a benefit/cost ratio of approximately 24:1, considering only one year of benefit.

7.4 Key Project Highlights

The project benefit analysis estimates the Signal Coordination Study resulted in a 24:1 benefit/cost ratio and an estimated annual economic savings of 4.0 million dollars, which includes an estimated annual savings of 228,000 gallons of gasoline. A number of factors contribute to the project benefit:

- Most routes and directions field measured were found to experience a travel time improvement during both the a.m. and p.m. peak hour and overall three-hour peak periods.
- Columbia Road experienced a significant travel time improvement during both the a.m. and p.m. peak periods (both directions). The largest improvement was found traveling southbound from 6th Avenue to 32nd Avenue (40 percent travel time improvement).
- Washington Street experienced a significant travel time improvement during both the a.m. and p.m. peak periods (both directions). The largest improvement was found traveling northbound from 32nd Avenue to 5th Avenue (26 percent travel time improvement).
- Gateway Drive experienced a significant travel time improvement during both the a.m. and p.m. peak periods (both directions). The largest improvement was found traveling westbound from 3rd Street to 47th Street (24 percent travel time improvement).
- On a daily basis, the overall network delay is estimated to be reduced by over 11 percent.
- The project benefited from the development of several new off peak and mid-day timing plans, improving intersection efficiency and reducing motorist delay.
- Overall an estimated 18 percent reduction in total vehicle stops was found, saving time and fuel.
- The result of Signal Coordination Study provided an improved balance between mainline progression and intersection delay, meeting the key objective of the project.

8.0 Potential Improvement Measures

As part of the Signal Coordination Study an operation review of each of the study corridors was completed. During the field implementation and signal timing review process, a few signal operation or roadway improvements were identified for further review and/or consideration. The purpose of the following sections is to document low cost signal operation or geometric modifications to improve intersection efficiency.

8.1 Programmed Future Improvements

The MPO has identified and programmed several future reconstruction projects within the study network that are expected to result in significant improvement at key intersections. Several of the items are currently programmed within the Long Range Transportation Plan (LRTP). These improvements include the following:

- Reconstruction of the Gateway Drive/Columbia Road intersection. Grand Forks is currently in the process of developing the preliminary intersection design layout.
- Reconstruction of the Washington Street/DeMers Avenue intersection. The Washington Street/DeMers Avenue intersection operates at capacity during both the a.m. and p.m. peak hours. The MPO recently awarded a planning study contract to determine the appropriate intersection and roadway improvements necessary to improve the intersection operations.
- Columbia Road at DeMers Avenue southbound entrance ramp – provide an exclusive auxiliary lane to 11th Avenue. The auxiliary lane would provide improved merging and weaving operations. This improvement is currently programmed for 2013.
- Columbia Road at 17th Avenue - construct an exclusive right turn lane on the northbound, southbound and eastbound approaches. Implementation should occur following the LRTP programmed 2013 improvements.
- Construct a secondary access to the Red River High School south of 17th Avenue, along the 20th Avenue alignment. The proposed access would extend 20th Avenue from 25th Street to Columbia Road and should be designed as a ¾ style intersection with Columbia Road (provide southbound left turn and northbound right turn movements into the site, and prohibit the westbound left turn (outbound) movement).This access road is currently programmed for 2013.

8.2 Future Intersection Operation Improvements

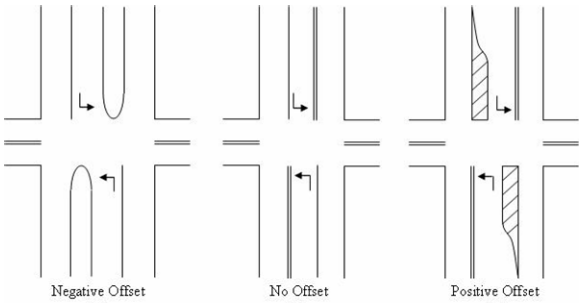
The following lane use signing/signal modifications, operations or pavement markings are expected to result in improved intersection efficiency or safety.

- 42nd Street at 6th Avenue – install front loop detector between the stop bar and railroad tracks.

- Gateway Drive at Washington Street – consider installing protected/permissive left turn phasing for all four left turn movements.
- Gateway Drive at I-29 East Ramp – install protected/permissive left turn phasing for the eastbound left turn movement.
- Columbia Road at 32nd Avenue – construct a second northbound and westbound left turn lanes.
- Columbia Road at 13th Avenue – construct exclusive northbound and southbound right turn lanes.
- In future traffic signal modifications and design policies, the City of Grand Forks and NDDOT should consider the installation of far side pole mounted signal indications. With only the overhead signal indication, waiting left turn vehicles can block the view of the indication. This results in reduced capacity and could be contributing to left turn related crashes.
- Review the mast arm signing at each intersection to ensure a consistent use of the "Left Turn Yield on Green Ball" sign.
- Develop a program (and funding source) for regular retiming of the major signalized corridors. Signal optimization degrades linearly over time due to growth and changes in traffic patterns. Depending on the growth or changes in land use, fully re-optimizing the system should occur every three to five years.

8.3 Washington Street Left Turn Lane Improvements

The MPO has recently submitted an application to the North Dakota Department of Transportation (NDDOT) to receive federal transportation funding under the 2012 Highway Safety Improvement Program (HISP). If awarded funding, the proposed improvements could be constructed as soon as 2015. The project submittal includes the reconstruction of Washington Street between 17th Avenue and 28th Avenue to provide left turn lane improvements and traffic signal modifications to provide a northbound and southbound protected/permissive left turn phasing. This improvement will allow motorists to turn left on a "green ball" saving delay. However, there is a safety concern. The wide median along Washington Street limits the sight distance and hinders the ability for motorists to choose a safe gap when the opposite side left turn lane also has cars waiting (negative left turn lane offset). By changing the position of the left turn lane, this safety concern can be reduced. The proposed improvement project will narrow the medians at the intersections to provide a positive left turn lane offset. The illustration below schematically shows the change.



An operation analysis has been completed to quantify the estimated benefit of the proposed left turn lane adjustment and protected/permissive left turn phasing. Table 30 provides a summary of the estimated intersection delay savings.

Table 30. Intersection Delay Summary for Protected Left Turn Phasing versus Protected/Permissive Left Turn Phasing – Washington Street

Intersection	Protected Left Turn Phasing (28th Avenue to 17th Avenue)					Protected/Permissive Left Turn Phasing (28th Avenue to 17th Avenue)				
	Intersection Delay					Intersection Delay				
	AM Peak	Mid-day Low	Mid-day Peak	PM Peak	Evening Low	AM Peak	Mid-day Low	Mid-day Peak	PM Peak	Evening Low
Washington Street at 32nd Ave S	25.4	20.0	27.0	32.9	22.0	26.1	20.0	28.0	33.9	26.0
Washington Street at 28th Ave S	13.4	7.0	19.0	29.4	8.0	10.3	6.0	14.0	27.7	6.0
Washington Street at 24th Ave S	15.8	13.0	28.0	20.6	19.0	15.3	10.0	25.0	17.7	13.0
Washington Street at Campbell Drive	5.5	2.0	10.0	7.5	3.0	6.0	5.0	14.0	7.4	5.0
Washington Street at 17th Ave S	32.4	20.0	39.0	56.4	29.0	25.2	19.0	33.0	65.8	28.0
Washington Street at 13th Ave S	12.0	6.0	13.0	12.4	7.0	12.2	7.0	13.0	17.3	7.0
Washington Street at DeMers Ave	32.1	24.0	37.0	48.6	27.0	30.9	24.0	37.0	54.9	27.0
	136.6	**92.0**	**173.0**	**207.8**	**115.0**	**126.0**	**91.0**	**164.0**	**224.7**	**112.0**

The primary beneficiaries of the proposed improvements are left turning motorists. It should be noted, the installation of protected/permissive left turn phasing will negate the ability for Washington Street to operate with lead/lag left turn operation (due to yellow ball trap safety issue). As a result, vehicle progression along the corridor will decrease. In most cases, the overall delay along the corridor is expected to outweigh the progression impact. The exception is during the p.m. peak hour. The p.m. peak hour traffic conditions benefit significantly from lead/lag left turn operation. As part of the Washington Street improvement project, the following additional recommendations are made:

- Construct exclusive northbound and southbound right turn lanes on Washington Street at the 28th Avenue and Campbell Drive intersections.
- Washington Street/Campbell Drive should continue to operate with permissive only left turn phasing.
- The northbound and southbound left turn lanes should be lengthened to provide a minimum of 400 feet (storage plus deceleration) of length wherever feasible.

Appendix A:
Minimum Green, Yellow, All Red and Pedestrian Interval Timings

Columbia Rd Yellow, All Red, Pedestrian Intervals (YARP)

***** Measurements Attached *****

28th Ave - Controller Input

Direction	Phase	Walk	FDW	Yellow	All Red (Calculated)	All Red (USE)	Min Green
SBL	Phase 1			3.0	2.1	**2.0**	5
NB	Phase 2	6	17	4.0	1.8	**2.0**	15
WBL	Phase 3			3.0	3.2	**2.0**	5
EB	Phase 4	15	17	3.0	3.5	**3.5**	10
NBL	Phase 5			3.0	2.1	**2.0**	5
SB	Phase 6	6	9	4.0	1.9	**2.0**	15
EBL	Phase 7			3.0	3.2	**2.0**	5
WB	Phase 8	12	17	3.0	3.7	**3.5**	10

Measurements

Car Dist (For All Red) ("c")	Total Crossing Distance ("a")	Longest Leg to Median Button ("b")	Total ped time
104			
85	72		21
98			
110	110	67	32
102			
94	85	45	25
99			
117	100	70	29

24th Ave - Controller Input

Direction	Phase	Walk	FDW	Yellow	All Red (Calculated)	All Red (USE)	Min Green
SBL	Phase 1			3.0	1.7	**2.0**	5
NB	Phase 2	12	6	4.0	1.7	**2.0**	15
WBL	Phase 3			3.0	2.7	**2.0**	5
EB	Phase 4	10	9	3.0	2.7	**2.5**	10
NBL	Phase 5			3.0	1.9	**2.0**	5
SB	Phase 6	14	8	4.0	1.8	**2.0**	15
EBL	Phase 7			3.0	2.5	**2.0**	5
WB	Phase 8	10	9	3.0	2.6	**2.5**	10

Measurements

Car Dist (For All Red) ("c")	Total Crossing Distance	Longest Leg to Median Button	Total ped time
79			
82	62	35	18
80			
80	64	39	19
91			
87	76	42	22
72			
75	65	41	19

17th Ave - Controller Input

Direction	Phase	Walk	FDW	Yellow	All Red (Calculated)	All Red (USE)	Min Green
SBL	Phase 1			3.0	1.4	**2.0**	5
NB	Phase 2	6	12	4.0	1.5	**1.5**	15
EBL	Phase 3			3.0	2.3	**2.0**	5
WB	Phase 4	6	18	3.0	2.6	**2.5**	10
NBL	Phase 5			3.0	1.4	**2.0**	5
SB	Phase 6	6	13	4.0	1.5	**1.5**	15
WBL	Phase 7			3.0	2.5	**2.0**	5
EB	Phase 8	6	16	3.0	2.6	**2.5**	10

Measurements

Car Dist (For All Red) ("c")	Total Crossing Distance ("a")	Longest Leg to Median Button ("b")	Total ped time
64			
67	56		16
65			
75	72		21
63			
69	59		17
70			
75	64		19

13th Ave - Controller Input

Direction	Phase	Walk	FDW	Yellow	All Red (Calculated)	All Red (USE)	Min Green
SBL	Phase 1			3.0	1.6	**2.0**	5
NB	Phase 2	6	15	4.0	1.5	**1.5**	15
EBL	Phase 3			3.0	2.5	**2.0**	5
WB	Phase 4	6	21	3.0	3.1	**3.0**	10
NBL	Phase 5			3.0	1.5	**2.0**	5
SB	Phase 6	6	14	4.0	1.5	**1.5**	15
WBL	Phase 7			3.0	2.8	**2.0**	5
EB	Phase 8	6	21	3.0	3.0	**3.0**	10

Measurements

Car Dist (For All Red) ("c")	Total Crossing Distance ("a")	Longest Leg to Median Button ("b")	Total ped time
71			
70	65		15
72			
94	83		21
68			
70	63		14
83			
90	83		21

11th Ave - Controller Input

Direction	Phase	Walk	FDW	Yellow	All Red (Calculated)	All Red (USE)	Min Green
SBL	Phase 1			3.0	1.6	**2.0**	5
NB	Phase 2	6	7	4.0	1.4	**1.5**	15
	Phase 3						
WB	Phase 4	6	19	3.0	2.9	**3.0**	10
NBL	Phase 5			3.0	1.6	**2.0**	5
SB	Phase 6	6	15	4.0	1.4	**1.5**	15
	Phase 7						
EB	Phase 8	6	19	3.0	2.8	**3.0**	10

Measurements

Car Dist (For All Red) ("c")	Total Crossing Distance ("a")	Longest Leg to Median Button ("b")	Total ped time
75			
61	38		7
86	76		19
73			
64	66		15
82	74		19

2nd Ave - Controller Input

Direction	Phase	Walk	FDW	Yellow	All Red (Calculated)	All Red (USE)	Min Green
SBL	Phase 1			3.0	1.8	**2.0**	5
NB	Phase 2	6	10	3.5	1.8	**2.0**	15
	Phase 3						
EB	Phase 4	6	20	3.5	2.4	**2.5**	10
NBL	Phase 5			3.0	1.5	**2.0**	5
SB	Phase 6	6	10	3.5	1.7	**2.0**	15
	Phase 7						
WB	Phase 8	6	22	3.5	2.4	**2.5**	10

Measurements

Car Dist (For All Red) ("c")	Total Crossing Distance ("a")	Longest Leg to Median Button ("b")	Total ped time
61			
61	47		10
84	80		20
48			
56	47		10
85	89		22

University Ave - Controller Input

Direction	Phase	Walk	FDW	Yellow	All Red (Calculated)	All Red (USE)	Min Green
SBL	Phase 1			3.0	2.5	**2.0**	5
NB	Phase 2	6	20	3.5	2.4	**2.5**	15
WBL	Phase 3			3.0	2.3	**2.0**	5
EB	Phase 4	6	20	3.5	2.6	**2.5**	10
NBL	Phase 5			3.0	2.4	**2.0**	5
SB	Phase 6	6	21	3.5	2.5	**2.5**	15
EBL	Phase 7			3.0	2.3	**2.0**	5
WB	Phase 8	6	21	3.5	2.4	**2.5**	10

Measurements

Car Dist (For All Red) ("c")	Total Crossing Distance ("a")	Longest Leg to Median Button ("b")	Total ped time
89			
85	82		20
81			
96	82		
84			
90	83		
81			
87	85		21

6th Ave - Controller Input

Direction	Phase	Walk	FDW	Yellow	All Red (Calculated)	All Red (USE)	Min Green
	Phase 1						
NB	Phase 2			3.5	1.7	**2.0**	15
	Phase 3						
EB	Phase 4	6	17	3.0	2.5	**2.5**	10
NBL	Phase 5			3.0	1.8	**2.0**	5
SB	Phase 6	6	15	3.5	2.0	**2.0**	15
	Phase 7						
WB	Phase 8	6	17	3.0	2.5	**2.5**	10

Measurements

Car Dist (For All Red) ("c")	Total Crossing Distance ("a")	Longest Leg to Median Button ("b")	Total ped time
55	48		11
73	67		17
60			
66	62		15
70	67		17

All Red = (width of intersection + Length of vehicle) / (1.467 * speed in mph), Use 2.0 seconds for Prot/Perm Left turn movements

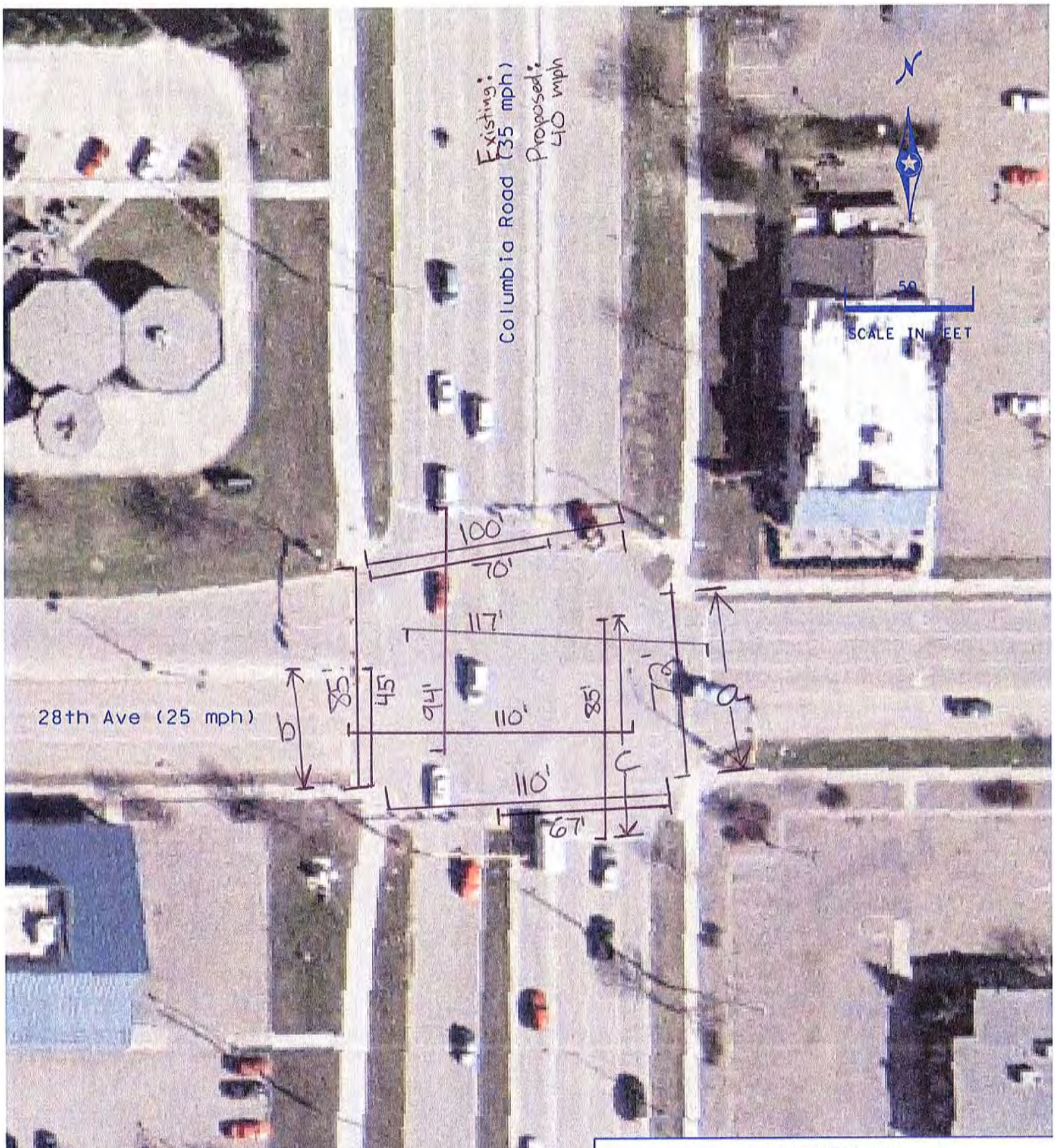
Yellow = 1 + ((1.467 * (speed in mph))/(2 * (deceleration rate + 64.4 * grade in percent))
Deceleration Rate = 10

Total Ped Time = (Total Crossing Distance / 3.5) - Yellow

FDW = (Longest Distance to Median Button / 3.5) - Yellow
Use Total distance / 3.5 - Yellow if no median button

Walk = Total Ped Time - FDW
Use 6 seconds if no median button.

Source: City of Grand Forks and Alliant Engineering, Inc.



LEGEND

a = distance from curb to curb
b = greater distance from curb to median
c = distance from stop bar to center of furthest traveled lane

LEGEND

a = distance from curb to curb
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LEGEND

a = distance from curb to curb
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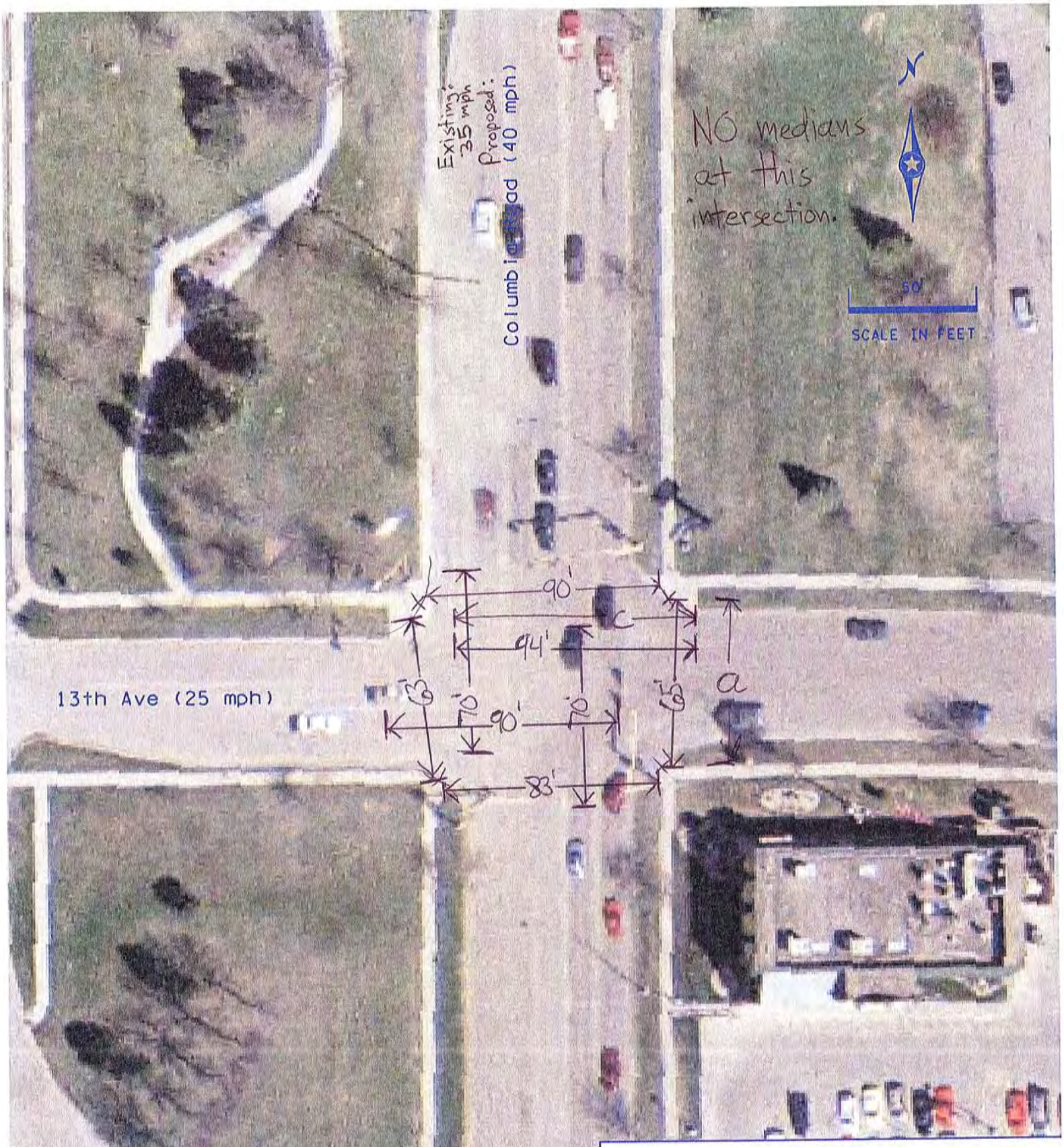
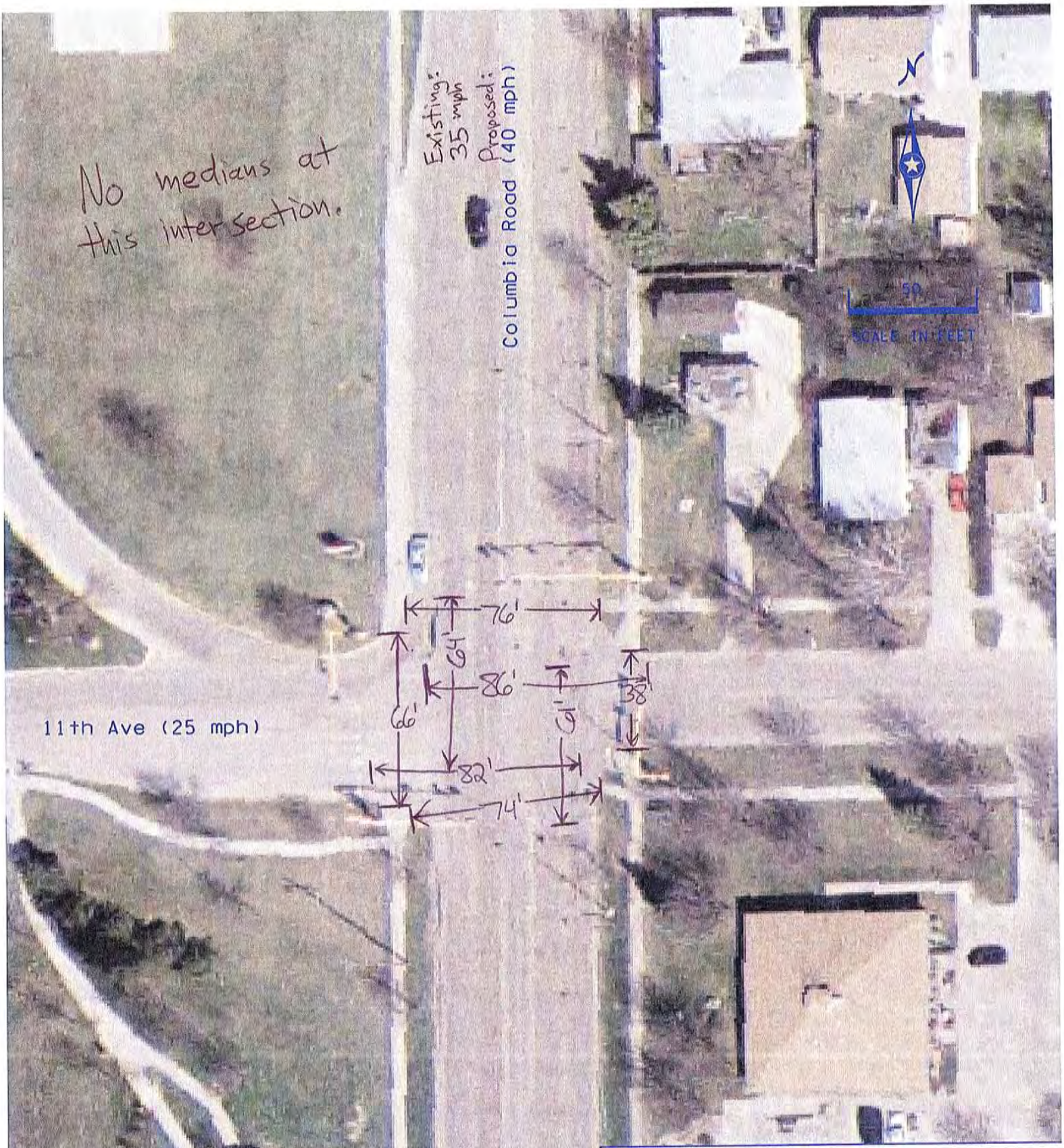


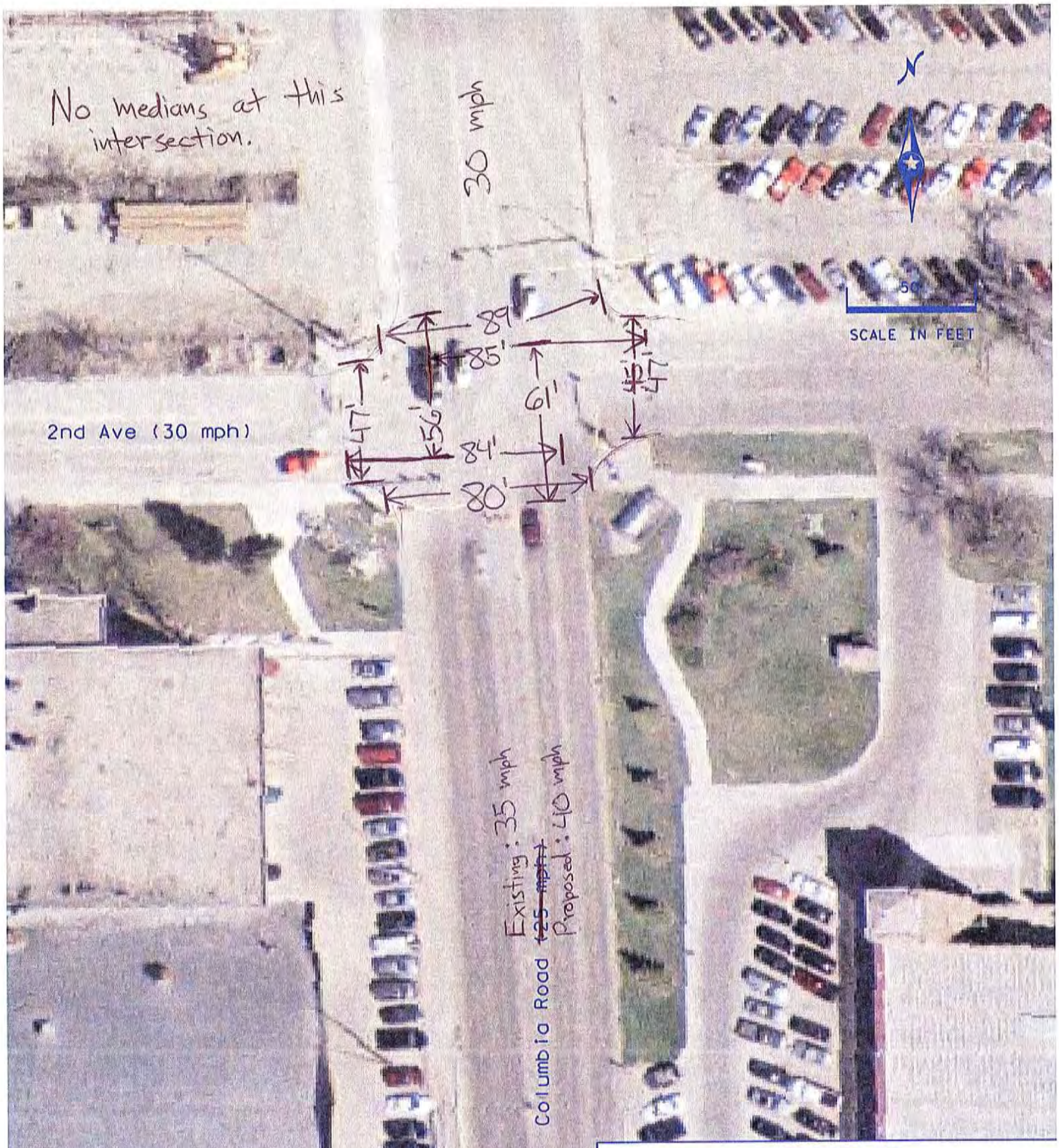
LEGEND

a = distance from curb to curb
b = greater distance from curb to median
c = distance from stop bar to center of furthest traveled lane



LEGEND

a = distance from curb to curb
b = greater distance from curb to median
c = distance from stop bar to center of furthest traveled lane



LEGEND

a = distance from curb to curb
b = greater distance from curb to median
c = distance from stop bar to center of furthest traveled lane

LEGEND

a = distance from curb to curb
b = greater distance from curb to median
c = distance from stop bar to center of furthest traveled lane

LEGEND

a = distance from curb to curb
b = greater distance from curb to median
c = distance from stop bar to center of furthest traveled lane

Washington St Yellow, All Red, Pedestrian Intervals (YARP)
*** Measurements Attached ***

32nd Ave - Controller Input

Direction	Phase	Walk	FDW	Yellow	All Red (Calculated)	All Red (USE)	Min Green
NBL	Phase 1			3.0	1.9	**2.0**	7
SB	Phase 2	6	11	4.0	1.9	**2.0**	15
WBL	Phase 3			3.0	1.7	**2.0**	7
EB	Phase 4	6	24	4.0	2.3	**2.5**	10
SBL	Phase 5			3.0	2.1	**2.0**	7
NB	Phase 6	6	12	4.0	1.3	**1.5**	15
EBL	Phase 7			3.0	1.7	**2.0**	7
WB - MED PB	Phase 8	15	9	4.0	2.1	**2.5**	10

Measurements

Car Dist (For All Red) ("c")	Total Crossing Distance ("a")	Longest Leg to Median Button ("b")	Total ped time
90			
93	52		11
77			
114	95		24
103			
54	54		12
81			
102	98	45	24

28th Ave - Controller Input

Direction	Phase	Walk	FDW	Yellow	All Red (Calculated)	All Red (USE)	Min Green
NBL	Phase 1			3.0	1.8	**2.0**	7
SB	Phase 2	6	15	4.0	1.7	**2.0**	15
	Phase 3						
EB - MED PB	Phase 4	13	9	3.5	2.6	**3.0**	10
SBL	Phase 5			3.0	1.7	**2.0**	7
NB	Phase 6	6	16	4.0	1.6	**2.0**	15
	Phase 7						
WB - MED PB	Phase 8	11	10	3.5	2.5	**2.5**	10

Measurements

Car Dist (For All Red) ("c")	Total Crossing Distance	Longest Leg to Median Button	Total ped time
83			
81	65		15
93	87	42	22
80			
72	69		16
91	83	44	21

24th Ave - Controller Input

Direction	Phase	Walk	FDW	Yellow	All Red (Calculated)	All Red (USE)	Min Green
NBL	Phase 1			3.0	2.5	**2.0**	7
SB	Phase 2	6	23	4.0	2.3	**2.5**	15
WBL	Phase 3			3.0	2.9	**2.0**	5
EB - MED PB	Phase 4	14	13	3.0	3.9	**3.5**	10
SBL	Phase 5			3.0	2.6	**2.0**	7
NB	Phase 6	6	21	4.0	2.4	**2.5**	15
EBL	Phase 7			3.0	3.4	**2.0**	5
WB - MED PB	Phase 8	14	13	3.0	4.0	**3.5**	10

Measurements

Car Dist (For All Red) ("c")	Total Crossing Distance ("a")	Longest Leg to Median Button ("b")	Total ped time
106			
100	93		23
86			
123	103	53	27
113			
101	85		21
105			
125	102	55	27

Campbell Dr - Controller Input

Direction	Phase	Walk	FDW	Yellow	All Red (Calculated)	All Red (USE)	Min Green
NBL	Phase 1			3.0		**2.0**	5
SB	Phase 2	6	13	4.0	2.0	**2.0**	15
	Phase 3						
EB	Phase 4	6	21	3.0	2.9	**3.0**	10
SBL	Phase 5			3.0		**2.0**	5
NB	Phase 6	6	13	4.0	2.0	**2.0**	15
	Phase 7						
WB	Phase 8	6	21	3.0	3.0	**3.0**	10

Measurements

Car Dist (For All Red) ("c")	Total Crossing Distance ("a")	Longest Leg to Median Button ("b")	Total ped time
81	59		13
87	82		21
81	59		13
89	82		21

17th Ave - Controller Input

Direction	Phase	Walk	FDW	Yellow	All Red (Calculated)	All Red (USE)	Min Green
NBL	Phase 1			3.0	2.5	**2.0**	5
SB	Phase 2	7	23	4.0	2.4	**2.5**	15
WBL	Phase 3			3.0		**2.0**	5
EB	Phase 4	7	31	3.0	4.1	**3.5**	10
SBL	Phase 5			3.0	2.1	**2.0**	5
NB	Phase 6	7	22	4.0	2.6	**2.5**	15
EBL	Phase 7			3.0		**2.0**	5
WB	Phase 8	7	30	3.0	3.8	**3.5**	10

Measurements

Car Dist (For All Red) ("c")	Total Crossing Distance ("a")	Longest Leg to Median Button ("b")	Total ped time
107			
103	94		23
91			
130	117		31
89			
112	91		22
100			
121	113		30

13th Ave - Controller Input

Direction	Phase	Walk	FDW	Yellow	All Red (Calculated)	All Red (USE)	Min Green
NBL	Phase 1			3.0	2.0	**2.0**	5
SB	Phase 2	6	15	4.0	1.6	**1.5**	15
EBL	Phase 3			3.0	2.2	**2.0**	5
WB	Phase 4	6	17	3.0	2.6	**2.5**	10
SBL	Phase 5			3.0	1.6	**2.0**	5
NB	Phase 6	6	13	4.0	1.6	**1.5**	15
WBL	Phase 7			3.0	2.2	**2.0**	5
EB	Phase 8	6	17	3.0	2.4	**2.5**	10

Measurements

Car Dist (For All Red) ("c")	Total Crossing Distance ("a")	Longest Leg to Median Button ("b")	Total ped time
67			
63	65		15
61			
75	69		17
61			
64	58		13
62			
68	67		17

DeMers Ave - Controller Input

Direction	Phase	Walk	FDW	Yellow	All Red (Calculated)	All Red (USE)	Min Green
NBL	Phase 1			3.0	2.4	**2.0**	5
SB	Phase 2	6	20	4.0	2.2	**2.0**	15
EBL	Phase 3			3.0	2.2	**2.0**	7
WB	Phase 4	6	16	4.0	1.7	**1.5**	10
SBL	Phase 5			3.0	2.2	**2.0**	5
NB	Phase 6	6	21	4.0	2.1	**2.0**	15
WBL	Phase 7			3.0	1.9	**2.0**	7
EB	Phase 8	6	14	4.0	1.5	**1.5**	10

Measurements

Car Dist (For All Red) ("c")	Total Crossing Distance ("a")	Longest Leg to Median Button ("b")	Total ped time
101			
93	83		20
107			
77	67		16
92			
88	87		21
89			
70	62		14

2nd Ave - Controller Input

Direction	Phase	Walk	FDW	Yellow	All Red (Calculated)	All Red (USE)	Min Green
	Phase 1						
NB	Phase 2	6	14	4.0	1.6	**1.5**	15
	Phase 3						
WB	Phase 4	6	16	3.0	2.5	**2.5**	10
NBL	Phase 5			3.0	1.6	**2.0**	5
SB	Phase 6	6	14	4.0	1.7	**1.5**	15
	Phase 7						
EB	Phase 8	6	17	3.0	2.4	**2.5**	10

Measurements

Car Dist (For All Red) ("c")	Total Crossing Distance ("a")	Longest Leg to Median Button ("b")	Total ped time
60	63		14
71	66		16
60			
65	61		14
67	70		17

University Ave - Controller Input

Direction	Phase	Walk	FDW	Yellow	All Red (Calculated)	All Red (USE)	Min Green
NBL	Phase 1			3.0	1.9	**2.0**	5
SB	Phase 2	6	18	3.5	1.9	**2.0**	15
WBL	Phase 3			3.0	2.0	**2.0**	5
EB	Phase 4	6	16	3.5	2.0	**2.0**	10
	Phase 5						
NB	Phase 6	6	18	3.5	1.9	**2.0**	15
	Phase 7						
WB	Phase 8	6	15	3.5	2.2	**2.0**	10

Measurements

Car Dist (For All Red) ("c")	Total Crossing Distance ("a")	Longest Leg to Median Button ("b")	Total ped time
78			
80	75		19
70			
68	65		16
80	74		19
77	64		16

5th Ave - Controller Input

Direction	Phase	Walk	FDW	Yellow	All Red (Calculated)	All Red (USE)	Min Green
	Phase 1						
SB	Phase 2	6	7	3.5	1.3	**1.5**	15
	Phase 3						
EB	Phase 4	6	15	3.5	2.0	**2.0**	10
	Phase 5						
NB	Phase 6	6	8	3.5	1.3	**1.5**	15
	Phase 7						
WB	Phase 8	6	15	3.5	2.1	**2.0**	10

Measurements

Car Dist (For All Red) ("c")	Total Crossing Distance ("a")	Longest Leg to Median Button ("b")	Total ped time
46	35		7
70	63		15
46	40		9
72	64		16

All Red = (width of intersection + Length of vehicle) / (1.467 * speed in mph), Use 2.0 seconds for Prot and Prot/Perm Left turn movements
Yellow = 1 + ((1.467 * (speed in mph))/(2 * (deceleration rate + 64.4 * grade in percent))
Deceleration Rate = 10
Total Ped Time = (Total Crossing Distance / 3.5) - Yellow
FDW = (Longest Distance to Median Button / 3.5) - Yellow
Use Total distance / 3.5 - Yellow if no median button
Walk = Total Ped Time - FDW
Use 6 seconds as original walk if no median button. Adjust up based on Note (1)

(1) An original difference that is positive represents the number of seconds that need to be added to the walk time.
An original difference that is negative represents a check that is okay (no change to the walk time).

Note: Washington Street is being posted 35 mph between 5th Avenue and 17th Avenue. Speed limit change exptected complete in Spring 2010, prior to timing plan implementation.

Source: City of Grand Forks and Alliant Engineering, Inc.

LEGEND

a = distance from curb to curb
b = greater distance from curb to median
c = distance from stop bar to center of furthest traveled lane

LEGEND

a = distance from curb to curb
b = greater distance from curb to median
c = distance from stop bar to center of furthest traveled lane

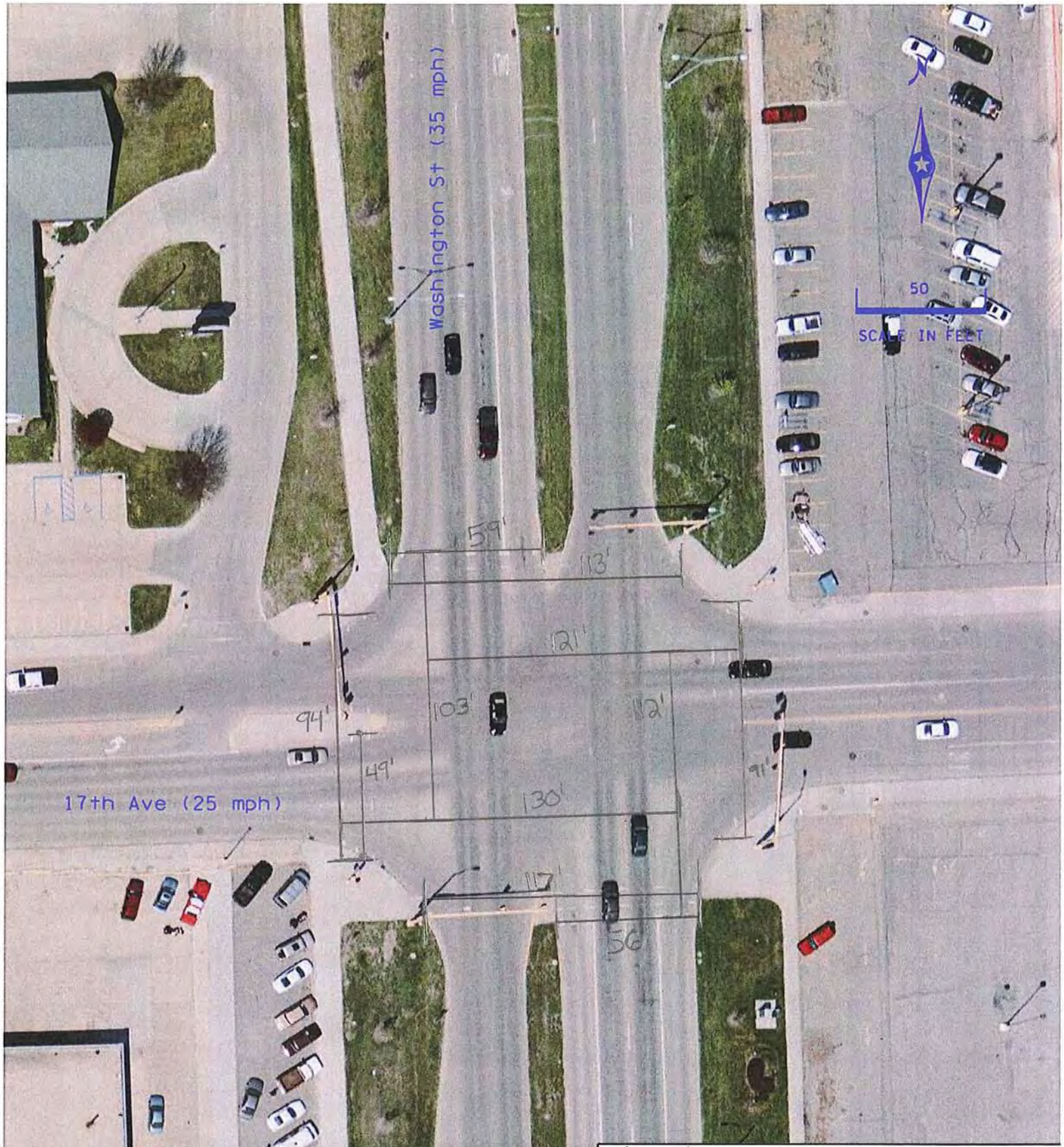
LEGEND

a = distance from curb to curb
b = greater distance from curb to median
c = distance from stop bar to center of furthest traveled lane

No median push button

LEGEND

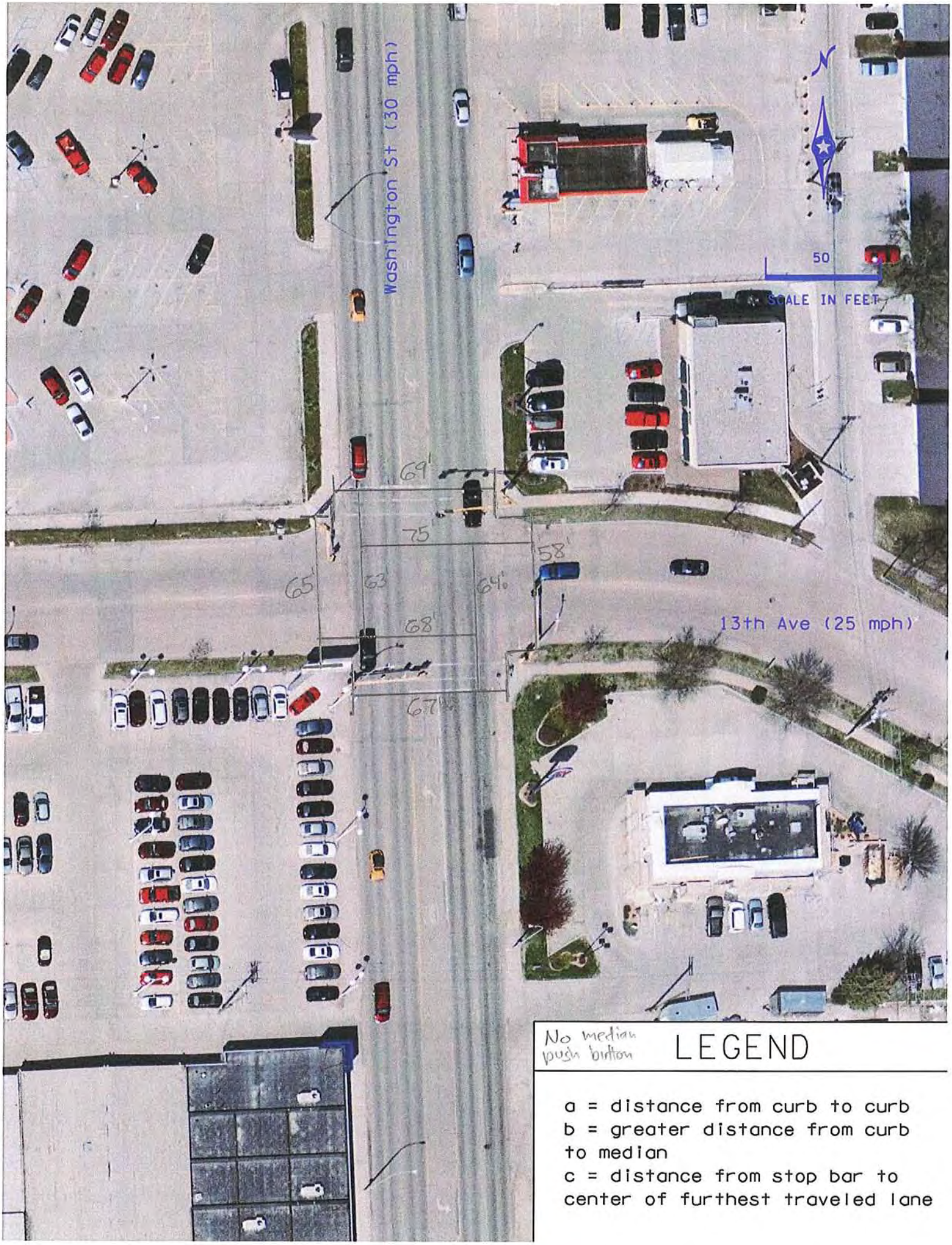
a = distance from curb to curb
b = greater distance from curb to median
c = distance from stop bar to center of furthest traveled lane



No median push button

LEGEND

a = distance from curb to curb
b = greater distance from curb to median
c = distance from stop bar to center of furthest traveled lane

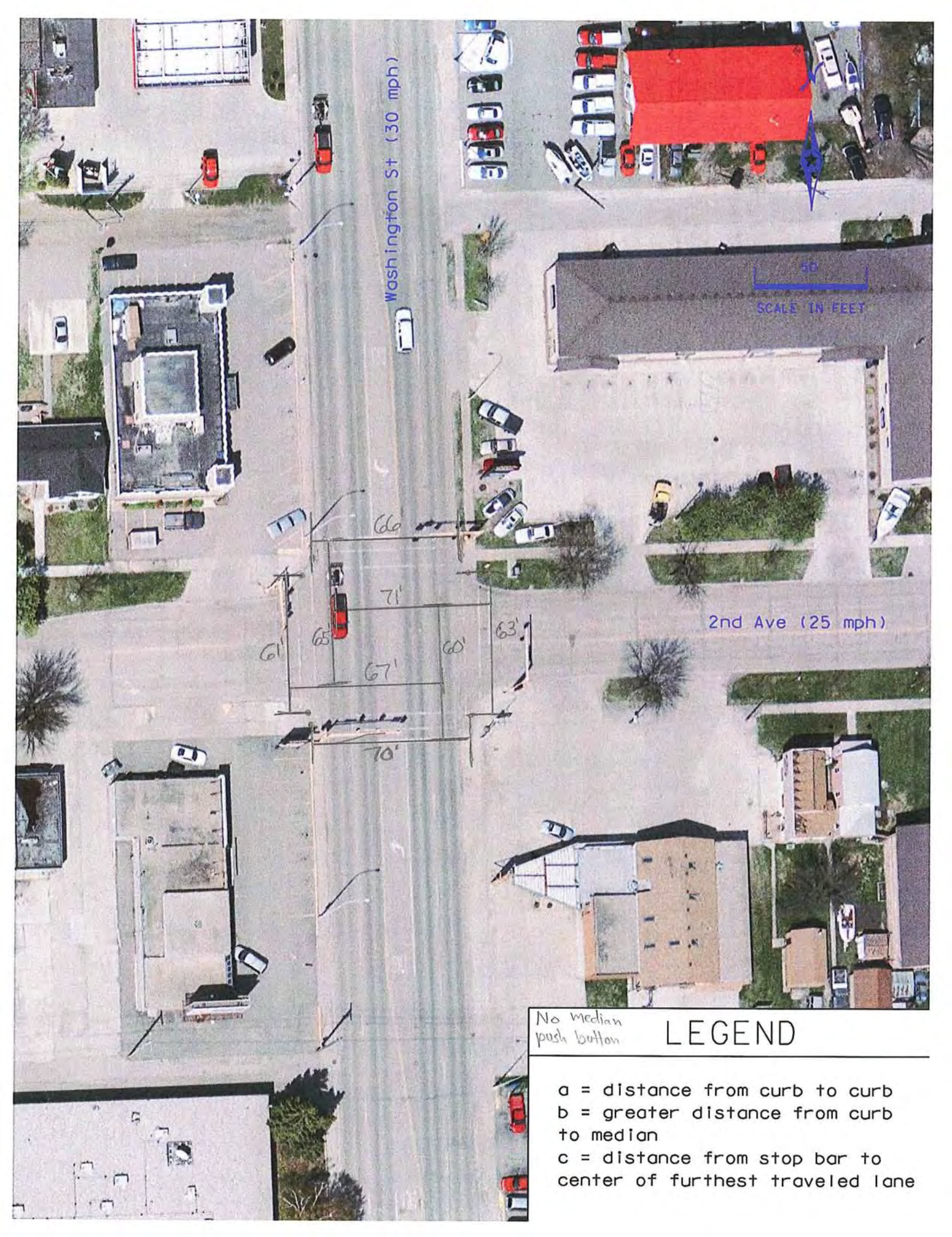


No median push button

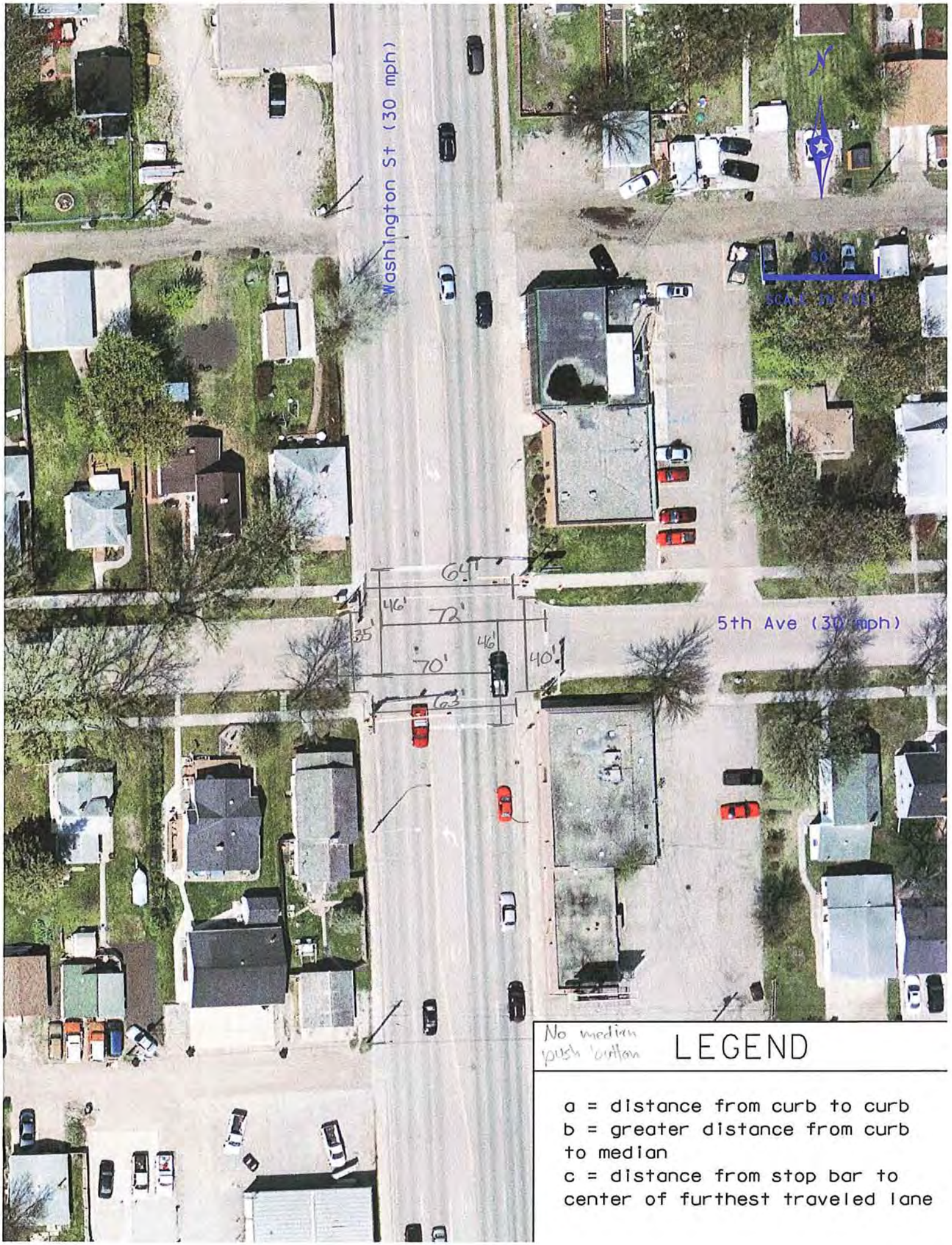
LEGEND

a = distance from curb to curb
b = greater distance from curb to median
c = distance from stop bar to center of furthest traveled lane


Washington St (30 mph)
DeMers Ave (40 mph)
50
SCALE IN FEET
67'
77'
83'
93'
88'
50'
51'
70'
87'
62'
No median push button
LEGEND
a = distance from curb to curb
b = greater distance from curb to median
c = distance from stop bar to center of furthest traveled lane


Washington St (30 mph)
50
SCALE IN FEET
66
71'
65'
63'
61'
60'
67'
70'
2nd Ave (25 mph)
No median push button
LEGEND
a = distance from curb to curb
b = greater distance from curb to median
c = distance from stop bar to center of furthest traveled lane


Washington St (30 mph)
50
SCALE IN FEET
64'
77'
75'
80'
80'
74'
68'
65'
University Ave
(30 mph)
Washington St (30 mph)
No median push button
LEGEND
a = distance from curb to curb
b = greater distance from curb to median
c = distance from stop bar to center of furthest traveled lane



No median push button

LEGEND

a = distance from curb to curb
b = greater distance from curb to median
c = distance from stop bar to center of furthest traveled lane

Gateway Dr Yellow, All Red, Pedestrian Intervals (YARP)

***** Measurements Attached *****

3rd St - Controller Input

Direction	Phase	Walk	FDW	Yellow	All Red (Calculated)	All Red (USE)	Min Green
	Phase 1						
EB	Phase 2	6	12	3.5	1.8	**2.0**	15
	Phase 3						
SB	Phase 4	6	22	3.5	2.5	**2.5**	10
	Phase 5						
WB	Phase 6	6	10	3.5	1.9	**2.0**	15
	Phase 7						
NB	Phase 8	6	20	3.0	2.9	**3.0**	10

Measurements

Car Dist (For All Red) ("c")	Total Crossing Distance ("a")	Longest Leg to Median Button ("b")	Total ped time
60	54		12
89	87		22
63	44		10
88	80		20

5th St - Controller Input

Direction	Phase	Walk	FDW	Yellow	All Red (Calculated)	All Red (USE)	Min Green
EBL	Phase 1			3.0	1.7	**2.0**	5
WB	Phase 2			3.5	2.1	**2.0**	15
	Phase 3						
SB	Phase 4			3.5	2.6	**2.5**	10
	Phase 5						
EB	Phase 6			3.5	2.4	**2.5**	15
	Phase 7						
NB	Phase 8			3.5	3.0	**3.0**	10

Measurements

Car Dist (For All Red) ("c")	Total Crossing Distance	Longest Leg to Median Button	Total ped time
54			
71	0		-4
95	0		-4
86	0		-4
114	0		-4

Washington St - Controller Input

Direction	Phase	Walk	FDW	Yellow	All Red (Calculated)	All Red (USE)	Min Green
EBL	Phase 1			3.0	2.5	**2.0**	7
WB	Phase 2			3.5	3.3	**3.0**	15
SBL	Phase 3			3.0	4.1	**2.0**	7
NB	Phase 4			3.5	3.0	**3.0**	10
WBL	Phase 5			3.0	2.0	**2.0**	7
EB	Phase 6			3.5	3.2	**3.0**	15
NBL	Phase 7			3.0	3.8	**2.0**	7
SB	Phase 8			3.5	3.4	**3.0**	10

Measurements

Car Dist (For All Red) ("c")	Total Crossing Distance ("a")	Longest Leg to Median Button ("b")	Total ped time
91			
125	0		-4
161			
114	0		-4
70			
123	0		-4
148			
129	0		-4

20th St - Controller Input

Direction	Phase	Walk	FDW	Yellow	All Red (Calculated)	All Red (USE)	Min Green
	Phase 1						
WB	Phase 2			3.5	1.9	**2.0**	15
	Phase 3						
SB	Phase 4	6	15	3.0	2.2	**2.0**	10
WBL	Phase 5			3.0	1.8	**2.0**	5
EB	Phase 6	6	11	4.0	1.6	**1.5**	15
	Phase 7						
NB	Phase 8	6	15	3.0	2.5	**2.5**	10

Measurements

Car Dist (For All Red) ("c")	Total Crossing Distance ("a")	Longest Leg to Median Button ("b")	Total ped time
63	0		-4
59	61		15
73			
60	52		11
73	61		15

Columbia Rd - Controller Input

Direction	Phase	Walk	FDW	Yellow	All Red (Calculated)	All Red (USE)	Min Green
EBL	Phase 1			3.0	1.9	**2.0**	5
WB	Phase 2	6	18	4.0	2.0	**2.0**	15
	Phase 3						
NB	Phase 4			4.0	1.8	**2.0**	10
WBL	Phase 5			3.0	1.9	**2.0**	5
EB	Phase 6			4.0	1.9	**2.0**	15
	Phase 7						
SB	Phase 8	6	23	4.0	2.1	**2.0**	10

Measurements

Car Dist (For All Red) ("c")	Total Crossing Distance ("a")	Longest Leg to Median Button ("b")	Total ped time
94			
84	74		18
74	0		-4
78			
92	0		-4
87	92		23

Stanford Rd - Controller Input

Direction	Phase	Walk	FDW	Yellow	All Red (Calculated)	All Red (USE)	Min Green
WBL	Phase 1			3.0	1.6	**2.0**	5
EB	Phase 2			4.0	1.6	**1.5**	15
	Phase 3						
NB	Phase 4			3.0	3.6	**3.5**	10
EBL	Phase 5			3.0	1.9	**2.0**	5
WB	Phase 6			4.0	1.4	**1.5**	15
	Phase 7						
SB	Phase 8	8	30	3.0	3.4	**3.5**	10

Measurements

Car Dist (For All Red) ("c")	Total Crossing Distance ("a")	Longest Leg to Median Button ("b")	Total ped time
76			
72	0		-4
113	0		-3
90			
61	0		-4
104	115		30

42nd St - Controller Input

Direction	Phase	Walk	FDW	Yellow	All Red (Calculated)	All Red (USE)	Min Green
EBL	Phase 1			3.0		**2.0**	5
WB	Phase 2			4.0	1.6	**1.5**	15
	Phase 3						
NB	Phase 4			3.5	2.9	**3.0**	10
WBL	Phase 5			3.0		**2.0**	5
EB	Phase 6			4.0	1.9	**2.0**	15
	Phase 7						
SB	Phase 8			3.5	3.2	**3.0**	10

Measurements

Car Dist (For All Red) ("c")	Total Crossing Distance ("a")	Longest Leg to Median Button ("b")	Total ped time
75	0		-4
106	0		-4
92	0		-4
123	0		-4

I29 East Ramp - Controller Input

Direction	Phase	Walk	FDW	Yellow	All Red (Calculated)	All Red (USE)	Min Green
EBL	Phase 1			3.0	1.7	**2.0**	7
WB	Phase 2			4.0	0.9	**1.0**	15
	Phase 3						
	Phase 4						
	Phase 5						
EB	Phase 6	6	5	4.0	1.1	**1.0**	15
	Phase 7						
NB	Phase 8			4.0	2.3	**2.5**	8

Measurements

Car Dist (For All Red) ("c")	Total Crossing Distance ("a")	Longest Leg to Median Button ("b")	Total ped time
82			
34	0		-4
			0
47	30		5
100	0		-4

I29 West Ramp - Controller Input

Direction	Phase	Walk	FDW	Yellow	All Red (Calculated)	All Red (USE)	Min Green
	Phase 1						
WB	Phase 2			4.0	1.1	**1.0**	15
	Phase 3						
SB	Phase 4			4.0	2.5	**2.5**	8
	Phase 5						
EB	Phase 6			4.0	1.0	**1.0**	15
	Phase 7						
	Phase 8						

Measurements

Car Dist (For All Red) ("c")	Total Crossing Distance ("a")	Longest Leg to Median Button ("b")	Total ped time
46			-4
106			-4
38			-4
			0

47th St - Controller Input

Direction	Phase	Walk	FDW	Yellow	All Red (Calculated)	All Red (USE)	Min Green
EBL	Phase 1			3.0	2.2	**2.0**	7
WB	Phase 2			4.0	2.1	**2.0**	15
	Phase 3						
SB	Phase 4			3.0	3.8	**3.5**	10
WBL	Phase 5			3.0	2.4	**2.0**	7
EB	Phase 6	7	26	4.0	2.2	**2.0**	15
	Phase 7						
NB	Phase 8			3.0	3.9	**3.5**	10

Measurements

Car Dist (For All Red) ("c")	Total Crossing Distance ("a")	Longest Leg to Median Button ("b")	Total ped time
111			
105	0		-4
121	0		-3
123			
112	105		26
124	0		-3

All Red = (width of intersection + Length of vehicle) / (1.467 * speed in mph), Use 2.0 seconds for Prot and Prot/Perm Left turn movements

Yellow = 1 + ((1.467 * (speed in mph))/(2 * (deceleration rate + 64.4 * grade in percent))
Deceleration Rate = 10

Total Ped Time = (Total Crossing Distance / 3.5) - Yellow

FDW = (Longest Distance to Median Button / 3.5) - Yellow
Use Total distance / 3.5 - Yellow if no median button

Walk = Total Ped Time - FDW
Use 6 seconds as original walk if no median button. Adjust up based on Note (1)

(1) An original difference that is positive represents the number of seconds that need to be added to the walk time.
An original difference that is negative represents a check that is okay (no change to the walk time).

Source: City of Grand Forks and Alliant Engineering, Inc.

No median buttons

LEGEND

a = distance from curb to curb
b = greater distance from curb to median
c = distance from stop bar to center of furthest traveled lane

No ped signals

LEGEND

a = distance from curb to curb
b = greater distance from curb to median
c = distance from stop bar to center of furthest traveled lane

No ped signals

LEGEND

a = distance from curb to curb
b = greater distance from curb to median
c = distance from stop bar to center of furthest traveled lane

No median buttons

LEGEND

a = distance from curb to curb
b = greater distance from curb to median
c = distance from stop bar to center of furthest traveled lane

No median buttons

LEGEND

a = distance from curb to curb
b = greater distance from curb to median
c = distance from stop bar to center of furthest traveled lane

No median buttons

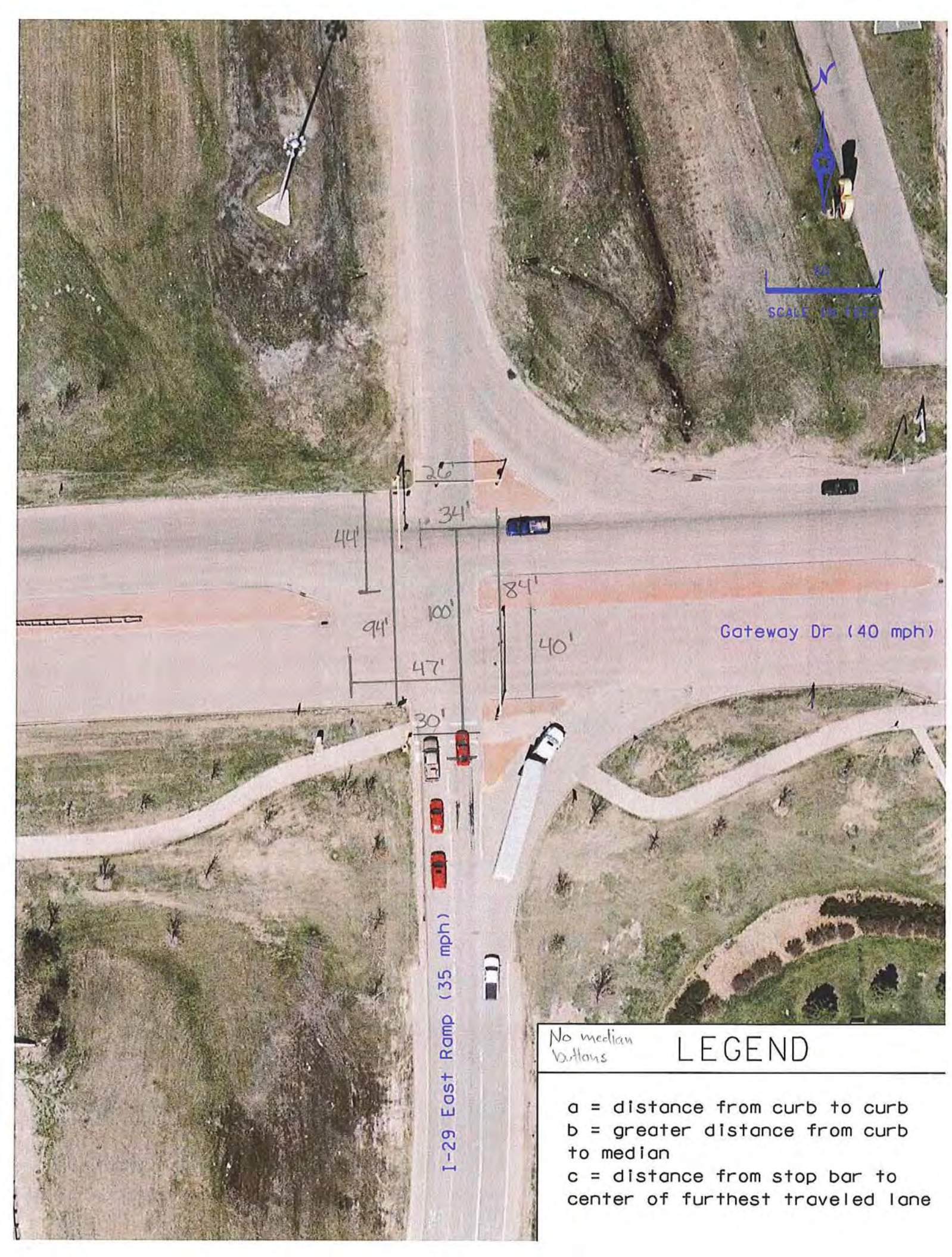
LEGEND

a = distance from curb to curb
b = greater distance from curb to median
c = distance from stop bar to center of furthest traveled lane

No ped signals

LEGEND

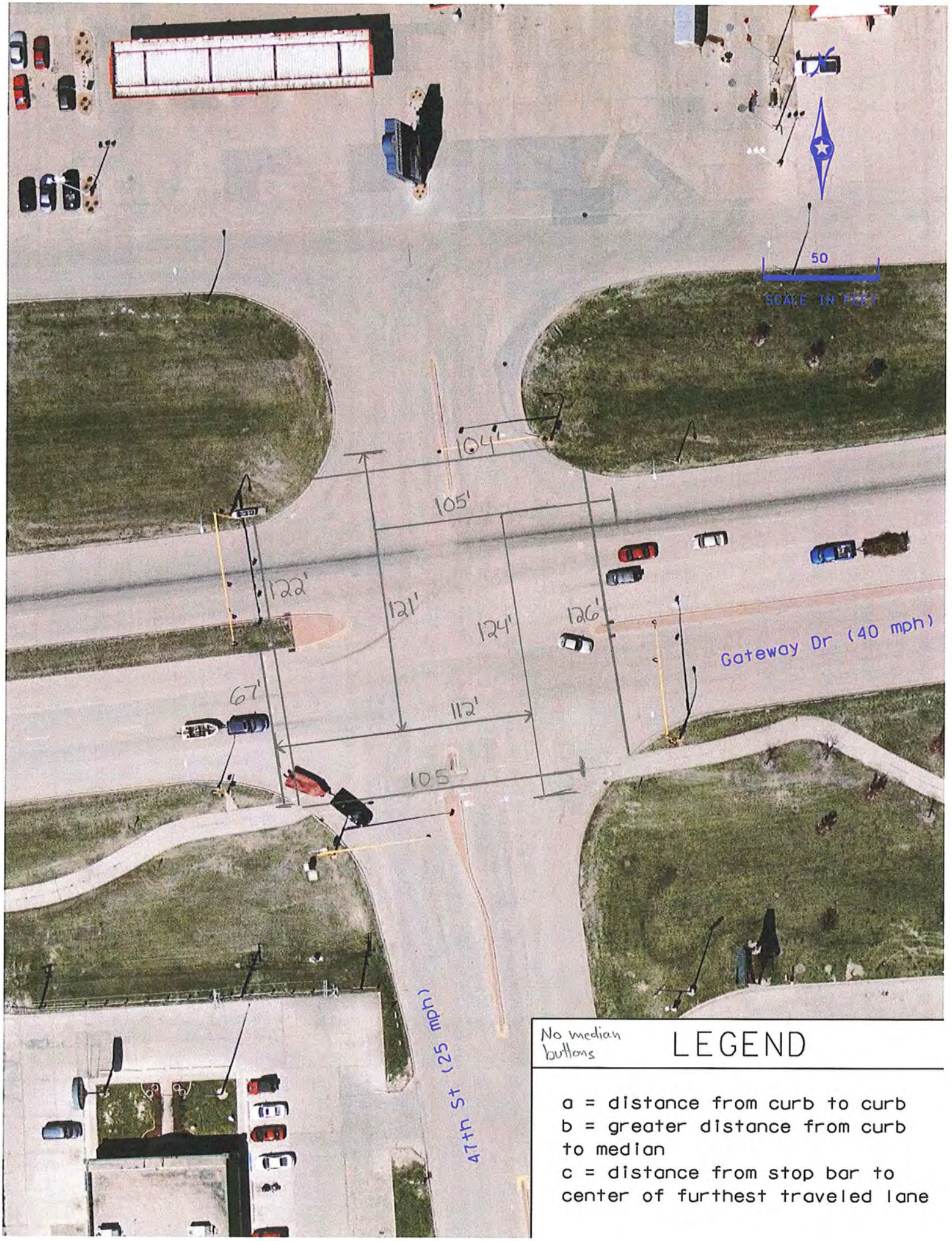
a = distance from curb to curb
b = greater distance from curb to median
c = distance from stop bar to center of furthest traveled lane


N
SCALE IN FEET
26'
34'
44'
84'
100'
94'
40'
47'
30'
Gateway Dr (40 mph)
I-29 East Ramp (35 mph)
No median buttons
LEGEND
a = distance from curb to curb
b = greater distance from curb to median
c = distance from stop bar to center of furthest traveled lane

No ped signals

LEGEND

a = distance from curb to curb
b = greater distance from curb to median
c = distance from stop bar to center of furthest traveled lane



No median buttons

LEGEND

a = distance from curb to curb
b = greater distance from curb to median
c = distance from stop bar to center of furthest traveled lane

DeMers Ave Yellow, All Red, Pedestrian Intervals (YARP)

*** Measurements Attached ***

34th St - Controller Input

Direction	Phase	Walk	FDW	Yellow	All Red (Calculated)	All Red (USE)	Min Green
	Phase 1						
EB	Phase 2			4.0	1.4	**1.5**	15
	Phase 3						
NB - Med PB	Phase 4	15	11	3.0	3.1	**3.0**	10
	Phase 5						
WB	Phase 6			4.0	1.6	**1.5**	15
	Phase 7						
	Phase 8						

Measurements

Car Dist (For All Red) ("c")	Total Crossing Distance ("a")	Longest Leg to Median Button ("b")	Total ped time
61	50		15
95	91	46	26
72			0
	73		21

Columbia Rd - Controller Input

Direction	Phase	Walk	FDW	Yellow	All Red (Calculated)	All Red (USE)	Min Green
	Phase 1						
NB/SB	Phase 2	6	20	3.0	1.8	**2.0**	10
WB LT	Phase 3			3.0	2.0	**2.0**	5
EB	Phase 4	6	12	4.0	1.7	**1.5**	15
	Phase 5						
	Phase 6						
	Phase 7						
WB	Phase 8	6	10	4.0	1.5	**1.5**	15

Measurements

Car Dist (For All Red) ("c")	Total Crossing Distance	Longest Leg to Median	Total ped time
86	78		23
67			
78	54		16
			0
67	46		14

20th St - Controller Input

Direction	Phase	Walk	FDW	Yellow	All Red (Calculated)	All Red (USE)	Min Green
WB LT	Phase 1			3.0	1.9	**2.0**	5
EB	Phase 2	6	17	4.0	1.4	**1.5**	15
	Phase 3						
NB	Phase 4	6	20	3.5	2.4	**2.5**	10
	Phase 5						
WB	Phase 6	6	8	4.0	1.4	**1.5**	15
	Phase 7						
SB	Phase 8	6	21	3.5	2.3	**2.5**	10

Measurements

Car Dist (For All Red) ("c")	Total Crossing Distance ("a")	Longest Leg to Median Button ("b")	Total ped time
64			
64	72		21
87	81		24
64	39		12
80	83		24

All Red = (width of intersection + Length of vehicle) / (1.467 * speed in mph), Use 2.0 seconds for Prot/Perm Left turn movements

Yellow = 1 + ((1.467 * (speed in mph))/(2 * (deceleration rate + 64.4 * grade in percent))
Deceleration Rate = 10

Total Ped Time = (Total Crossing Distance / 3.5) - Yellow

FDW = (Longest Distance to Median Button / 3.5) - Yellow
Use Total distance / 3.5 - Yellow if no median button

Walk = Total Ped Time - FDW
Use 6 seconds if no median button.

Source: City of Grand Forks and Alliant Engineering, Inc.

LEGEND

a = distance from curb to curb
b = greater distance from curb to median
c = distance from stop bar to center of furthest traveled lane

No median buttons

LEGEND

a = distance from curb to curb
b = greater distance from curb to median
c = distance from stop bar to center of furthest traveled lane

No median buttons

LEGEND

a = distance from curb to curb
b = greater distance from curb to median
c = distance from stop bar to center of furthest traveled lane

42nd St Yellow, All Red, Pedestrian Intervals (YARP)

***** Measurements Attached *****

6th Ave - Controller Input

Direction	Phase	Walk	FDW	Yellow	All Red (Calculated)	All Red (USE)	Min Green
	Phase 1						
SB	Phase 2	6	11	3.5	1.8	**2.0**	15
	Phase 3						
WB	Phase 4	6	15	3.5	2.1	**2.0**	10
	Phase 5						
NB	Phase 6			3.5	1.8	**2.0**	15
	Phase 7						
EB	Phase 8			3.5	2.1	**2.0**	10

Measurements

Car Dist (For All Red) ("c")	Total Crossing Distance ("a")	Longest Leg to Median Button ("b")	Total ped time
60	50		15
71	62		18
61	50		15
74	60		18

University Ave - Controller Input

Direction	Phase	Walk	FDW	Yellow	All Red (Calculated)	All Red (USE)	Min Green
NBLT	Phase 1			3.0	1.5	**2.0**	5
SB	Phase 2	6	16	4.0	1.7	**2.0**	15
EBLT	Phase 3			3.0	2.0	**2.0**	5
WB	Phase 4	6	17	3.5	2.3	**2.5**	10
SBLT	Phase 5			3.0	1.6	**2.0**	5
NB	Phase 6	6	15	4.0	1.5	**1.5**	15
WBLT	Phase 7			3.0	2.0	**2.0**	5
EB	Phase 8	6	22	3.5	2.5	**2.5**	10

Measurements

Car Dist (For All Red) ("c")	Total Crossing Distance	Longest Leg to Median Button	Total ped time
69			
79	69		20
66			
80	70		20
75			
68	65		19
70			
88	87		25

DeMers Ave - Controller Input

Direction	Phase	Walk	FDW	Yellow	All Red (Calculated)	All Red (USE)	Min Green
WBLT	Phase 1			3.0	1.8	**2.0**	5
EB	Phase 2	7	25	4.0	2.3	**2.5**	15
NBLT	Phase 3			3.0	1.9	**2.0**	5
SB	Phase 4	6	22	4.0	2.0	**2.0**	10
EBLT	Phase 5			3.0	2.1	**2.0**	5
WB	Phase 6	7	27	4.0	2.2	**2.5**	15
SBLT	Phase 7			3.0	1.9	**2.0**	5
NB	Phase 8	6	22	4.0	2.0	**2.0**	10

Measurements

Car Dist (For All Red) ("c")	Total Crossing Distance ("a")	Longest Leg to Median Button ("b")	Total ped time
84			
113	100		29
94			
98	90		26
104			
110	107		31
94			
97	88		26

11th Ave - Controller Input

Direction	Phase	Walk	FDW	Yellow	All Red (Calculated)	All Red (USE)	Min Green
NBLT	Phase 1			3.0	1.4	**2.0**	5
SB	Phase 2	6	4	4.0	1.1	**1.5**	15
	Phase 3						
WB	Phase 4	6	18	3.0	2.9	**3.0**	10
SBLT	Phase 5			3.0	1.3	**2.0**	5
NB	Phase 6	6	9	4.0	1.3	**1.5**	15
	Phase 7						
EB	Phase 8	6	16	3.0	2.8	**3.0**	10

Measurements

Car Dist (For All Red) ("c")	Total Crossing Distance ("a")	Longest Leg to Median Button ("b")	Total ped time
62			
46	26		4
86	73		18
54			
58	44		9
84	66		16

17th Ave - Controller Input

Direction	Phase	Walk	FDW	Yellow	All Red (Calculated)	All Red (USE)	Min Green
	Phase 1						
SB	Phase 2	6	13	4.0	1.3	**1.5**	15
	Phase 3						
WB	Phase 4	6	20	3.0	2.6	**2.5**	10
SBLT	Phase 5			3.0	1.2	**2.0**	5
NB	Phase 6	6	14	4.0	1.2	**1.5**	15
	Phase 7						
EB PED	Phase 8	6	20	3.0			

Measurements

Car Dist (For All Red) ("c")	Total Crossing Distance ("a")	Longest Leg to Median Button ("b")	Total ped time
55	57		13
76	79		20
50			
53	60		14
80	80		20

All Red = (width of intersection + Length of vehicle) / (1.467 * speed in mph), Use 2.0 seconds for Prot/Perm Left turn movements

Yellow = 1 + ((1.467 * (speed in mph))/(2 * (deceleration rate + 64.4 * grade in percent))
Deceleration Rate = 10

Total Ped Time = (Total Crossing Distance / 3.5) - Yellow

FDW = (Longest Distance to Median Button / 3.5) - Yellow
Use Total distance / 3.5 - Yellow if no median button

Walk = Total Ped Time - FDW
Use 6 seconds if no median button.

Source: City of Grand Forks and Alliant Engineering, Inc.

No median buttons

LEGEND

a = distance from curb to curb
b = greater distance from curb to median
c = distance from stop bar to center of furthest traveled lane

No median buttons

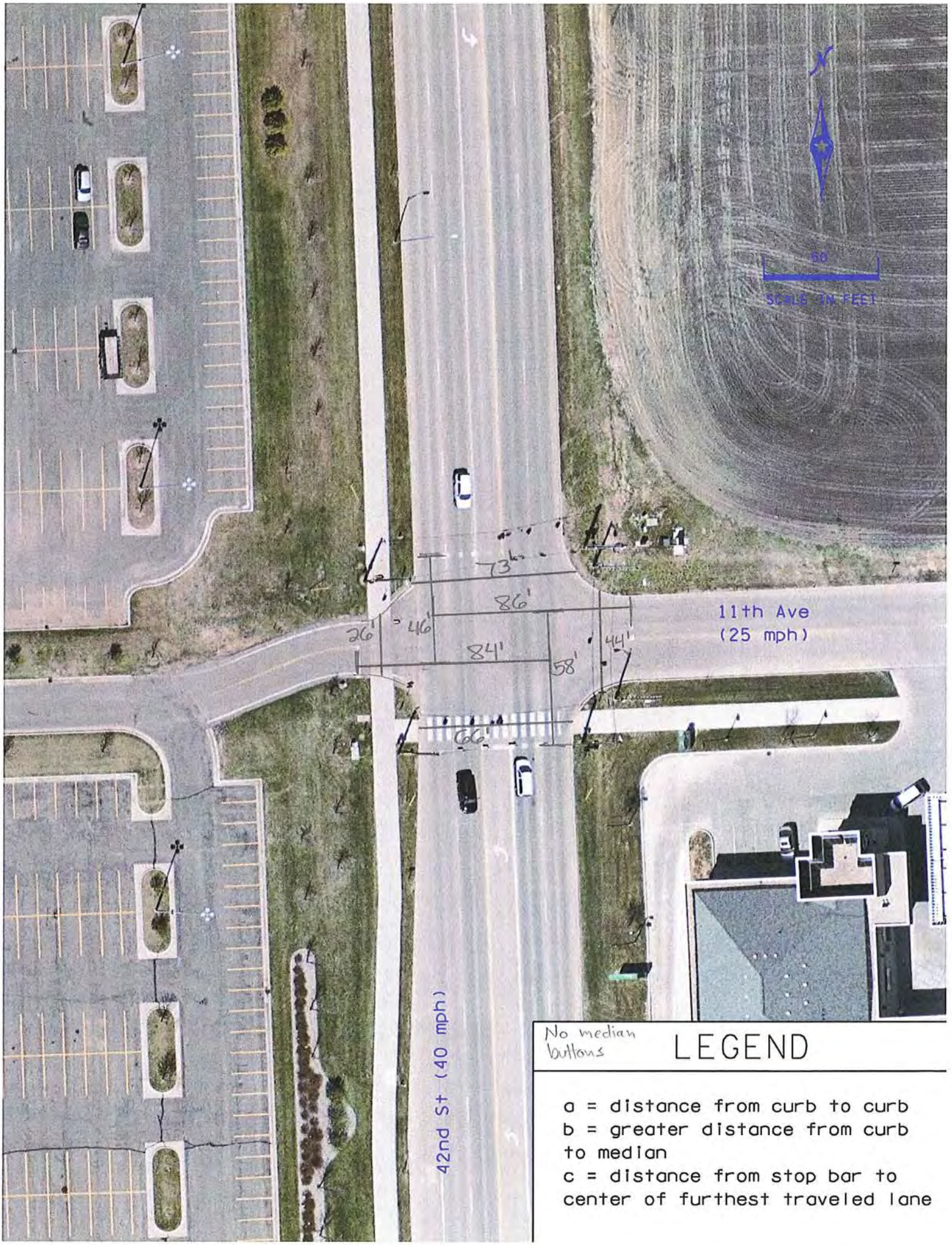
LEGEND

a = distance from curb to curb
b = greater distance from curb to median
c = distance from stop bar to center of furthest traveled lane

No median buttons

LEGEND

a = distance from curb to curb
b = greater distance from curb to median
c = distance from stop bar to center of furthest traveled lane



No median buttons

LEGEND

a = distance from curb to curb
b = greater distance from curb to median
c = distance from stop bar to center of furthest traveled lane

No median buttons

LEGEND

a = distance from curb to curb
b = greater distance from curb to median
c = distance from stop bar to center of furthest traveled lane

Appendix B:
Final Signal Timing Charts by Intersection

Zone 1 - Columbia Road (28th Avenue to 6th Avenue)

Revised: December 28, 2010

Columbia Road at 28th Avenue (407

Plan Identification	System ID	Split 1 (Sec)	Split 2 (Sec)	Split 3 (Sec)	Split 4 (Sec)	Split 5 (Sec)	Split 6 (Sec)	Split 7 (Sec)	Split 8 (Sec)	Cycle Length (s)	Offset (Sec)	Leading Phase	Coordinated Phase	Phase Sequence	Phase Timing	Notes
Plan 1	407	12	48	0	20	12	48	0	20	80	70	15	26+	1	1	Omit Phase 3 and 7
Plan 2	407	12	43	0	25	12	43	0	25	80	14	15	26+	1	1	Omit Phase 3 and 7
Plan 3	407	13	56	13	18	13	56	13	18	100	33	1357	26+	1	1	
Plan 4	407	13	76	13	18	20	69	13	18	120	14	1357	26+	1	1	
Plan 5	407	11	68	11	20	11	68	11	20	110	95	1357	26+	1	1	
Plan 6	407	20	45	20	25	15	50	20	25	110	95	1357	26+	1	1	
Pattern 120	407	20	35	20	25	20	35	20	25	100	--					
Plan 21	407	12	48	0	20	12	48	0	20	80	79	15	26+	1	1	Omit Phase 3 and 7
Plan 23	407	13	56	13	18	13	56	13	18	100	21	1357	26+	1	1	
Plan 24	407	30	59	13	18	15	74	13	18	120	108	1357	26+	1	1	
Plan 25	407	30	52	13	25	20	62	13	25	120	1	1357	26+	1	1	
Plan 31	407	29.2	51	0	31.5	29.2	51	0	36.5	0	0	15	0	1	1	Free
Min Split	**407**	**11.0**	**29.0**	**11.0**	**16.0**	**11.0**	**21.0**	**11.0**	**16.0**							
Max Initial Check	**407**	**15.0**	**21.0**	**15.0**	**16.5**	**15.0**	**21.0**	**15.0**	**16.5**							

Columbia Road at 24th Avenue (409

Plan Identification	System ID	Split 1 (Sec)	Split 2 (Sec)	Split 3 (Sec)	Split 4 (Sec)	Split 5 (Sec)	Split 6 (Sec)	Split 7 (Sec)	Split 8 (Sec)	Cycle Length (s)	Offset (Sec)	Leading Phase	Coordinated Phase	Phase Sequence	Phase Timing	Notes
Plan 1	409	11	37	13	19	12	36	13	19	80	33	1357	26+	1	1	
Plan 2	409	12	37	12	19	15	34	12	19	80	48	1357	26+	1	1	
Plan 3	409	15	50	15	20	13	52	15	20	100	6	1357	26+	1	1	
Plan 4	409	20	59	15	26	12	67	23	18	120	9	1357	26+	1	1	
Plan 5	409	18	56	15	21	12	62	15	21	110	97	1357	26+	1	1	
Plan 6	409	13	52	15	20	13	52	15	20	100	1	1357	26+	1	1	
Pattern 120	409	25	35	20	25	25	35	20	25	105	--					
Plan 21	409	15	52	15	38	13	54	23	30	120	109	1357	26+	1	1	
Plan 23	409	15	48	15	22	13	50	15	22	100	75	1357	26+	1	1	
Plan 24	409	20	54	16	30	15	59	24	22	120	62	1357	26+	1	1	
Plan 25	409	20	59	13	28	15	64	19	22	120	52	1357	26+	1	1	
Plan 31	409	22	31.4	24	26.5	22	31.4	19	26.5	0	0	1357	0	1	1	Free
Min Split	**409**	**11.0**	**24.0**	**11.0**	**16.0**	**11.0**	**28.0**	**11.0**	**16.0**							
Max Initial Check	**409**	**14.0**	**23.0**	**14.0**	**21.5**	**14.0**	**23.0**	**14.0**	**21.5**							

Columbia Road at 17th Avenue (411

Plan Identification	System ID	Split 1 (Sec)	Split 2 (Sec)	Split 3 (Sec)	Split 4 (Sec)	Split 5 (Sec)	Split 6 (Sec)	Split 7 (Sec)	Split 8 (Sec)	Cycle Length (s)	Offset (Sec)	Leading Phase	Coordinated Phase	Phase Sequence	Phase Timing	Notes
Plan 1	411	18	59	21	22	11	66	9	34	120	40	1357	26+	1	1	
Plan 2	411	11	39	11	19	11	39	11	19	80	4	1357	26+	1	1	
Plan 3	411	13	54	13	20	13	54	13	20	100	50	1357	26+	1	1	
Plan 4	411	15	63	13	29	11	67	16	26	120	78	1357	26+	1	1	
Plan 5	411	12	57	15	26	12	57	15	26	110	52	1357	26+	1	1	
Plan 6	411	13	54	13	20	13	54	13	20	100	45	1357	26+	1	1	
Pattern 120	411	20	35	20	25	20	35	20	25	100	--					
Plan 21	411	18	59	21	22	15	62	10	33	120	47	1357	26+	1	1	
Plan 23	411	13	44	18	25	13	44	18	25	100	6	1357	26+	1	1	
Plan 24	411	15	60	16	29	11	64	16	29	120	110	1357	26+	1	1	
Plan 25	411	15	60	16	29	15	60	16	29	120	117	1357	26+	1	1	
Plan 31	411	44	39.9	39	29.7	34	44.9	34	29.7	0	0	1357	0	1	1	Free
Min Split	**411**	**10.5**	**23.5**	**10.5**	**15.5**	**10.5**	**24.5**	**10.5**	**15.5**							
Max Initial Check	**411**	**15.0**	**25.5**	**15.0**	**20.5**	**15.0**	**25.5**	**15.0**	**20.5**							

Columbia Road at 13th Avenue (413

Plan Identification	System ID	Split 1 (Sec)	Split 2 (Sec)	Split 3 (Sec)	Split 4 (Sec)	Split 5 (Sec)	Split 6 (Sec)	Split 7 (Sec)	Split 8 (Sec)	Cycle Length (s)	Offset (Sec)	Leading Phase	Coordinated Phase	Phase Sequence	Phase Timing	Notes
Plan 1	413	12	78	12	18	12	78	12	18	120	65	1357	26+	1	1	
Plan 2	413	12	35	0	33	12	35	0	33	80	56	15	26+	1	1	Omit Phase 3 and 7
Plan 3	413	13	54	0	33	13	54	0	33	100	25	15	26+	1	1	Omit Phase 3 and 7
Plan 4	413	21	62	17	20	13	70	17	20	120	39	1357	26+	1	1	
Plan 5	413	15	57	15	23	15	57	20	18	110	20	1357	26+	1	1	
Plan 6	413	13	54	0	33	13	54	0	33	100	25	15	26+	1	1	Omit Phase 3 and 7
Plan 11	413	0	30	0	20	0	30	0	20	50	33	0	26+	1	1	Omit Phase 1,5, 3 and 7
Pattern 120	413	20	35	20	25	20	35	20	25	100	--					
Plan 21	413	12	75	12	21	12	75	15	18	120	93	1357	26+	1	1	
Plan 23	413	13	54	0	33	13	54	0	33	100	57	15	26+	1	1	Omit Phase 3 and 7
Plan 24	413	21	62	17	20	13	70	15	22	120	51	1357	26+	1	1	
Plan 25	413	20	54	13	33	13	61	13	33	120	53	1357	26+	1	1	
Plan 31	413	0	30	0	20	0	30	0	20	50	33	0	26+	1	1	Omit Phase 1, 3, 5, 7
Min Split	**413**	**10.5**	**26.5**	**10.5**	**15.5**	**10.5**	**25.5**	**10.5**	**15.5**							
Max Initial Check	**413**	**15.0**	**25.5**	**15.0**	**21.0**	**15.0**	**25.5**	**15.0**	**21.0**							

Zone 1 - Columbia Road (28th Avenue to 6th Avenue)

Revised: December 28, 2010

Columbia Road at 11th Avenue (415

Plan Identification	System ID	Split 1 (Sec)	Split 2 (Sec)	Split 3 (Sec)	Split 4 (Sec)	Split 5 (Sec)	Split 6 (Sec)	Split 7 (Sec)	Split 8 (Sec)	Cycle Length (s)	Offset (Sec)	Leading Phase	Coordinated Phase	Phase Sequence	Phase Timing	Notes
Plan 1	415	12	74	0	34	18	68	0	34	120	77	15	26+	1	1	
Plan 2	415	16	42	0	**22**	12	46	0	**22**	80	42	15	26+	1	1	
Plan 3	415	20	57	0	**23**	13	64	0	**23**	100	23	15	26+	1	1	
Plan 4	415	12	74	0	34	12	74	0	34	120	37	15	26+	1	1	
Plan 5	415	16	64	0	**30**	16	64	0	**30**	110	16	15	26+	1	1	
Plan 6	415	20	57	0	**23**	13	64	0	**23**	100	23	15	26+	1	1	
Plan 11	415	0	30	0	**20**	0	30	0	**20**	50	34	0	26+	1	1	Omit Phase 1 and 5
Pattern 120	415	0	0	0	**0**	0	0	0	**0**	0	--					
Plan 21	415	12	74	0	**34**	18	68	0	**34**	120	105	15	26+	1	1	
Plan 23	415	20	57	0	**23**	13	64	0	**23**	100	53	15	26+	1	1	
Plan 24	415	12	74	0	**34**	12	74	0	**34**	120	52	15	26+	1	1	
Plan 25	415	12	74	0	**34**	12	74	0	**34**	120	57	15	26+	1	1	
Plan 31	415	0	30	0	**20**	0	30	0	**20**	50	9	0	26+	1	1	Omit Phase 1 and 5
Min Split	**415**	**10.5**	**20.5**	**5.5**	**15.5**	**10.5**	**26.5**	**5.5**	**15.5**							
Max Initial Check	**415**	**15.0**	**15.5**	**0.0**	**16.0**	**13.0**	**15.5**	**0.0**	**16.0**							

Columbia Road at 2nd Avenue (417

Plan Identification	System ID	Split 1 (Sec)	Split 2 (Sec)	Split 3 (Sec)	Split 4 (Sec)	Split 5 (Sec)	Split 6 (Sec)	Split 7 (Sec)	Split 8 (Sec)	Cycle Length (s)	Offset (Sec)	Leading Phase	Coordinated Phase	Phase Sequence	Phase Timing	Notes
Plan 1	417	12	73	0	35	33	52	0	35	120	11	15	26+	1	1	
Plan 2	417	13	33	0	34	18	28	0	34	80	48	15	26+	1	1	
Plan 3	417	12	48	0	40	12	48	0	40	100	94	15	26+	1	1	
Plan 4	417	12	63	0	45	12	63	0	45	120	100	15	26+	1	1	
Plan 5	417	13	52	0	45	13	52	0	45	110	79	15	26+	1	1	
Plan 6	417	12	48	0	40	12	48	0	40	100	93	15	26+	1	1	
Plan 7 (EVENT OB)	417	13	72	0	55	0	85	0	55	140	103	1	26+	1	1	Omit Phase 5
Plan 8 (EVENT IB)	417	20	86	0	34	30	76	0	34	140	83	15	26+	1	1	
Plan 11	417	0	30	0	20	0	30	0	20	50	0	0	26+	1	1	Omit Phase 5
Pattern 120	417	20	40	0	35	20	40	0	35	95	--					
Plan 21	417	12	73	0	**35**	33	52	0	**35**	120	91	15	26+	1	1	
Plan 23	417	12	48	0	**40**	12	48	0	**40**	100	72	15	26+	1	1	
Plan 24	417	12	63	0	**45**	12	63	0	**45**	120	62	15	26+	1	1	
Plan 25	417	12	63	0	**45**	12	63	0	**45**	120	53	15	26+	1	1	
Plan 31	417	0	30	0	**20**	0	30	0	**20**	50	0	0	26+	1	1	Omit Phase 1 and 5
Min Split	**417**	**10.5**	**21.5**	**5.5**	**15.5**	**10.5**	**21.5**	**5.5**	**15.5**							
Max Initial Check	**417**	**13.0**	**15.5**	**0.0**	**16.0**	**13.0**	**15.5**	**0.0**	**16.0**							

Columbia Road at University Avenue (418

Plan Identification	System ID	Split 1 (Sec)	Split 2 (Sec)	Split 3 (Sec)	Split 4 (Sec)	Split 5 (Sec)	Split 6 (Sec)	Split 7 (Sec)	Split 8 (Sec)	Cycle Length (s)	Offset (Sec)	Leading Phase	Coordinated Phase	Phase Sequence	Phase Timing	Notes
Plan 1	418	12	60	15	33	25	47	12	36	120	26	1357	26+	1	1	
Plan 2	418	12	35	0	33	12	35	0	33	80	48	15	26+	1	1	Omit Phase 3 and 7
Plan 3	418	13	42	12	33	17	38	12	33	100	96	1357	26+	1	1	
Plan 4	418	15	56	17	32	18	53	13	36	120	100	1357	26+	1	1	
Plan 5	418	15	49	14	32	18	46	13	33	110	89	1357	26+	1	1	
Plan 6	418	11	45	11	33	17	39	11	33	100	96	1357	26+	1	1	
Plan 7 (EVENT OB)	418	13	65	17	45	13	65	17	45	140	119	1357	26+	1	1	
Plan 8 (EVENT IB)	418	15	79	13	33	25	69	13	33	140	80	1357	26+	1	1	
Plan 11	418	0	30	0	20	0	30	0	20	50	1	0	26+	1	1	Omit Phase 1,5, 3 and 7
Pattern 120	418	20	35	20	25	20	35	20	25	100	--					
Plan 21	418	12	60	15	**33**	25	47	12	**36**	120	107	1357	26+	1	1	
Plan 23	418	13	42	12	**33**	17	38	12	**33**	100	76	1357	26+	1	1	
Plan 24	418	15	54	15	**36**	18	51	15	**36**	120	64	1357	26+	1	1	
Plan 25	418	15	54	15	**36**	18	51	15	**36**	120	57	1357	26+	1	1	
Plan 31	418	0	30	0	**20**	0	30	0	**20**	50	1	0	26+	1	1	Omit Phase 1,5, 3 and 7
Min Split	**418**	**11.0**	**32.0**	**11.0**	**16.0**	**11.0**	**33.0**	**11.0**	**16.0**							
Max Initial Check	**418**	**14.0**	**21.0**	**14.0**	**19.0**	**14.0**	**21.0**	**14.5**	**19.0**							

Columbia Road at 6th Avenue (420

Plan Identification	System ID	Split 1 (Sec)	Split 2 (Sec)	Split 3 (Sec)	Split 4 (Sec)	Split 5 (Sec)	Split 6 (Sec)	Split 7 (Sec)	Split 8 (Sec)	Cycle Length (s)	Offset (Sec)	Leading Phase	Coordinated Phase	Phase Sequence	Phase Timing	Notes
Plan 1	420	0	91	0	29	15	76	0	29	120	11	5	26+	1	1	
Plan 2	420	0	51	0	29	20	31	0	29	80	0	5	26+	1	1	
Plan 3	420	0	71	0	29	41	30	0	29	100	85	5	26+	1	1	
Plan 4	420	0	91	0	29	20	71	0	29	120	75	5	26+	1	1	
Plan 5	420	0	75	0	35	20	55	0	35	110	76	5	26+	1	1	
Plan 6	420	0	71	0	29	15	56	0	29	100	86	5	26+	1	1	
Plan 7 (EVENT OB)	420	0	35	0	**105**	0	35	0	**105**	140	18	0	26+	1	1	Omit Phase 5
Plan 8 (EVENT IB)	420	0	110	0	**30**	75	35	0	**30**	140	76	5	26+	1	1	
Pattern 120	420	0	60	0	**35**	20	40	0	**35**	95	--					
Plan 21	420	0	91	0	**29**	13	78	0	**29**	120	98	5	26+	1	1	
Plan 23	420	0	71	0	**29**	41	30	0	**29**	100	8	5	26+	1	1	
Plan 24	420	0	91	0	**29**	15	76	0	**29**	120	44	5	26+	1	1	
Plan 25	420	0	91	0	**29**	15	76	0	**29**	120	34	5	26+	1	1	
Plan 31	420	0	60.1	0	**39.7**	29.5	60.1	0	**39.7**	0	0	5	0	1	1	Free
Min Split	**420**	**5.5**	**20.5**	**5.5**	**15.5**	**10.5**	**26.5**	**5.5**	**15.5**							
Max Initial Check	**420**	**0.0**	**23.5**	**0.0**	**15.5**	**13.0**	**30.5**	**0.0**	**15.5**							

Zone 2 - Washington Street (5th Avenue to 32nd Avenue)

Revised: December 28, 2010

9. Washington Street at 28th Avenue S

Plan Identification	System ID	Split 1 (Sec)	Split 2 (Sec)	Split 3 (Sec)	Split 4 (Sec)	Split 5 (Sec)	Split 6 (Sec)	Split 7 (Sec)	Split 8 (Sec)	Cycle Length (s)	Offset (Sec)	Leading Phase	Coordinated Phase	COS (STD)	Cycle Pattern	Split Pattern	Action Plan	Sequence	Timing Plan	Notes
Plan 1	9	20	69	0	21	18	71	0	21	110	16	16	26+	111	1	1	1	5	1	
Plan 2	9	20	45	0	25	17	48	0	25	90	45	25	26+	211	2	2	2	2	1	
Plan 3	9	20	61	0	19	13	68	0	19	100	92	16	26+	311	3	3	3	5	1	
Plan 4	9	19	73	0	38	17	75	0	38	130	15	26	26+	411	4	4	4	6	1	
Plan 5	9	20	66	0	34	18	68	0	34	120	91	16	26+	511	5	5	5	5	1	
Plan 6	9	23	62	0	25	23	62	0	25	110	70	16	26+	611	6	6	6	5	1	
Plan 21	9	21	66	0	23	20	67	0	23	110	28	16	26+	221	21	21	21	5	1	
Plan 23	9	25	56	0	19	22	59	0	19	100	17	16	26+	223	23	23	23	5	1	
Plan 24	9	22	70	0	38	17	75	0	38	130	120	25	26+	224	24	24	24	2	1	
Plan 25	9	24	62	0	34	18	68	0	34	120	84	25	26+	232	25	25	25	2	1	
Min Split -- PED	**9**	**12.0**	**27.0**	**0.0**	**28.5**	**12.0**	**28.0**	**0.0**	**27.0**											DE 4/8, No BU Prot
Max Initial Check	**9**	**13.0**	**35.0**		**18.5**	**13.0**	**35.0**		**18.0**											Lock det
Min Split -- COORD	**9**	**13.0**	**21.0**	**6.0**	**16.0**	**13.0**	**21.0**	**6.0**	**16.0**											

10. Washington Street at DeMers Avenue

Plan Identification	System ID	Split 1 (Sec)	Split 2 (Sec)	Split 3 (Sec)	Split 4 (Sec)	Split 5 (Sec)	Split 6 (Sec)	Split 7 (Sec)	Split 8 (Sec)	Cycle Length (s)	Offset (Sec)	Leading Phase	Coordinated Phase	COS (STD)	Cycle Pattern	Split Pattern	Action Plan	Sequence	Timing Plan	Notes
Plan 1	10	20	38	15	37	13	45	22	30	110	81	1357	26+	111	1	1	1	1	1	
Plan 2	10	13	35	15	27	13	35	20	22	90	68	1358	26+	211	2	2	2	9	1	
Plan 3	10	13	40	20	27	13	40	23	24	100	64	1358	26+	311	3	3	3	9	1	
Plan 4	10	11	52	23	44	20	43	28	39	130	115	1358	26+	411	4	4	4	9	1	
Plan 5	10	15	49	21	35	15	49	28	28	120	71	1358	26+	511	5	5	5	9	1	
Plan 6	10	13	50	17	30	13	50	24	23	110	107	1357	26+	611	6	6	6	1	1	
Pattern 120	10	20	35	20	25	20	35	20	25	100	--			122						
Plan 21	10	20	38	15	37	13	45	22	30	110	30	1358	26+	221	21	21	21	9	1	
Plan 23	10	13	40	20	27	13	40	23	24	100	41	1358	26+	223	23	23	23	9	1	
Plan 24	10	13	50	23	44	20	43	28	39	130	14	1358	26+	224	24	24	24	9	1	
Plan 25	10	15	49	21	35	15	49	28	28	120	83	1357	26+	232	25	25	25	1	1	
Min Split -- PED	**10**	**10.0**	**32.0**	**12.0**	**27.5**	**10.0**	**33.0**	**12.0**	**25.5**											No DE, BU Prot 1/5
Max Initial Check	**10**	**15.0**	**21.0**	**15.0**	**15.5**	**15.0**	**21.0**	**15.0**	**15.5**											Lock EB/WB
Min Split -- COORD	**10**	**11.0**	**21.0**	**13.0**	**16.0**	**11.0**	**21.0**	**13.0**	**16.0**											

11. Washington Street at 13th Avenue S

Plan Identification	System ID	Split 1 (Sec)	Split 2 (Sec)	Split 3 (Sec)	Split 4 (Sec)	Split 5 (Sec)	Split 6 (Sec)	Split 7 (Sec)	Split 8 (Sec)	Cycle Length (s)	Offset (Sec)	Leading Phase	Coordinated Phase	COS (STD)	Cycle Pattern	Split Pattern	Action Plan	Sequence	Timing Plan	Notes
Plan 1	11	11	52	15	32	11	52	16	31	110	41	1357	26+	111	1	1	1	1	1	
Plan 2	11	13	46	13	18	13	46	13	18	90	19	1357	26+	211	2	2	2	1	1	
Plan 3	11	11	56	13	20	11	56	13	20	100	98	1357	26+	311	3	3	3	1	1	
Plan 4	11	11	84	11	24	11	84	11	24	130	7	1357	26+	411	4	4	4	1	1	
Plan 5	11	11	74	11	24	11	74	11	24	120	94	1357	26+	511	5	5	5	1	1	
Plan 6	11	11	66	11	22	11	66	11	22	110	65	1357	26+	611	6	6	6	1	1	
Pattern 120	11	20	35	20	25	20	35	20	25	100	--			122						
Plan 21	11	11	52	15	32	11	52	16	31	110	94	1357	26+	221	21	21	21	1	1	
Plan 23	11	11	55	13	21	11	55	13	21	100	89	1357	26+	223	23	23	23	1	1	
Plan 24	11	11	84	11	24	11	84	11	24	130	55	1357	26+	224	24	24	24	1	1	
Plan 25	11	11	74	11	24	11	74	11	24	120	44	1357	26+	232	25	25	25	1	1	
Min Split -- PED	**11**	**10.0**	**26.5**	**10.0**	**28.5**	**10.0**	**24.5**	**10.0**	**28.5**											DE 4/8, BU Prot All
Max Initial Check	**11**	**15.0**	**20.5**	**17.0**	**25.5**	**15.0**	**20.5**	**17.0**	**25.5**											Non lock
Min Split -- COORD	**11**	**10.5**	**20.5**	**10.5**	**15.5**	**10.5**	**20.5**	**10.5**	**15.5**											

12. Washington Street at 17th Avenue S

Plan Identification	System ID	Split 1 (Sec)	Split 2 (Sec)	Split 3 (Sec)	Split 4 (Sec)	Split 5 (Sec)	Split 6 (Sec)	Split 7 (Sec)	Split 8 (Sec)	Cycle Length (s)	Offset (Sec)	Leading Phase	Coordinated Phase	COS (STD)	Cycle Pattern	Split Pattern	Action Plan	Sequence	Timing Plan	Notes
Plan 1	12	15	51	14	30	17	49	16	28	110	91	1357	26+	111	1	1	1	1	1	
Plan 2	12	15	40	11	24	15	40	15	20	90	51	2357	26+	211	2	2	2	2	1	
Plan 3	12	15	45	15	25	15	45	18	22	100	37	2357	26+	311	3	3	3	2	1	
Plan 4	12	20	63	17	30	20	63	20	27	130	73	2357	26+	411	4	4	4	2	1	
Plan 5	12	17	65	11	27	17	65	15	23	120	29	2357	26+	511	5	5	5	2	1	
Plan 6	12	15	56	16	23	15	56	16	23	110	11	2357	26+	611	6	6	6	2	1	
Pattern 120	12	20	35	20	25	20	35	20	25	100	--			122						
Plan 21	12	17	52	13	28	18	51	15	26	110	24	1367	26+	221	21	21	21	5	1	
Plan 23	12	15	45	15	25	19	41	15	25	100	27	1367	26+	223	23	23	23	5	1	
Plan 24	12	20	60	16	34	20	60	20	30	130	4	1357	26+	224	24	24	24	1	1	
Plan 25	12	17	65	11	27	17	65	15	23	120	86	2357	26+	232	25	25	25	2	1	
Min Split -- PED	**12**	**10.0**	**36.5**	**10.0**	**44.5**	**10.0**	**35.5**	**10.0**	**43.5**											DE 4/8, BU Prot all
Max Initial Check	**12**	**15.0**	**21.5**	**20.0**	**16.5**	**15.0**	**21.5**	**15.0**	**21.5**											Non Lock
Min Split -- COORD	**12**	**11.5**	**21.5**	**11.5**	**16.5**	**11.5**	**21.5**	**11.5**	**16.5**											

Zone 2 - Washington Street (5th Avenue to 32nd Avenue)

Revised: December 28, 2010

13. Washington Street at 24th Avenue S

Plan Identification	System ID	Split 1 (Sec)	Split 2 (Sec)	Split 3 (Sec)	Split 4 (Sec)	Split 5 (Sec)	Split 6 (Sec)	Split 7 (Sec)	Split 8 (Sec)	Cycle Length (s)	Offset (Sec)	Leading Phase	Coordinated Phase	COS (STD)	Cycle Pattern	Split Pattern	Action Plan	Sequence	Timing Plan	Notes
Plan 1	13	20	57	13	20	20	57	13	20	110	25	2357	26+	111	1	1	1	2	1	
Plan 2	13	15	44	13	18	15	44	13	18	90	12	1357	26+	211	2	2	2	1	1	
Plan 3	13	15	54	13	18	15	54	13	18	100	92	2357	26+	311	3	3	3	2	1	
Plan 4	13	27	67	13	23	25	69	15	21	130	129	2357	26+	411	4	4	4	2	1	
Plan 5	13	23	63	13	21	20	66	15	19	120	85	2357	26+	511	5	5	5	2	1	
Plan 6	13	15	64	13	18	17	62	13	18	110	64	2357	26+	611	6	6	6	2	1	
Plan 21	13	23	51	13	23	20	54	13	23	110	40	2357	26+	221	21	21	21	2	1	
Plan 23	13	15	54	13	18	15	54	13	18	100	21	2357	26+	223	23	23	23	2	1	
Plan 24	13	27	65	15	23	24	68	15	23	130	73	1357	26+	224	24	24	24	1	1	
Plan 25	13	23	63	13	21	20	66	15	19	120	34	1357	26+	232	25	25	25	1	1	
Min Split -- PED	**13**	**12.0**	**35.5**	**10.0**	**33.5**	**12.0**	**33.5**	**10.0**	**33.5**											DE 4/8, BU Prot 3/7
Max Initial Check	**13**	**15.0**	**21.5**	**15.0**	**16.5**	**15.0**	**21.5**	**15.0**	**16.5**											Lock 1/5
Min Split -- COORD	**13**	**13.5**	**21.5**	**13.5**	**16.5**	**13.5**	**21.5**	**13.5**	**16.5**											

14. Washington Street at 32nd Avenue S

Plan Identification	System ID	Split 1 (Sec)	Split 2 (Sec)	Split 3 (Sec)	Split 4 (Sec)	Split 5 (Sec)	Split 6 (Sec)	Split 7 (Sec)	Split 8 (Sec)	Cycle Length (s)	Offset (Sec)	Leading Phase	Coordinated Phase	COS (STD)	Cycle Pattern	Split Pattern	Action Plan	Sequence	Timing Plan	Notes
Plan 1	14	21	32	18	39	19	34	18	39	110	94	2357	26+	111	1	1	1	2	1	
Plan 2	14	17	25	15	33	17	25	19	29	90	71	2368	26+	211	2	2	2	14	1	
Plan 3	14	17	37	15	31	20	34	24	22	100	51	2457	26+	311	3	3	3	4	1	
Plan 4	14	18	52	15	45	30	40	28	32	130	21	1367	26+	411	4	4	4	13	1	
Plan 5	14	18	52	15	35	28	42	24	26	120	101	1368	26+	511	5	5	5	13	1	
Plan 6	14	18	35	15	42	18	35	30	27	110	77	1368	26+	611	6	6	6	13	1	
Plan 21	14	21	32	18	39	19	34	18	39	110	0	2368	26+	221	21	21	21	14	1	
Plan 23	14	19	29	17	35	19	29	23	29	100	2	2368	26+	223	23	23	23	14	1	
Plan 24	14	20	45	20	45	30	35	33	32	130	14	1368	26+	224	24	24	24	13	1	
Plan 25	14	20	35	21	44	25	30	33	32	120	112	1368	26+	232	25	25	25	13	1	
Min Split -- PED	**14**	**12.0**	**23.0**	**12.0**	**36.5**	**12.0**	**23.5**	**12.0**	**30.5**											No DE, No BU Prot
Max Initial Check	**14**	**15.0**	**21.0**	**13.0**	**16.5**	**13.0**	**20.5**	**18.0**	**18.5**											Lock det
Min Split -- COORD	**14**	**13.0**	**21.0**	**13.0**	**16.0**	**13.0**	**21.0**	**13.0**	**16.0**											

34. Washington Street at Campbell Drive

Plan Identification	System ID	Split 1 (Sec)	Split 2 (Sec)	Split 3 (Sec)	Split 4 (Sec)	Split 5 (Sec)	Split 6 (Sec)	Split 7 (Sec)	Split 8 (Sec)	Cycle Length (s)	Offset (Sec)	Leading Phase	Coordinated Phase	COS (STD)	Cycle Pattern	Split Pattern	Action Plan	Sequence	Timing Plan	Notes
Plan 1	34	0	88	0	22	0	88	0	22	110	78	0	26+	111	1	1	1	1	1	
Plan 2	34	0	72	0	18	0	72	0	18	90	41	0	26+	211	2	2	2	1	1	
Plan 3	34	0	80	0	20	0	80	0	20	100	29	0	26+	311	3	3	3	1	1	
Plan 4	34	0	106	0	24	0	106	0	24	130	54	0	26+	411	4	4	4	1	1	
Plan 5	34	0	92	0	28	0	92	0	28	120	20	0	26+	511	5	5	5	1	1	
Plan 6	34	0	89	0	21	0	89	0	21	110	2	0	26+	611	6	6	6	1	1	
Pattern 120	34	0	40	0	30	0	40	0	30	70	--			122						
Plan 21	34	0	88	0	22	0	88	0	22	110	70	0	26+	221	21	21	21	1	1	
Plan 23	34	0	80	0	20	0	80	0	20	100	57	0	26+	223	23	23	23	1	1	
Plan 24	34	0	108	0	22	0	108	0	22	130	114	0	26+	224	24	24	24	1	1	
Plan 25	34	0	92	0	28	0	92	0	28	120	84	0	26+	232	25	25	25	1	1	
Min Split -- PED	**34**	**10.0**	**25.0**	**0.0**	**33.0**	**10.0**	**25.0**	**0.0**	**33.0**											DE 4/8, BU Prot 1/5
Max Initial Check	**34**	**15.0**	**21.0**	**10.0**	**16.0**	**15.0**	**21.0**	**10.0**	**16.0**											Non-lock
Min Split -- COORD	**34**	**11.0**	**21.0**	**6.0**	**16.0**	**11.0**	**21.0**	**6.0**	**16.0**											

110. Washington Street at University Avenue

Plan Identification	System ID	Split 1 (Sec)	Split 2 (Sec)	Split 3 (Sec)	Split 4 (Sec)	Split 5 (Sec)	Split 6 (Sec)	Split 7 (Sec)	Split 8 (Sec)	Cycle Length (s)	Offset (Sec)	Leading Phase	Coordinated Phase	COS (STD)	Cycle Pattern	Split Pattern	Action Plan	Sequence	Timing Plan	Notes
Plan 1	110	29	36	15	30	0	65	0	45	110	11	13	26+	111	1	1	1	1	1	
Plan 2	110	13	44	13	20	0	57	0	33	90	16	13	26+	211	2	2	2	1	1	
Plan 3	110	15	50	13	22	0	65	0	35	100	1	13	26+	311	3	3	3	1	1	
Plan 4	110	20	63	17	30	0	83	0	47	130	30	13	26+	411	4	4	4	1	1	
Plan 5	110	15	67	13	25	0	82	0	38	120	109	13	26+	511	5	5	5	1	1	
Plan 6	110	15	61	13	21	0	76	0	34	110	36	13	26+	611	6	6	6	1	1	
Pattern 120	110	20	35	20	25	0	75	0	25	100	--			122						
Plan 21	110	20	45	13	32	0	65	0	45	110	71	13	26+	221	21	21	21	1	1	
Plan 23	110	13	51	13	23	0	64	0	36	100	73	13	26+	223	23	23	23	1	1	
Plan 24	110	15	67	15	33	0	82	0	48	130	71	13	26+	224	24	24	24	1	1	
Plan 25	110	15	62	13	30	0	77	0	43	120	17	13	26+	232	25	25	25	1	1	
Min Split -- PED	**110**	**10.0**	**29.5**	**10.0**	**27.5**	**0.0**	**29.5**	**0.0**	**26.5**											DE 4/8, BU Prot 1, 3
Max Initial Check	**110**	**13.0**	**23.5**	**13.0**	**17.5**		**23.5**		**17.5**											Non-lock
Min Split -- COORD	**110**	**10.5**	**20.5**	**10.5**	**15.5**	**5.5**	**20.5**	**5.5**	**15.5**											

Zone 2 - Washington Street (5th Avenue to 32nd Avenue)

Revised: December 28, 2010

111. Washington Street at 2nd Avenue N

Plan Identification	System ID	Split 1 (Sec)	Split 2 (Sec)	Split 3 (Sec)	Split 4 (Sec)	Split 5 (Sec)	Split 6 (Sec)	Split 7 (Sec)	Split 8 (Sec)	Cycle Length (s)	Offset (Sec)	Leading Phase	Coordinated Phase	COS (STD)	Cycle Pattern	Split Pattern	Action Plan	Sequence	Timing Plan	Notes
Plan 1	111	0	81	0	29	25	56	0	29	110	10	5	26+	111	1	1	1	1	1	
Plan 2	111	0	70	0	20	13	57	0	20	90	11	5	26+	211	2	2	2	1	1	
Plan 3	111	0	71	0	29	13	58	0	29	100	2	5	26+	311	3	3	3	1	1	
Plan 4	111	0	108	0	22	20	88	0	22	130	20	5	26+	411	4	4	4	1	1	
Plan 5	111	0	91	0	29	13	78	0	29	120	109	5	26+	511	5	5	5	1	1	
Plan 6	111	0	88	0	22	13	75	0	22	110	31	5	26+	611	6	6	6	1	1	
Plan 21	111	0	81	0	29	25	56	0	29	110	78	5	26+	221	21	21	21	1	1	
Plan 23	111	0	71	0	29	13	58	0	29	100	77	5	26+	223	23	23	23	1	1	
Plan 24	111	0	108	0	22	20	88	0	22	130	55	5	26+	224	24	24	24	1	1	
Plan 25	111	0	91	0	29	13	78	0	29	120	10	5	26+	232	25	25	25	1	1	
Min Split -- PED	**111**	**0.0**	**25.5**	**0.0**	**27.5**	**10.0**	**25.5**	**0.0**	**28.5**											DE 4/8, BU Prot 5
Max Initial Check	**111**		**20.5**		**19.5**	**14.0**	**20.5**		**19.5**											Non-lock
Min Split -- COORD	**111**	**5.5**	**20.5**	**5.5**	**15.5**	**10.5**	**20.5**	**5.5**	**15.5**											

114. Washington Street at 5th Avenue N

Plan Identification	System ID	Split 1 (Sec)	Split 2 (Sec)	Split 3 (Sec)	Split 4 (Sec)	Split 5 (Sec)	Split 6 (Sec)	Split 7 (Sec)	Split 8 (Sec)	Cycle Length (s)	Offset (Sec)	Leading Phase	Coordinated Phase	COS (STD)	Cycle Pattern	Split Pattern	Action Plan	Sequence	Timing Plan	Notes
Plan 1	114	0	37	0	18	0	37	0	18	55	27	0	26+	111	1	1	1	1	1	
Plan 2	114	0	60	0	30	0	60	0	30	90	28	0	26+	211	2	2	2	1	1	
Plan 3	114	0	30	0	20	0	30	0	20	50	19	0	26+	311	3	3	3	1	1	
Plan 4	114	0	90	0	40	0	90	0	40	130	56	0	26+	411	4	4	4	1	1	
Plan 5	114	0	40	0	20	0	40	0	20	60	7	0	26+	511	5	5	5	1	1	
Plan 6	114	0	37	0	18	0	37	0	18	55	54	0	26+	611	6	6	6	1	1	
Pattern 120	114	0	35	0	30	0	35	0	30	65	--			122						
Plan 21	114	0	80	0	30	0	80	0	30	110	91	0	26+	221	21	21	21	1	1	
Plan 23	114	0	70	0	30	0	70	0	30	100	82	0	26+	223	23	23	23	1	1	
Plan 24	114	0	90	0	40	0	90	0	40	130	80	0	26+	224	24	24	24	1	1	
Plan 25	114	0	42	0	18	0	42	0	18	60	30	0	26+	232	25	25	25	1	1	
Min Split -- PED	**114**	**0.0**	**20.0**	**0.0**	**26.5**	**0.0**	**20.0**	**0.0**	**26.5**											DE 4/8, No BU Prot
Max Initial Check	**114**		**30.0**		**20.5**		**30.0**		**17.5**											Non-lock
Min Split -- COORD	**114**	**5.0**	**20.0**	**5.0**	**15.0**	**5.0**	**20.0**	**5.0**	**15.0**											

#	= High Priority Ped
#	= Change to Columbia/32nd Avenue

Zone 3 - Gateway Drive (47th Street to 3rd Street)

Revised: December 10, 2010

61. Gateway Drive at 3rd Street

Plan Identification	System ID	Split 1 (Sec)	Split 2 (Sec)	Split 3 (Sec)	Split 4 (Sec)	Split 5 (Sec)	Split 6 (Sec)	Split 7 (Sec)	Split 8 (Sec)	Cycle Length (s)	Offset (Sec)	Leading Phase	Coordinated Phase	COS (STD)	Cycle Pattern	Split Pattern	Action Plan	Sequence	Timing Plan	Notes
Plan 1	61	0	66	0	34	0	66	0	34	100	16	0	26+	111	1	1	1	1	1	
Plan 2	61	0	70	0	20	0	70	0	20	90	82	0	26+	211	2	2	2	1	1	
Plan 4	61	0	85	0	35	0	85	0	35	120	20	0	26+	411	4	4	4	1	1	
Plan 11	61	0	57	0	18	0	57	0	18	75	26	0	26+	133	11	11	11	1	1	
Plan 7 (EVENT OB)	61	0	85	0	35	0	85	0	35	120	20	0	26+	144	7	7	7	1	1	
Pattern 120	61	0	35	0	25	0	35	0	25	60	--			122						
Plan 21	61	0	76	0	34	0	76	0	34	110	20	0	26+	221	21	21	21	1	1	
Plan 22	61	0	70	0	20	0	70	0	20	90	37	0	26+	222	22	22	22	1	1	
Plan 24	61	0	97	0	23	0	97	0	23	120	6	0	26+	224	24	24	24	1	1	
Plan 31	61	0	57	0	18	0	57	0	18	75	4	0	26+	231	31	31	31	1	1	
Min Split -- PED	**61**	**0.0**	**23.5**	**0.0**	**34.0**	**0.0**	**21.5**	**0.0**	**32.0**											DE 4/8
Max Initial Check	**61**		**20.5**		**18.0**		**20.5**		**18.0**											
Min Split -- COORD	**61**		**20.5**		**15.5**		**20.5**		**15.5**											

62. Gateway Drive at 5th Street

Plan Identification	System ID	Split 1 (Sec)	Split 2 (Sec)	Split 3 (Sec)	Split 4 (Sec)	Split 5 (Sec)	Split 6 (Sec)	Split 7 (Sec)	Split 8 (Sec)	Cycle Length (s)	Offset (Sec)	Leading Phase	Coordinated Phase	COS (STD)	Cycle Pattern	Split Pattern	Action Plan	Sequence	Timing Plan	Notes
Plan 1	62	13	62	0	25	0	75	0	25	100	6	1	26+	111	1	1	1	1	1	
Plan 2	62	13	55	0	22	0	68	0	22	90	81	1	26+	211	2	2	2	1	1	
Plan 4	62	13	72	0	35	0	85	0	35	120	10	1	26+	411	4	4	4	1	1	
Plan 11	62	0	57	0	18	0	57	0	18	75	43	0	26+	133	11	11	11	1	1	Omit Phase 1
Plan 7 (EVENT OB)	62	13	72	0	35	0	85	0	35	120	10	1	26+	144	7	7	7	1	1	
Plan 21	62	13	72	0	25	0	85	0	25	110	2	1	26+	221	21	21	21	1	1	
Plan 22	62	13	55	0	22	0	68	0	22	90	39	1	26+	222	22	22	22	1	1	
Plan 24	62	13	72	0	35	0	85	0	35	120	6	1	26+	224	24	24	24	1	1	
Plan 31	62	0	57	0	18	0	57	0	18	75	31	0	26+	231	31	31	31	1	1	Omit Phase 1
Min Split -- PED	**62**	**10.0**	**20.5**	**0.0**	**16.0**	**0.0**	**21.0**	**0.0**	**16.5**											DE 4/8, NonLock 1, BU Protect 1
Max Initial Check	**62**	**15.0**	**20.5**		**19.0**		**21.0**		**21.5**											
Min Split -- COORD	**62**	**11.0**	**21.0**		**16.0**		**21.0**		**16.0**											

63. Gateway Drive at Washington Street

Plan Identification	System ID	Split 1 (Sec)	Split 2 (Sec)	Split 3 (Sec)	Split 4 (Sec)	Split 5 (Sec)	Split 6 (Sec)	Split 7 (Sec)	Split 8 (Sec)	Cycle Length (s)	Offset (Sec)	Leading Phase	Coordinated Phase	COS (STD)	Cycle Pattern	Split Pattern	Action Plan	Sequence	Timing Plan	Notes
Plan 1	63	18	41	19	22	22	37	22	19	100	0	1467	26+	111	1	1	1	7	1	
Plan 2	63	16	35	22	17	20	31	21	18	90	86	1467	26+	211	2	2	2	7	1	
Plan 4	63	15	61	26	18	29	47	23	21	120	20	2467	26+	411	4	4	4	8	1	
Plan 11	63	15	27	15	18	15	27	15	18	75	47	2457	26+	133	11	11	11	4	1	
Plan 7 (EVENT OB)	63	15	61	26	18	20	56	23	21	120	19	2467	26+	144	7	7	7	8	1	
Plan 21	63	18	50	21	21	29	39	21	21	110	8	1467	26+	221	21	21	21	7	1	
Plan 22	63	16	35	22	17	22	29	20	19	90	44	1467	26+	222	22	22	22	7	1	
Plan 24	63	20	55	26	19	27	48	23	22	120	8	1467	26+	224	24	24	24	7	1	
Plan 31	63	15	27	15	18	15	27	15	18	75	40	1467	26+	231	31	31	31	7	1	
Min Split -- PED	**63**	**12.0**	**21.5**	**12.0**	**16.5**	**12.0**	**21.5**	**12.0**	**16.5**											No DE, No BU Protect
Max Initial Check	**63**	**20.0**	**21.5**	**20.0**	**21.5**	**20.0**	**21.5**	**20.0**	**21.5**											Lock 3/7,
Min Split -- COORD	**63**	**13.5**	**21.5**	**13.5**	**16.5**	**13.5**	**21.5**	**13.5**	**16.5**											

64. Gateway Drive at 20th Street

Plan Identification	System ID	Split 1 (Sec)	Split 2 (Sec)	Split 3 (Sec)	Split 4 (Sec)	Split 5 (Sec)	Split 6 (Sec)	Split 7 (Sec)	Split 8 (Sec)	Cycle Length (s)	Offset (Sec)	Leading Phase	Coordinated Phase	COS (STD)	Cycle Pattern	Split Pattern	Action Plan	Sequence	Timing Plan	Notes
Plan 1	64	0	75	0	25	13	62	0	25	100	39	5	26+	111	1	1	1	1	1	
Plan 2	64	0	65	0	25	12	53	0	25	90	35	5	26+	211	2	2	2	1	1	
Plan 4	64	0	97	0	23	12	85	0	23	120	117	5	26+	411	4	4	4	1	1	
Plan 11	64	0	55	0	20	13	42	0	20	75	41	5	26+	133	11	11	11	1	1	
Plan 7 (EVENT OB)	64	0	100	0	20	12	88	0	20	120	107	5	26+	144	7	7	7	1	1	
Pattern 120	64	0	50	0	30	20	30	0	30	80	--			122						
Plan 21	64	0	82	0	28	13	69	0	28	110	57	5	26+	221	21	21	21	1	1	
Plan 22	64	0	60	0	30	12	48	0	30	90	82	5	26+	222	22	22	22	1	1	
Plan 24	64	0	90	0	30	12	78	0	30	120	56	5	26+	224	24	24	24	1	1	
Plan 31	64	0	55	0	20	13	42	0	20	75	0	5	26+	231	31	31	31	1	1	
Min Split -- PED	**64**	**0.0**	**20.5**	**0.0**	**26.0**	**10.0**	**22.5**	**0.0**	**26.5**											DE 4/8, BU Protect 1/5
Max Initial Check	**64**		**20.5**		**15.0**	**15.0**	**20.5**		**20.5**											Non Lock
Min Split -- COORD	**64**		**20.5**		**15.5**	**10.5**	**20.5**		**15.5**											

Zone 3 - Gateway Drive (47th Street to 3rd Street)

Revised: December 10, 2010

65. Gateway Drive at Columbia Road

Plan Identification	System ID	Split 1 (Sec)	Split 2 (Sec)	Split 3 (Sec)	Split 4 (Sec)	Split 5 (Sec)	Split 6 (Sec)	Split 7 (Sec)	Split 8 (Sec)	Cycle Length (s)	Offset (Sec)	Leading Phase	Coordinated Phase	COS (STD)	Cycle Pattern	Split Pattern	Action Plan	Sequence	Timing Plan	Notes
Plan 1	65	13	57	0	30	22	48	0	30	100	6	15	26+	111	1	1	1	1	1	
Plan 2	65	13	47	0	30	25	35	0	30	90	5	15	26+	211	2	2	2	1	1	
Plan 4	65	13	57	0	30	22	48	0	30	100	8	15	26+	411	4	4	4	1	1	
Plan 11	65	35.5	61.1	0	45.7	35.7	61.1	0	45.2	0	0	15	0	133	11	11	11	1	1	Free
Plan 7 (EVENT OB)	65	12	39	0	69	12	39	0	69	120	77	15	26+	144	7	7	7	1	1	
Plan 21	65	13	65	0	32	22	56	0	32	110	5	15	26+	221	21	21	21	1	1	
Plan 22	65	13	47	0	30	20	40	0	30	90	7	15	26+	222	22	22	22	1	1	
Plan 24	65	13	55	0	32	18	50	0	32	100	57	15	26+	224	24	24	24	1	1	
Plan 31	65	35.5	61.1	0	45.7	35.7	61.1	0	45.2	0	0	15	0	231	31	31	31	1	1	Free
Min Split -- PED	**65**	**10.0**	**30.0**	**0.0**	**16.0**	**10.0**	**21.0**	**0.0**	**35.0**											DE 4/8, BU Prot 1/5
Max Initial Check	**65**	**15.0**	**38.0**		**21.0**	**15.0**	**36.0**		**21.0**											Non-lock
Min Split -- COORD	**65**	**11.0**	**21.0**		**16.0**	**11.0**	**21.0**		**16.0**											

66. Gateway Street at Stanford Street

Plan Identification	System ID	Split 1 (Sec)	Split 2 (Sec)	Split 3 (Sec)	Split 4 (Sec)	Split 5 (Sec)	Split 6 (Sec)	Split 7 (Sec)	Split 8 (Sec)	Cycle Length (s)	Offset (Sec)	Leading Phase	Coordinated Phase	COS (STD)	Cycle Pattern	Split Pattern	Action Plan	Sequence	Timing Plan	Notes
Plan 1	66	15	60	0	25	13	62	0	25	100	55	15	26+	111	1	1	1	1	1	
Plan 2	66	20	48	0	22	13	55	0	22	90	38	15	26+	211	2	2	2	1	1	
Plan 4	66	15	60	0	25	13	62	0	25	100	59	15	26+	411	4	4	4	1	1	
Plan 11	66	13	39	0	18	13	39	0	18	70	67	15	26+	133	11	11	11	1	1	
Plan 7 (EVENT OB)	66	13	57	0	50	13	57	0	50	120	2	15	26+	144	7	7	7	1	1	
Plan 21	66	15	67	0	28	13	69	0	28	110	4	15	26+	221	21	21	21	1	1	
Plan 22	66	20	45	0	25	13	52	0	25	90	9	15	26+	222	22	22	22	1	1	
Plan 24	66	15	60	0	25	13	62	0	25	100	52	15	26+	224	24	24	24	1	1	
Plan 31	66	13	39	0	18	13	39	0	18	70	22	15	26+	231	31	31	31	1	1	
Min Split -- PED	**66**	**10.0**	**20.5**	**0.0**	**16.5**	**10.0**	**20.5**	**0.0**	**44.5**											DE 4/8, BU Prot 1/5
Max Initial Check	**66**	**15.0**	**17.5**		**18.0**	**13.0**	**18.0**		**14.0**											Non-lock
Min Split -- COORD	**66**	**11.0**	**21.0**		**16.0**	**11.0**	**21.0**		**16.0**											

67. Gateway Drive at 42nd Street

Plan Identification	System ID	Split 1 (Sec)	Split 2 (Sec)	Split 3 (Sec)	Split 4 (Sec)	Split 5 (Sec)	Split 6 (Sec)	Split 7 (Sec)	Split 8 (Sec)	Cycle Length (s)	Offset (Sec)	Leading Phase	Coordinated Phase	COS (STD)	Cycle Pattern	Split Pattern	Action Plan	Sequence	Timing Plan	Notes
Plan 1	67	0	77	0	23	0	77	0	23	100	98	0	26+	111	1	1	1	1	1	
Plan 2	67	0	64	0	26	0	64	0	26	90	85	0	26+	211	2	2	2	1	1	
Plan 4	67	0	75	0	25	0	75	0	25	100	95	0	26+	411	4	4	4	1	1	
Plan 11	67	0	50	0	20	0	50	0	20	70	20	0	26+	133	11	11	11	1	1	
Plan 7 (EVENT OB)	67	0	90	0	30	0	90	0	30	120	0	0	26+	144	7	7	7	1	1	
Plan 9 (ALERUS OB)	67	0	35	0	55	0	35	0	55	90	12	0	26+	244	9	9	9	1		
Plan 21	67	0	81	0	29	0	81	0	29	110	57	0	26+	221	21	21	21	1	1	
Plan 22	67	0	62	0	28	0	62	0	28	90	45	0	26+	222	22	22	22	1	1	
Plan 24	67	0	70	0	30	0	70	0	30	100	92	0	26+	224	24	24	24	1	1	
Plan 31	67	0	50	0	20	0	50	0	20	70	57	0	26+	231	31	31	31	1	1	
Min Split -- PED	**67**	**10.0**	**20.5**	**0.0**	**16.5**	**10.0**	**21.0**	**0.0**	**16.5**											DE 4/8, BU Prot 1/5
Max Initial Check	**67**		**26.5**		**20.5**		**27.0**		**20.5**											Non-lock
Min Split -- COORD	**67**	**11.0**	**21.0**		**16.0**	**11.0**	**21.0**		**16.0**											

68. Gateway Drive at I-29 East Ramp

Plan Identification	System ID	Split 1 (Sec)	Split 2 (Sec)	Split 3 (Sec)	Split 4 (Sec)	Split 5 (Sec)	Split 6 (Sec)	Split 7 (Sec)	Split 8 (Sec)	Cycle Length (s)	Offset (Sec)	Leading Phase	Coordinated Phase	COS (STD)	Cycle Pattern	Split Pattern	Action Plan	Sequence	Timing Plan	Notes
Plan 1	68	20	58	0	0	0	78	0	22	100	10	2	26+	111	1	1	1	2	1	
Plan 2	68	19	49	0	0	0	68	0	22	90	3	2	26+	211	2	2	2	2	1	
Plan 4	68	15	63	0	0	0	78	0	22	100	3	2	26+	411	4	4	4	2	1	
Plan 11	68	15	35	0	0	0	50	0	20	70	19	2	26+	133	11	11	11	2	1	
Plan 7 (EVENT OB)	68	15	87	0	0	0	102	0	18	120	6	1	26+	144	7	7	7	1	1	
Pattern 120	68	25	30	0	0	0	55	0	30	55	--			122						
Plan 21	68	20	65	0	0	0	85	0	25	110	56	2	26+	221	21	21	21	2	1	
Plan 22	68	19	46	0	0	0	65	0	25	90	83	2	26+	222	22	22	22	2	1	
Plan 24	68	18	55	0	0	0	73	0	27	100	56	2	26+	224	24	24	24	2	1	
Plan 31	68	15	35	0	0	0	50	0	20	70	19	2	26+	231	31	31	31	2	1	
Min Split -- PED	**68**	**12.0**	**20.0**	**0.0**	**0.0**	**0.0**	**20.0**	**0.0**	**14.5**											No DE, No BU Prot
Max Initial Check	**68**	**25.0**	**33.0**				**33.0**		**16.5**											Lock Det
Min Split -- COORD	**68**	**12.0**	**20.0**				**20.0**		**13.0**											

Zone 3 - Gateway Drive (47th Street to 3rd Street)

Revised: December 10, 2010

69. Gateway Drive a tl-29 West Ramp

Plan Identification	System ID	Split 1 (Sec)	Split 2 (Sec)	Split 3 (Sec)	Split 4 (Sec)	Split 5 (Sec)	Split 6 (Sec)	Split 7 (Sec)	Split 8 (Sec)	Cycle Length (s)	Offset (Sec)	Leading Phase	Coordinated Phase	COS (STD)	Cycle Pattern	Split Pattern	Action Plan	Sequence	Timing Plan	Notes
Plan 1	69	0	78	0	22	0	78	0	0	100	6	0	26+	111	1	1	1	1	1	
Plan 2	69	0	68	0	22	0	68	0	0	90	85	0	26+	211	2	2	2	1	1	
Plan 4	69	0	78	0	22	0	78	0	0	100	96	0	26+	411	4	4	4	1	1	
Plan 11	69	0	50	0	20	0	50	0	0	70	18	0	26+	133	11	11	11	1	1	
Pattern 120	69	0	35	0	25	0	35	0	0	60	--			122						
Plan 21	69	0	90	0	20	0	90	0	0	110	44	0	26+	221	21	21	21	1	1	
Plan 22	69	0	68	0	22	0	68	0	0	90	84	0	26+	222	22	22	22	1	1	
Plan 24	69	0	78	0	22	0	78	0	0	100	50	0	26+	224	24	24	24	1	1	
Plan 31	69	0	50	0	20	0	50	0	0	70	18	0	26+	231	31	31	31	1	1	
Min Split -- PED	**69**	**0.0**	**20.0**	**0.0**	**14.5**	**0.0**	**20.0**	**0.0**	**0.0**											No DE, No BU Prot
Max Initial Check	**69**		**31.0**		**16.5**		**31.0**													Lock Det
Min Split -- COORD	**69**		**20.0**		**13.0**		**20.0**													

70. Gateway Drive at 47th Street

Plan Identification	System ID	Split 1 (Sec)	Split 2 (Sec)	Split 3 (Sec)	Split 4 (Sec)	Split 5 (Sec)	Split 6 (Sec)	Split 7 (Sec)	Split 8 (Sec)	Cycle Length (s)	Offset (Sec)	Leading Phase	Coordinated Phase	COS (STD)	Cycle Pattern	Split Pattern	Action Plan	Sequence	Timing Plan	Notes
Plan 1	70	15	58	0	27	28	45	0	27	100	5	16	26+	111	1	1	1	5	1	
Plan 2	70	15	51	0	24	25	41	0	24	90	85	16	26+	211	2	2	2	5	1	
Plan 4	70	15	60	0	25	30	45	0	25	100	93	16	26+	411	4	4	4	5	1	
Plan 11	70	15	35	0	20	18	32	0	20	70	18	16	26+	133	11	11	11	5	1	
Plan 21	70	15	65	0	30	26	54	0	30	110	39	15	26+	221	21	21	21	1	1	
Plan 22	70	15	49	0	26	23	41	0	26	90	80	16	26+	222	22	22	22	5	1	
Plan 24	70	15	55	0	30	25	45	0	30	100	57	16	26+	224	24	24	24	5	1	
Plan 31	70	15	35	0	20	18	32	0	20	70	14	16	26+	231	31	31	31	5	1	
Min Split -- PED	**70**	**12.0**	**21.0**	**0.0**	**16.5**	**12.0**	**39.0**	**0.0**	**16.5**											DE 4/8, No BU Protect
Max Initial Check	**70**	**15.0**	**34.0**		**16.5**	**20.0**	**32.0**		**16.5**											Lock 1/5,
Min Split -- COORD	**70**	**13.0**	**21.0**		**16.0**	**13.0**	**21.0**		**16.0**											

#	= High Priority Ped
#	= Change to Columbia/32nd Avenue

Zone 4 - 42nd Street (11th Ave to 6th Ave) and DeMers Ave (20th St to 42nd St)

Revised: December 10, 2010

16. DeMers Avenue at 20th Street

Plan Identification	System ID	Split 1 (Sec)	Split 2 (Sec)	Split 3 (Sec)	Split 4 (Sec)	Split 5 (Sec)	Split 6 (Sec)	Split 7 (Sec)	Split 8 (Sec)	Cycle Length (s)	Offset (Sec)	Leading Phase	Coordinated Phase	COS (STD)	Cycle Pattern	Split Pattern	Action Plan	Sequence	Timing Plan	Notes
Plan 1	16	13	72	0	25	0	85	0	25	110	40	1	26+	701	1	1	1	1	1	
Plan 2	16	13	37	0	20	0	50	0	20	70	57	1	26+	702	2	2	2	1	1	
Plan 3	16	13	47	0	20	0	60	0	20	80	70	1	26+	703	3	3	3	1	1	
Plan 4	16	13	34	0	18	0	47	0	18	65	42	1	26+	704	4	4	4	1	1	
Plan 5	16	13	57	0	20	0	70	0	20	90	43	1	26+	705	5	5	5	1	1	
Plan 9 (EVENT OB)	16	12	30	0	18	0	42	0	18	60	39	1	26+	709	9	9	9	1	1	
Plan 10 (EVENT IB)	16	13	57	0	20	0	70	0	20	90	43	1	26+	710	10	10	10	1	1	
Plan 21	16	13	68	0	29	0	81	0	29	110	7	1	26+	221	21	21	21	1	1	
Plan 23	16	13	44	0	23	0	57	0	23	80	36	1	26+	223	23	23	23	1	1	
Plan 24	16	13	34	0	18	0	47	0	18	65	11	1	26+	224	24	24	24	1	1	
Min Split -- PED	**16**	**10.0**	**28.5**	**0.0**	**32.0**	**0.0**	**20.5**	**0.0**	**33.0**											DE 4/8, BU Protect 1
Max Initial Check	**16**	**15.0**	**27.5**		**28.0**		**20.5**		**28.0**											Lock 4, 8
Min Split -- COORD	**16**	**10.5**	**28.5**		**15.5**		**20.5**		**15.5**											

23. DeMers Avenue at 34th Street

Plan Identification	System ID	Split 1 (Sec)	Split 2 (Sec)	Split 3 (Sec)	Split 4 (Sec)	Split 5 (Sec)	Split 6 (Sec)	Split 7 (Sec)	Split 8 (Sec)	Cycle Length (s)	Offset (Sec)	Leading Phase	Coordinated Phase	COS (STD)	Cycle Pattern	Split Pattern	Action Plan	Sequence	Timing Plan	Notes
Plan 1	23	0	90	0	20	0	90	0	0	110	60	0	26+	701	1	1	1	1	1	
Plan 2	23	0	50	0	20	0	50	0	0	70	48	0	26+	702	2	2	2	1	1	
Plan 3	23	0	62	0	18	0	62	0	0	80	76	0	26+	703	3	3	3	1	1	
Plan 4	23	0	49	0	16	0	49	0	0	65	9	0	26+	704	4	4	4	1	1	
Plan 5	23	0	70	0	20	0	70	0	0	90	49	0	26+	705	5	5	5	1	1	
Plan 9 (EVENT OB)	23	0	42	0	18	0	42	0	0	60	10	0	26+	709	9	9	9	1	1	
Plan 10 (EVENT IB)	23	0	70	0	20	0	70	0	0	90	49	0	26+	710	10	10	10	1	1	
Plan 21	23	0	88	0	22	0	88	0	0	110	10	0	26+	221	21	21	21	1	1	
Plan 23	23	0	62	0	18	0	62	0	0	80	71	0	26+	223	23	23	23	1	1	
Plan 24	23	0	49	0	16	0	49	0	0	65	0	0	26+	224	24	24	24	1	1	
Min Split -- PED	**23**	**0.0**	**20.5**	**0.0**	**32.0**	**0.0**	**20.5**	**0.0**	**0.0**											
Max Initial Check	**23**		**35.5**		**28.0**		**35.5**													
Min Split -- COORD	**23**		**20.5**		**15.5**		**20.5**													

41. 42nd Street at University Avenue

Plan Identification	System ID	Split 1 (Sec)	Split 2 (Sec)	Split 3 (Sec)	Split 4 (Sec)	Split 5 (Sec)	Split 6 (Sec)	Split 7 (Sec)	Split 8 (Sec)	Cycle Length (s)	Offset (Sec)	Leading Phase	Coordinated Phase	COS (STD)	Cycle Pattern	Split Pattern	Action Plan	Sequence	Timing Plan	Notes
Plan 1	41	12	36	12	20	12	36	12	20	80	17	1357	26+	701	1	1	1	1	1	
Plan 2	41	12	28	12	18	12	28	12	18	70	16	1357	26+	702	2	2	2	1	1	
Plan 3	41	12	36	12	20	12	36	14	18	80	41	1357	26+	703	3	3	3	1	1	
Plan 4	41	12	63	13	42	13	62	32	23	130	30	1357	26+	704	4	4	4	1	1	
Plan 5	41	12	39	12	27	12	39	20	19	90	13	1357	26+	705	5	5	5	1	1	
Plan 7 (EVENT REA OB)	41	12	40	15	33	12	40	30	18	100	26	1357	26+	707	7	7	7	1	1	
Plan 9 (EVENT OB)	41	25	41	13	41	13	53	34	20	120	114	1357	26+	709	9	9	9	1	1	
Plan 10 (EVENT IB)	41	12	46	13	19	12	46	13	19	90	4	1357	26+	710	10	10	10	1	1	
Pattern 120	41	20	35	20	25	20	35	20	25	100	--	1357	26							
Plan 21	41	12	34	14	20	12	34	12	22	80	34	1357	26+	221	21	21	21	1	1	
Plan 23	41	12	30	15	23	12	30	18	20	80	50	1357	26+	223	23	23	23	1	1	
Plan 24	41	12	61	17	40	12	61	31	26	130	71	1357	26+	224	24	24	24	1	1	
Min Split -- PED	**41**	**10.0**	**28.0**	**10.0**	**29.0**	**10.0**	**26.5**	**10.0**	**34.0**											DE 4 and 8, BU Protect 1, 3, 5, 7
Max Initial Check	**41**	**14.0**	**23.0**	**14.0**	**22.0**	**14.0**	**22.5**	**14.0**	**22.0**											Lock 4, 8
Min Split -- COORD	**41**	**11.0**	**28.0**	**11.0**	**16.0**	**11.0**	**27.0**	**11.0**	**16.0**											

42. 42nd Street at DeMers Avenue

Plan Identification	System ID	Split 1 (Sec)	Split 2 (Sec)	Split 3 (Sec)	Split 4 (Sec)	Split 5 (Sec)	Split 6 (Sec)	Split 7 (Sec)	Split 8 (Sec)	Cycle Length (s)	Offset (Sec)	Leading Phase	Coordinated Phase	COS (STD)	Cycle Pattern	Split Pattern	Action Plan	Sequence	Timing Plan	Notes
Plan 1	42	12	29	13	26	13	28	14	25	80	67	1357	48+	701	1	1	1	1	1	
Plan 2	42	12	23	12	23	12	23	12	23	70	16	1357	26+	702	2	2	2	1	1	
Plan 3	42	12	29	13	26	13	28	15	24	80	42	1357	26+	703	3	3	3	1	1	
Plan 4	42	15	40	13	62	15	40	23	52	130	34	1357	48+	704	4	4	4	1	1	
Plan 5	42	13	30	13	34	13	30	15	32	90	53	1357	48+	705	5	5	5	1	1	
Plan 7 (EVENT REA OB)	42	12	25	12	51	12	25	41	22	100	65	1357	48+	707	7	7	7	1	1	
Plan 9 (EVENT OB)	42	12	27	56	25	12	27	13	68	120	77	1357	48+	709	9	9	9	1	1	
Plan 10 (EVENT IB)	42	28	22	12	28	13	37	12	28	90	5	1357	26+	710	10	10	10	1	1	
Plan 21	42	12	29	13	26	13	28	14	25	80	77	1357	48+	221	21	21	21	1	1	
Plan 23	42	12	29	13	26	13	28	15	24	80	45	1357	26+	223	23	23	23	1	1	
Plan 24	42	13	42	13	62	15	40	35	40	130	126	1357	48+	224	24	24	24	1	1	
Min Split -- PED	**42**	**10.0**	**38.5**	**10.0**	**34.0**	**10.0**	**40.5**	**10.0**	**34.0**											DE 4 and 8, BU Protect 1, 3, 5, 7
Max Initial Check	**42**	**13.0**	**21.5**	**14.0**	**16.0**	**13.0**	**21.5**	**15.0**	**16.0**											Lock 2, 6, 4, 8
Min Split -- COORD	**42**	**11.5**	**38.5**	**11.5**	**16.5**	**11.5**	**40.5**	**11.5**	**16.5**											

Zone 4 - 42nd Street (11th Ave to 6th Ave) and DeMers Ave (20th St to 42nd St)

Revised: December 10, 2010

43. 42nd Street at 17th Avenue

Plan Identification	System ID	Split 1 (Sec)	Split 2 (Sec)	Split 3 (Sec)	Split 4 (Sec)	Split 5 (Sec)	Split 6 (Sec)	Split 7 (Sec)	Split 8 (Sec)	Cycle Length (s)	Offset (Sec)	Leading Phase	Coordinated Phase	COS (STD)	Cycle Pattern	Split Pattern	Action Plan	Sequence	Timing Plan	Notes
Plan 1	43	0	62	0	18	13	49	0	0	80	55	5	26+	701	1	1	1	1	1	
Plan 2	43	0	52	0	18	13	39	0	0	70	34	5	26+	702	2	2	2	1	1	
Plan 3	43	0	62	0	18	13	49	0	0	80	71	5	26+	703	3	3	3	1	1	
Plan 4	43	0	49	0	16	12	37	0	0	65	57	6	26+	704	4	4	4	5	1	
Plan 5	43	0	72	0	18	13	59	0	0	90	34	5	26+	705	5	5	5	1	1	
Plan 9 (EVENT OB)	43	0	102	0	18	75	27	0	0	0	0	5	0	709	9	9	9	1	1	Free
Plan 10 (EVENT IB)	43	0	72	0	18	0	72	0	0	90	51	0	26+	710	10	10	10	1	1	Omit Phase 5
Plan 21	43	0	62	0	18	13	49	0	0	80	30	5	26+	221	21	21	21	1	1	
Plan 23	43	0	62	0	18	13	49	0	0	80	49	5	26+	223	23	23	23	1	1	
Plan 24	43	0	49	0	16	12	37	0	0	65	42	6	26+	224	24	24	24	5	1	
Min Split -- PED	**43**	**0.0**	**24.5**	**0.0**	**31.5**	**10.0**	**25.5**	**0.0**	**29.0**											DE 4/8, BU Prot 1/5
Max Initial Check	**43**		**20.5**		**20.5**	**15.0**	**20.5**													Lock 4
Min Split -- COORD	**43**		**24.5**		**15.5**	**10.5**	**25.5**													

44. 42nd Street at 6th Avenue

Plan Identification	System ID	Split 1 (Sec)	Split 2 (Sec)	Split 3 (Sec)	Split 4 (Sec)	Split 5 (Sec)	Split 6 (Sec)	Split 7 (Sec)	Split 8 (Sec)	Cycle Length (s)	Offset (Sec)	Leading Phase	Coordinated Phase	COS (STD)	Cycle Pattern	Split Pattern	Action Plan	Sequence	Timing Plan	Notes
Plan 1	44	0	53	0	27	0	53	0	27	80	9	0	26+	701	1	1	1	1	1	
Plan 2	44	0	45	0	25	0	45	0	25	70	11	0	26+	702	2	2	2	1	1	
Plan 3	44	0	47	0	33	0	47	0	33	80	41	0	26+	703	3	3	3	1	1	
Plan 4	44	0	37	0	28	0	37	0	28	65	41	0	26+	704	4	4	4	1	1	
Plan 5	44	0	63	0	27	0	63	0	27	90	89	0	26+	705	5	5	5	1	1	
Plan 7 (EVENT REA OB)	44	0	35	0	65	0	35	0	65	100	47	0	26+	707	7	7	7	1	1	
Plan 9 (EVENT OB)	44	0	80	0	40	0	80	0	40	120	5	0	26+	709	9	9	9	1	1	
Plan 10 (EVENT IB)	44	0	63	0	27	0	63	0	27	90	81	0	26+	710	10	10	10	1	1	
Plan 21	44	0	48	0	32	0	48	0	32	80	73	0	26+	221	21	21	21	1	1	
Plan 23	44	0	43	0	37	0	43	0	37	80	77	0	26+	223	23	23	23	1	1	
Plan 24	44	0	37	0	28	0	37	0	28	65	33	0	26+	224	24	24	24	1	1	
Min Split -- PED	**44**	**0.0**	**22.5**	**0.0**	**26.5**	**0.0**	**20.5**	**0.0**	**15.5**											DE 4/8
Max Initial Check	**44**		**20.5**		**18.5**		**18.5**		**18.5**											Lock 4, 8
Min Split -- COORD	**44**		**22.5**		**15.5**		**20.5**		**15.5**											

45. 42nd Street at 11th Avenue

Plan Identification	System ID	Split 1 (Sec)	Split 2 (Sec)	Split 3 (Sec)	Split 4 (Sec)	Split 5 (Sec)	Split 6 (Sec)	Split 7 (Sec)	Split 8 (Sec)	Cycle Length (s)	Offset (Sec)	Leading Phase	Coordinated Phase	COS (STD)	Cycle Pattern	Split Pattern	Action Plan	Sequence	Timing Plan	Notes
Plan 1	45	13	49	0	18	13	49	0	18	80	27	15	26+	701	1	1	1	1	1	
Plan 2	45	13	39	0	18	13	39	0	18	70	13	15	26+	702	2	2	2	1	1	
Plan 3	45	13	49	0	18	13	49	0	18	80	43	15	26+	703	3	3	3	1	1	
Plan 4	45	0	48	0	17	0	48	0	17	65	10	0	26+	704	4	4	4	1	1	Omit Phase 1 and 5
Plan 5	45	13	57	0	20	13	57	0	20	90	89	15	26+	705	5	5	5	1	1	
Plan 9 (EVENT OB)	45	29.8	61.2	0	31.9	30.8	61.2	0	31.9	0	0	15	0	709	9	9	9	1	1	FREE
Plan 10 (EVENT IB)	45	0	58	0	32	0	58	0	32	90	5	0	26+	710	10	10	10	1	1	
Plan 21	45	11	49	0	20	11	49	0	20	80	26	15	26+	221	21	21	21	1	1	
Plan 23	45	11	47	0	22	11	47	0	22	80	44	15	26+	223	23	23	23	1	1	
Plan 24	45	0	45	0	20	0	45	0	20	65	36	0	26+	224	24	24	24	1	1	Omit Phase 1 and 5
Min Split -- PED	**45**	**10.0**	**20.5**	**0.0**	**30.0**	**10.0**	**20.5**	**0.0**	**28.0**											DE 4/8, BU Prot 1/5
Max Initial Check	**45**	**15.0**	**27.5**		**25.0**	**15.0**	**27.5**		**25.0**											Lock 4, 8
Min Split -- COORD	**45**	**10.5**	**20.5**		**15.5**	**10.5**	**20.5**		**15.5**											

100. DeMers Avenue at Columbia Road

Plan Identification	System ID	Split 1 (Sec)	Split 2 (Sec)	Split 3 (Sec)	Split 4 (Sec)	Split 5 (Sec)	Split 6 (Sec)	Split 7 (Sec)	Split 8 (Sec)	Cycle Length (s)	Offset (Sec)	Leading Phase	Coordinated Phase	COS (STD)	Cycle Pattern	Split Pattern	Action Plan	Sequence	Timing Plan	Notes
Plan 1	100	0	23	15	72	0	0	0	87	110	3	3	48+	701	1	1	1	1	1	
Plan 2	100	0	20	13	37	0	0	0	50	70	21	3	48+	702	2	2	2	1	1	
Plan 3	100	0	25	13	42	0	0	0	55	80	32	3	48+	703	3	3	3	1	1	
Plan 4	100	0	19	11	35	0	0	0	46	65	12	3	48+	704	4	4	4	1	1	
Plan 5	100	0	25	13	52	0	0	0	65	90	86	3	48+	705	5	5	5	1	1	
Plan 9 (EVENT OB)	100	0	18	12	30	0	0	0	42	60	4	3	48+	709	9	9	9	1	1	
Plan 10 (EVENT IB)	100	0	25	13	52	0	0	0	65	90	86	3	48+	710	10	10	10	1	1	
Plan 21	100	0	23	15	72	0	0	0	87	110	67	3	48+	221	21	21	21	1	1	
Plan 23	100	0	28	13	39	0	0	0	52	80	79	3	48+	223	23	23	23	1	1	
Plan 24	100	0	19	11	35	0	0	0	46	65	62	3	48+	224	24	24	24	1	1	
Min Split -- PED	**100**	**0.0**	**31.0**	**10.0**	**23.5**	**0.0**	**0.0**	**0.0**	**21.5**											No DE, BU Prot 3
Max Initial Check	**100**		**20.0**	**15.0**	**22.5**				**22.5**											Lock 2
Min Split -- COORD	**100**		**31.0**	**10.0**	**20.0**				**20.0**											

= Ped Min Split Violation

= Remove MAX INI

Appendix C:
TSP Maximum Reduction and Detection Zone Parameters

TSP Location	Timing Plan	ASC/3 Split Pattern Parameters Programming Location: MM-4-4								Detection Zone (USE)							
		MAX RDNT								NBL	NB	SBL	SB	EBL	EB	WBL	WB
		Ø 1	Ø 2	Ø 3	Ø 4	Ø 5	Ø 6	Ø 7	Ø 8	Detection Zone Length (feet)*	Detection Zone Length (feet)*	Detection Zone Length (feet)*	Detection Zone Length (feet)*	Detection Zone Length (feet)*	Detection Zone Length (feet)*	Detection Zone Length (feet)*	Detection Zone Length (feet)*
Columbia Rd & 6th Ave	1	0	0	0	0	5	0	0	0								
	2	0	20	0	0	10	20	0	0								
	3	0	0	0	0	31	0	0	0								
	4	0	0	0	0	10	0	0	0								
	5	0	0	0	0	10	0	0	0								
	6	0	0	0	0	5	0	0	0								**330**
	7	0	0	0	0	3	0	0	0								
	8	0	0	0	0	15	0	0	0								
	21	0	0	0	0	3	0	0	0								
	23	0	25	0	0	31	25	0	0								
	24	0	0	0	0	5	0	0	0								
	25	0	5	0	0	5	5	0	0								
	31	0	40	0	24	19	40	0	24								
	Pattern 120	0	40	0	20	10	20	0	20								
Columbia Rd & University Ave	1	0	0	0	11	1	0	1	1								
	2	1	10	0	17	1	10	0	17		**330**				**330**		**330**
	3	2	0	1	17	6	0	1	17								
	4	4	0	0	1	7	0	2	11								
	5	4	0	3	16	7	0	2	17								
	6	0	0	0	17	6	0	0	17								
	7	2	0	6	19	2	0	6	19								
	8	9	0	9	17	5	0	9	17								
	21	1	0	4	5	14	0	1	10								
	23	2	5	1	10	6	5	1	10								
	24	4	0	4	8	7	0	4	8								
	25	4	10	4	10	7	10	4	10								
	31	0	0	0	4	0	0	0	4								
	Pattern 120	9	14	9	9	9	14	9	9								
Columbia Rd & 11th Ave **NO TSP**	1	0	0	0	0	0	0	0	0								
	2	0	0	0	0	0	0	0	0								
	3	0	0	0	0	0	0	0	0								
	4	0	0	0	0	0	0	0	0								
	5	0	0	0	0	0	0	0	0								
	6	0	0	0	0	0	0	0	0								
	7	0	0	0	0	0	0	0	0								
	8	0	0	0	0	0	0	0	0								
	Pattern 120	0	0	0	0	0	0	0	0								
Columbia Rd & 13th Ave	1	2	10	2	0	2	10	2	3								
	2	2	10	0	0	2	10	0	18								
	3	3	14	0	18	3	14	0	18								
	4	6	10	6	0	2	10	0	1								
	5	5	0	5	8	5	0	10	3						**350**		**350**
	6	3	10	0	18	3	10	0	18								
	21	2	0	2	0	2	0	5	3								
	23	3	15	0	0	3	15	0	0								
	24	11	12	7	0	3	12	5	0								
	25	10	8	3	0	3	8	3	0								
	31	0	9	0	5	0	9	0	5								
	Pattern 120	10	15	10	10	10	15	10	10								

TSP Location	Timing Plan	ASC/3 Split Pattern Parameters Programming Location: MM-4-4								Detection Zone (USE)							
		MAX RDNT								NBL	NB	SBL	SB	EBL	EB	WBL	WB
		Ø 1	Ø 2	Ø 3	Ø 4	Ø 5	Ø 6	Ø 7	Ø 8	Detection Zone Length (feet)*	Detection Zone Length (feet)*	Detection Zone Length (feet)*	Detection Zone Length (feet)*	Detection Zone Length (feet)*	Detection Zone Length (feet)*	Detection Zone Length (feet)*	Detection Zone Length (feet)*
Columbia Rd & 17th Ave	1	7	0	7	3	0	9	0	1								
	2	0	6	0	4	1	6	0	4								
	3	0	12	0	5	2	12	0	2								
	4	6	0	4	0	2	0	6	0								
	5	6	0	6	0	1	0	6	0				**310**				
	6	2	8	2	5	2	8	2	2								
	21	5	0	5	7	5	0	3	0								
	23	3	5	8	5	3	5	5	5								
	24	5	0	6	0	1	0	6	0								
	25	5	0	6	6	5	0	6	6								
	31	34	19	29	14	24	24	24	14								
	Pattern 120	10	15	10	10	10	15	10	10						**300**		
Columbia Rd & 24th Ave	1	0	5	2	1	0	5	0	0								
	2	1	10	1	3	4	10	1	3								
	3	4	8	4	4	2	8	4	4								
	4	0	0	0	0	0	0	0	0								
	5	7	0	4	5	1	0	4	5								
	6	2	20	4	4	2	20	4	4				**440**				**300**
	21	4	0	4	10	2	0	5	10								
	23	4	5	4	6	2	5	4	6								
	24	9	0	2	12	4	0	8	6								
	25	9	0	2	12	4	0	8	6								
	31	11	10	13	11	11	10	8	11								
	Pattern 120	14	14	9	9	14	14	9	9								
Columbia Rd & 28th Ave	1	1	0	0	4	1	0	0	4								
	2	1	0	0	9	1	0	0	9		**440**		**440**				
	3	2	0	2	2	2	0	2	2								
	4	2	0	2	2	9	0	2	2								
	5	0	0	0	4	0	0	0	4								
	6	9	0	9	9	4	0	9	9								
	21	1	0	0	4	1	0	0	4								
	23	2	0	2	2	2	0	2	2								
	24	19	0	2	2	4	0	2	2								
	25	19	0	2	9	9	0	2	9								
	31	18	30	0	16	18	30	0	21								
	Pattern 120	9	14	0	9	9	14	0	9								
Columbia Rd & 32nd Ave	1	2	0	2	3	2	0	2	0								
	2	2	0	5	2	2	0	5	2								
	3	2	0	0	2	5	0	6	3								
	4	2	0	0	0	4	0	9	6								
	5	4	0	0	0	5	0	4	5								
	9	4	0	0	0	5	0	2	7		**330**	**330**	**330**				
	21	3	0	4	0	3	0	2	0								
	23	5	0	8	6	7	0	5	9								
	24	6	0	5	0	5	0	5	10								
	25	5	0	0	5	5	0	5	5								
	Pattern 120	7	14	7	9	7	14	7	9								

TSP Location	Timing Plan	ASC/3 Split Pattern Parameters Programming Location: MM-4-4								Detection Zone (USE)							
		MAX RDNT								NBL	NB	SBL	SB	EBL	EB	WBL	WB
		Ø 1	Ø 2	Ø 3	Ø 4	Ø 5	Ø 6	Ø 7	Ø 8	Detection Zone Length (feet)*	Detection Zone Length (feet)*	Detection Zone Length (feet)*	Detection Zone Length (feet)*	Detection Zone Length (feet)*	Detection Zone Length (feet)*	Detection Zone Length (feet)*	Detection Zone Length (feet)*
Washington St & 5th Ave	1	0	0	0	0	0	0	0	0								
	2	0	30	0	0	0	30	0	0								
	3	0	0	0	0	0	0	0	0								
	4	0	30	0	0	0	30	0	0						**440**		
	5	0	10	0	0	0	10	0	0								
	6	0	5	0	0	0	5	0	0								
	21	0	20	0	0	0	20	0	0								
	23	0	40	0	0	0	40	0	0								
	24	0	25	0	0	0	25	0	0								
	25	0	5	0	0	0	5	0	0								
	Pattern 120	0	15	0	0	0	15	0	0								
Washington St & University Ave	1	12	20	4	0	0	20	0	0								
	2	5	30	5	0	0	30	0	0								
	3	5	20	3	0	0	20	0	0								
	4	9	25	6	0	0	25	0	0						**660**		**660**
	5	5	35	3	0	0	35	0	0								
	6	5	30	3	0	0	30	0	0								
	21	9	10	3	0	0	10	0	0								
	23	3	10	3	0	0	10	0	0								
	24	9	30	6	0	0	30	0	0								
	25	5	20	3	0	0	20	0	0								
	Pattern 120	10	15	10	0	0	55	0	0								
Washington St & DeMers Ave	1	4	0	2	0	4	0	2	0								
	2	2	8	2	0	2	8	0	3								
	3	2	10	6	0	2	10	0	10							**500**	**500**
	4	0	0	0	1	0	0	0	6								
	5	4	10	4	0	4	10	0	8								
	6	2	8	2	0	2	8	0	5								
	21	4	0	2	0	4	0	0	6								
	23	2	0	7	0	2	0	0	8								
	24	2	0	6	0	9	0	0	6								
	25	4	5	8	0	4	5	0	5								
	Pattern 120	9	14	7	9	9	14	7	9								
Washington St & 13th Ave	1	1	5	5	8	1	5	6	8								
	2	3	10	3	3	3	10	3	3								
	3	3	15	3	5	3	15	3	5		**485**		**485**				**300**
	4	1	5	1	5	1	5	1	5								
	5	1	10	1	9	1	10	1	9								
	6	1	0	1	7	1	0	1	7								
	21	1	0	1	5	1	0	3	5								
	23	1	5	3	6	1	5	3	6								
	24	1	0	1	5	1	0	1	5								
	25	1	10	1	9	1	10	1	9								
	Pattern 120	10	15	10	10	10	15	10	10								
Washington St & 17th Ave	1	3	2	0	1	3	2	0	0								
	2	3	0	0	5	3	0	3	2								
	3	3	0	3	3	3	0	6	3								
	4	0	0	5	4	0	0	5	4				**400**		**300**		
	5	3	5	4	4	3	5	6	4								
	6	3	3	4	4	3	3	4	4								
	21	3	0	2	5	7	0	4	5								
	23	4	5	4	5	3	5	6	5								
	24	0	0	5	4	0	0	5	4								
	25	3	10	2	5	3	10	3	4								
	Pattern 120	9	14	9	9	9	14	9	9								

TSP Location	Timing Plan	ASC/3 Split Pattern Parameters Programming Location: MM-4-4								Detection Zone (USE)							
		MAX RDNT								NBL	NB	SBL	SB	EBL	EB	WBL	WB
		Ø 1	Ø 2	Ø 3	Ø 4	Ø 5	Ø 6	Ø 7	Ø 8	Detection Zone Length (feet)*	Detection Zone Length (feet)*	Detection Zone Length (feet)*	Detection Zone Length (feet)*	Detection Zone Length (feet)*	Detection Zone Length (feet)*	Detection Zone Length (feet)*	Detection Zone Length (feet)*
Washington St & Campbell Dr	1	0	0	0	6	0	0	0	6								
	2	0	0	0	2	0	0	0	2								
	3	0	0	0	4	0	0	0	4								
	4	0	0	0	8	0	0	0	8				**355**				
	5	0	0	0	5	0	0	0	5								
	6	0	0	0	5	0	0	0	5								
	21	0	0	0	6	0	0	0	6								
	23	0	0	0	4	0	0	0	4								
	24	0	0	0	6	0	0	0	6								
	25	0	0	0	4	0	0	0	4								
	Pattern 120	0	19	0	14	0	19	0	14								
32nd Ave & 34th St	1	2	0	1	1	1	0	1	0								
	2	2	4	2	2	2	4	2	2								
	3	12	20	5	3	1	20	1	7		**315**		**315**				
	4	5	10	6	6	1	10	0	0								
	5	19	0	7	11	6	0	1	17								
	9	17	0	7	11	1	0	1	17								
	21	1	5	4	4	1	5	1	4								
	23	14	8	6	0	7	8	4	0								
	24	10	10	6	0	6	10	2	0								
	25	19	0	5	0	9	0	2	0								
	Pattern 120	9	14	9	9	9	14	9	9								
42nd St & University Ave	1	1	0	1	4	1	0	1	4								
	2	1	0	1	2	1	0	1	2								
	3	1	0	1	4	1	0	3	2								
	4	1	8	2	16	2	8	10	3								
	5	1	5	1	11	1	5	6	3				**300**				**300**
	7	1	0	1	0	1	0	0	3								
	9	14	0	2	4	2	0	2	4								
	10	1	0	2	3	1	0	2	3								
	21	1	3	3	4	1	3	1	6								
	23	1	5	4	7	1	5	7	4								
	24	1	20	6	24	1	20	20	10								
	Pattern 120	9	14	9	9	9	14	9	9								
32nd Ave & 38th St	1	0	10	2	1	2	10	0	2								
	2	2	10	2	2	2	10	2	2								
	3	6	15	7	5	1	15	1	11								
	4	3	15	3	0	0	15	0	13								
	5	9	0	11	8	19	0	2	17		**300**		**330**				
	9	1	0	10	2	1	0	1	10								
	21	1	10	2	5	1	10	2	5								
	23	11	8	8	0	1	8	2	0								
	24	9	15	9	0	4	15	2	0								
	25	14	5	14	0	14	5	4	0								
	Pattern 120	9	19	9	9	9	19	9	9								
17th Ave & 20th St	Pattern 120	0	20	0	0	0	20	0	15		**660**						
17th Ave & 34th St	Pattern 120	0	0	10	12	0	22	0	32				**660**				
24th Ave & 20th St	Pattern 120	0	11	0	11	0	11	0	0								**505**

TSP Location	Timing Plan	ASC/3 Split Pattern Parameters Programming Location: MM-4-4								Detection Zone (USE)							
		MAX RDNT								NBL	NB	SBL	SB	EBL	EB	WBL	WB
		Ø 1	Ø 2	Ø 3	Ø 4	Ø 5	Ø 6	Ø 7	Ø 8	Detection Zone Length (feet)*	Detection Zone Length (feet)*	Detection Zone Length (feet)*	Detection Zone Length (feet)*	Detection Zone Length (feet)*	Detection Zone Length (feet)*	Detection Zone Length (feet)*	Detection Zone Length (feet)*
Columbia Rd & 2nd Ave	1	2	0	0	15	8	0	0	15								
	2	3	0	0	10	8	0	0	10								
	3	2	0	0	15	2	0	0	15								
	4	2	0	0	10	2	0	0	10								
	5	3	0	0	15	3	0	0	15								
	6	2	0	0	15	2	0	0	15								
	7	3	0	0	10	0	0	0	10								
	8	5	0	0	10	0	0	0	10		**660**		**330**				
	21	2	0	0	15	10	0	0	15								
	23	2	0	0	15	2	0	0	15								
	24	2	0	0	15	2	0	0	15								
	25	2	0	0	15	2	0	0	15								
	31	0	9	0	5	0	9	0	5								
	Pattern 120	10	20	0	20	10	20	0	20								
Gateway Dr & 3rd St/11th Ave	1	0	12	0	0	0	12	0	0								
	2	0	10	0	0	0	10	0	0								
	4	0	3	0	0	0	3	0	0								
	7	0	3	0	0	0	3	0	0								
	21	0	10	0	0	0	10	0	0								
	22	0	5	0	0	0	5	0	0								
	24	0	5	0	0	0	5	0	0								
	31	0	10	0	0	0	10	0	0								
	Pattern 120	0	15	0	0	0	15	0	0		**300**						
Gateway Dr & I-29 East Ramps	1	8	0	0	0	0	0	0	9								
	2	3	0	0	0	0	0	0	9								
	4	3	0	0	0	0	0	0	9						**395**		
	7	3	0	0	0	0	0	0	5								
	21	6	0	0	0	0	0	0	12								
	22	7	0	0	0	0	0	0	12								
	24	6	0	0	0	0	0	0	14								
	31	3	10	0	0	0	10	0	7								
	Pattern 120	13	0	0	0	0	0	0	17								
Gateway Dr & I-29 West Ramps	1	0	0	0	9	0	0	0	0								
	2	0	0	0	9	0	0	0	0								
	4	0	0	0	9	0	0	0	0						**395**		
	21	0	0	0	7	0	0	0	0								
	22	0	0	0	9	0	0	0	0								
	24	0	0	0	9	0	0	0	0								
	31	0	10	0	7	0	10	0	0								
	Pattern 120	0	0	0	12	0	0	0	0								
Gateway Dr & 20th St	1	0	0	0	10	0	0	0	10								
	2	0	0	0	10	0	0	0	10								**350**
	4	0	0	0	5	0	0	0	5								
	7	0	10	0	5	0	10	0	5								
	21	0	0	0	13	0	0	0	13								
	22	0	0	0	15	0	0	0	15								
	24	0	0	0	15	0	0	0	15								
	31	0	10	0	5	3	10	0	5								
	Pattern 120	0	0	0	15	0	0	0	15								

TSP Location	Timing Plan	ASC/3 Split Pattern Parameters Programming Location: MM-4-4								Detection Zone (USE)							
		MAX RDNT								NBL	NB	SBL	SB	EBL	EB	WBL	WB
		Ø 1	Ø 2	Ø 3	Ø 4	Ø 5	Ø 6	Ø 7	Ø 8	Detection Zone Length (feet)*	Detection Zone Length (feet)*	Detection Zone Length (feet)*	Detection Zone Length (feet)*	Detection Zone Length (feet)*	Detection Zone Length (feet)*	Detection Zone Length (feet)*	Detection Zone Length (feet)*
Washington St & 47th Ave	Pattern 120	9	19	9	0	9	19	9	9						**660**		
32nd Ave & 24th St	1	2	0	4	0	0	0	0	4								
	2	2	0	4	0	0	0	0	4								
	3	4	0	6	0	0	0	0	6								
	4	9	0	11	0	0	0	0	11								
	5	12	0	11	0	0	0	0	11								
	9	12	0	11	0	0	0	0	11						**500**		
	21	2	0	4	0	0	0	0	4								
	23	4	0	6	0	0	0	0	6								
	24	9	0	11	0	0	0	0	11								
	25	12	0	11	0	0	0	0	11								
	Pattern 120	9	14	11	0	0	34	0	11								
32nd Ave & 20th St	1	4	0	0	6	4	0	0	6								
	2	4	0	0	6	4	0	0	6								
	3	9	0	0	13	9	0	0	13								
	4	7	0	0	22	14	0	0	22						**465**		
	5	14	0	0	13	14	0	0	13								
	9	14	0	0	13	14	0	0	13								
	21	4	0	0	9	4	10	0	9								
	23	6	0	0	13	6	0	0	13								
	24	7	0	0	10	14	0	0	10								
	25	9	0	0	16	9	0	0	16								
	Pattern 120	9	14	0	9	9	14	0	9								

Notes:

1) The TSP/SCP SPLIT PATTERN number for each timing plan must be the same as the SPLIT PATTERN specified in the COORDINATOR PATTERN Window located at MM-3-2.

2) Values with underline correspond to the TSP phase.

*Detection zone is upstream distance measured from the Stop Bar

= Omitted phase