SDOT
Seattle Department of Transportation

NW MARKET/NE 45TH STREET TRANSIT PRIORITY CORRIDOR IMPROVEMENT PROJECT

Traffic Alternatives Report

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EXECUTIVE SUMMARY

The City of Seattle is exploring measures to increase the speed of bus travel in the corridor served by King County Metro Route 44, connecting the Ballard, Phinney, Wallingford, University District, and Montlake neighborhoods. The bus route travels along several congested arterial streets including NW Market Street, N 46th Street, N 45th Street, NE 45th Street, 15th Avenue NE, and NE Pacific Street. Existing one-way travel time for buses on the 5½-mile route can reach up to 44 minutes.

Techniques investigated to improve bus speeds include provisions for buses to circumvent queues at traffic signals, bus bulbs to provide for in-line bus stops, reserved lanes for buses, and priority treatment for buses at traffic signals. Consolidation and relocation of bus stops also will be considered in a separate effort by the Seattle Department of Transportation (SDOT) and King County Metro.

Several projects were developed that warrant advancement to the design stage:

- Restripe NE 45th Street between 7th Avenue NE and University Way NE to provide four lanes, with left turns prohibited. Left turns would be diverted to other routes, including NE 50th, NE 47th and NE 43rd Streets. Travel speeds would be improved by removing left-turn signal phases and assigning additional green-time to through movements.

- Construct a queue jump lane for westbound buses on N Midvale Place approaching the N 46th Street/Green Lake Way N intersection. This location experiences considerable traffic delays for outbound (westbound) buses.

- Provide bus bulbs at about 15 locations along the route to allow for in-line bus stops. This action eliminates delays for buses merging into the travel lane from a bus pullout.

- Provide transit signal priority treatment at about 19 signalized intersections in the corridor. The arrival of a Route 44 bus would extend the green indication for the affected approach, or advance the start of a green indication.

- Other intersection channelization or signal modifications at spot locations throughout the corridor would provide bus priority treatment.

Projects recommended for advancement to the design stage are shown in Figure 1.

These projects are limited to construction or technology applications within existing street rights-of-way. Several projects would involve the removal of on-street parking spaces, or design deviations from the landscaping provisions of the City's Complete Streets guidelines. Other impacts include diversion of traffic to adjacent corridors, but generally without degradation of conditions in the affected corridors. An ongoing public involvement program is aimed at soliciting community input regarding the transit priority projects.

The transit priority projects for Route 44 are part of the Urban Village Transit Network (UVTN) described in the *Seattle Transit Plan* (2004). Targeted routes will connect neighborhoods in the City with frequent, reliable transit service, making it competitive with travel by private

automobile. With service every 15 minutes over 18 hours daily, travelers can use the UVTN routes without consulting bus schedules. The UVTN is intended to reduce reliance on single-occupant vehicle travel, improve air quality and reduce greenhouse gas emissions.

The objective of the project is to improve bus travel times by at least ten percent in both directions of travel during the morning, midday, and evening peak periods. At this level, Metro would provide additional service hours, potentially with 10-minute headways, further increasing the propensity of travelers to use transit.

Table 1 presents the travel time results from the traffic studies for the Route 44 improvements. Travel time improvements over ten percent are indicated for transit service in the outbound (westbound) direction of travel during the PM peak hour. In four other cases, travel time improvements exceed eight percent, but inbound travel during the midday hour would experience an improvement below five percent.

Table 1
Summary of Route 44 Travel Time Savings

		Existing Travel Time	Potential Savings	
Period	**Direction**	**(min)**	**(min)**	**(%)**
AM Peak	Inbound	34	2.8	8.2%
	Outbound	33	2.7	8.2%
Midday	Inbound	36	1.7	4.7%
	Outbound	37	3.5	9.6%
PM Peak	Inbound	38	3.1	8.1%
	Outbound	44	5.3	12.1%

Note: Inbound – Ballard to Montlake, Outbound – Montlake to Ballard
Source: HNTB Corporation, 2009.

Additional improvements in travel time may be associated with consolidation, relocation or closure of bus stops in the corridor. With closure of three stops in each direction, the objective of a ten percent or more travel time reduction would likely be met in four additional cases in Table 1. The selected program of transit priority projects provides a cost-effective approach to improving bus travel times in the corridor.

Figure 1
Route 44 Proposed Improvements

INTRODUCTION

The City of Seattle, in partnership with King County Metro, is investigating measures to improve the speed and reliability of bus travel on several high-ridership transit routes. These measures are intended to support the Urban Village Transit Network (UVTN) that will link neighborhood centers throughout the City with frequent transit service. Metro Route 44 will be the focus of various transit priority treatments in the corridor connecting the Ballard, Wallingford, University District, and Montlake neighborhoods shown on Figure 2.

Transit priority treatments would be applied in the NW and N Market Streets, N 46th Street, N and NE 45th Streets, 15th Avenue NE, and NE Pacific Street corridors where Route 44 operates. Among the transit priority treatments under consideration are the following:

- **Transit Signal Priority (TSP)** – At traffic signals, wireless TSP antennas will be used to communicate with the traffic signal system to provide a green signal indication to the approaching bus. It would serve as a "soft pre-emption" to normal signal operation, by extending the green indication, or terminating a conflicting red indication. In this way, delay for buses at intersections can be reduced.

- **Transit Queue Jump Lane** – At signalized intersections, a transit bus would be provided with a lane, adjacent to general-purpose traffic, and an advanced green signal indication, to bypass congested areas. This treatment would place buses ahead of queues of general-purpose traffic.

- **Business Access and Transit (BAT) Lane** – A curb lane, currently used for general-purpose traffic, would be reserved for exclusive use by buses and for general-purpose traffic right-turn movements onto cross streets and for access to adjacent properties. Through movements by general-purpose traffic would be prohibited in the curb lane at signalized cross streets. This treatment would reduce conflicts experienced by buses, and provide higher operating speeds.

- **Bus Bulbs/In-Line Transit Stops** – Buses stopping at street side pullouts frequently are trapped by passing vehicles, unable to return to the flow of traffic. By stopping in the lane of travel, the delays associated with merging back into traffic can be eliminated.

- **Bus Stop Consolidation/Relocation** – In some circumstances, the locations of transit stops can be adjusted to reduce their overall number, reducing bus travel times. King County Metro and SDOT have identified transit stops to be closed, independent of this corridor project.

Transit priority treatments are being implemented by the City in several corridors and their use is widespread in other urban areas. Their adoption is based on numerous factors involved with urban transportation. These include increasing land development densities, difficulties in serving additional travel demand with the private automobile, inability to expand transportation corridors for additional lanes and requirements to reduce emissions of air pollutants and greenhouse gases.

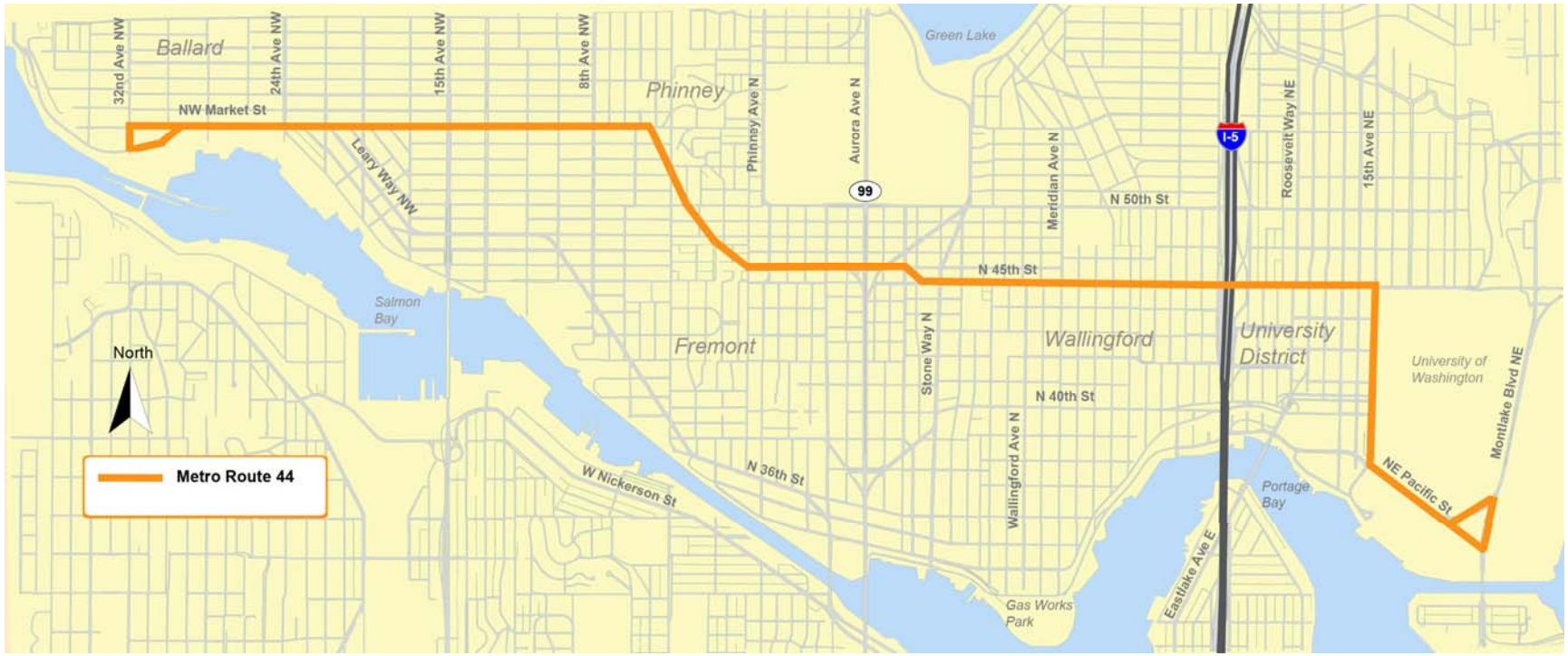


Figure 2
Route 44 Area Map

Policy Background

Policy direction for transportation planning in the City is established by the *Transportation Strategic Plan* (SDOT, 2005 Update). This document emphasizes planning for an enhanced role for public transportation in the City's transportation infrastructure. It addresses the adoption of the UVTN as the backbone of the City's transit system, carrying the highest concentration of transit riders. It also establishes goals for transit mode split, or the fraction of travelers choosing transit as their preferred mode.

Details of the UVTN are provided in the *Seattle Transit Plan* (SDOT, September, 2004). Corridors were defined as those in which transit operates every 15 minutes or more frequently through at least 18 hours of the day. These are the essential features of a transit system that enables it to effectively compete with the private automobile for all kinds of trips. Very frequent transit service with long service hours provides the freedom of movement that people associate with driving, such as the ability to make trips spontaneously, or to make multiple stops in the course of a trip.

Previous Studies

SDOT and Metro have conducted several studies on Route 44. In 1998, a Corridor Improvement Project study was conducted. In 2007, SDOT and Metro conducted a Route 44 UVTN Corridor Study. Both studies identified a variety of measures to be taken, including the implementation of signal priority, queue jump lanes, bus bulbs and bus lanes.

In the University District, the University Area Transportation Action Strategy (UATAS) was completed in 2008 as an update to SDOT's University Area Transportation Study (UATS) completed in 2002. The Action Strategy identified a project to provide a westbound Business Access and Transit (BAT) Lane on NE 45th Street between 7th and 15th Avenues, combined with prohibition of left turns at the intervening cross streets. Several queue jump lanes also were included in the recommendations.

Project Objectives

The objective of this traffic analysis is to compose a program of transit priority treatments that will provide at least a ten percent improvement in transit travel times in the corridor in both directions of travel during the AM, midday and PM analysis periods.

Organization of This Report

This report addresses the traffic operations impacts of the transit priority treatments proposed to serve the Route 44 corridor. Priority treatments were drawn from the previous studies and from an exploratory analysis of additional intersection/channelization/signal operation measures. A description and traffic analysis have been prepared for each potential application of particular priority treatments. In addition, a preliminary screening of the treatments was prepared to evaluate their effectiveness in reducing transit travel times, relative to their cost.

The analysis of alternatives also includes a cost analysis to judge the effectiveness of each project in attaining the travel time goals. Several alternatives are recommended for advancement to the design level.

TRAFFIC ANALYSIS AND ALTERNATIVES SCREENING APPROACH

Traffic Analysis Methodology

Traffic analysis for the Route 44 Transit Priority Corridor Improvements was performed to assess the opportunities for improving transit travel times along the route. A travel time survey was conducted on Wednesday, July 22 and Thursday, July 23, 2009 to collect end-to-end travel times, dwell time at transit stops, and delay data at signalized intersections. The survey covered the 6 to 9 AM, noon to 2 PM midday, and 3 to 6 PM periods.

End-to-end travel times were compared with the scheduled times of Route 44. Additional analysis revealed total dwell times and movement-specific intersection delay times for bus operations on the route. With this data, the sources of bus delay could be identified, and transit priority treatments targeted for these locations.

Route 44 passes through 43 signalized intersections, as shown on Figure 3. 35 of these locations were selected for intersection capacity analysis. The assessment includes analysis of overall intersection operations for the three weekday analysis periods. This analysis is based on traffic count data provided by the City and additional data collected during the week of August 4 through 7, 2009. Average weekday traffic (AWDT) count data was obtained from the City's 2006 Traffic Flow Map, augmented by other data sources dating back to 2001. Peak-hour intersection turning movement counts include data from 2006 through 2009.

The traffic analysis uses existing traffic volumes for the transit priority measures, because the project is intended for short-term (2011) implementation, pending the availability of funding. No forecasts of future traffic volumes were prepared. In the University District, previous studies included estimates of revised traffic patterns attributable to potential left-turn prohibition along NE 45th Street (*NE 45th Street BAT Westbound Lanes Memorandum*, Mirai Associates, January 4, 2008).

Operations analysis of the signalized intersections was assisted by the use of two software packages: Synchro 7 by TrafficWare and VISSIM 5.1 by PTV. Synchro provides estimates of intersection delay for specific movements and for the overall intersection, based on hourly volume input, signal phasing and timing, peaking patterns, truck and bus percentages, and pedestrian activity. Three Synchro models were available for the study corridor; all based on 2007 traffic data:

- A version used in the Route 44 UVTN Corridor Study, extending from NW Market Street on the west to the 15th Avenue NE/NE Pacific Street intersection on the east. It is characterized by reduced volumes in the University District area.

- A version used in the UATS reflecting higher volumes in the University District.

- A City version with more typical weekday volumes and current signal timings.

The City version of Synchro was selected for use in the traffic analyses along the Route 44 corridor. King County Metro has developed techniques to adapt the Synchro package for the analysis of transit priority treatments (*Travel Time Analysis Guidelines*, August 3, 2007). These guidelines were applied in estimating the effects of the various priority treatments at specific locations.

Detailed analysis of transit priority treatments in the University District and the Phinney/Wallingford areas was conducted using the VISSIM micro-simulation software. VISSIM explicitly simulates the traffic flow impacts of signal control strategies accompanying transit priority treatments, including signal priority, reserved lanes, queue jump lanes, and transit stop locations. Traffic signal timings from the City's Synchro model are also used in VISSIM. As a probabilistic model, ten simulation runs are performed for each AM, midday, and PM analysis period. Different random seed numbers are used for each run to vary the arrival rates of vehicles. Results are reported as the average values for all simulation runs.

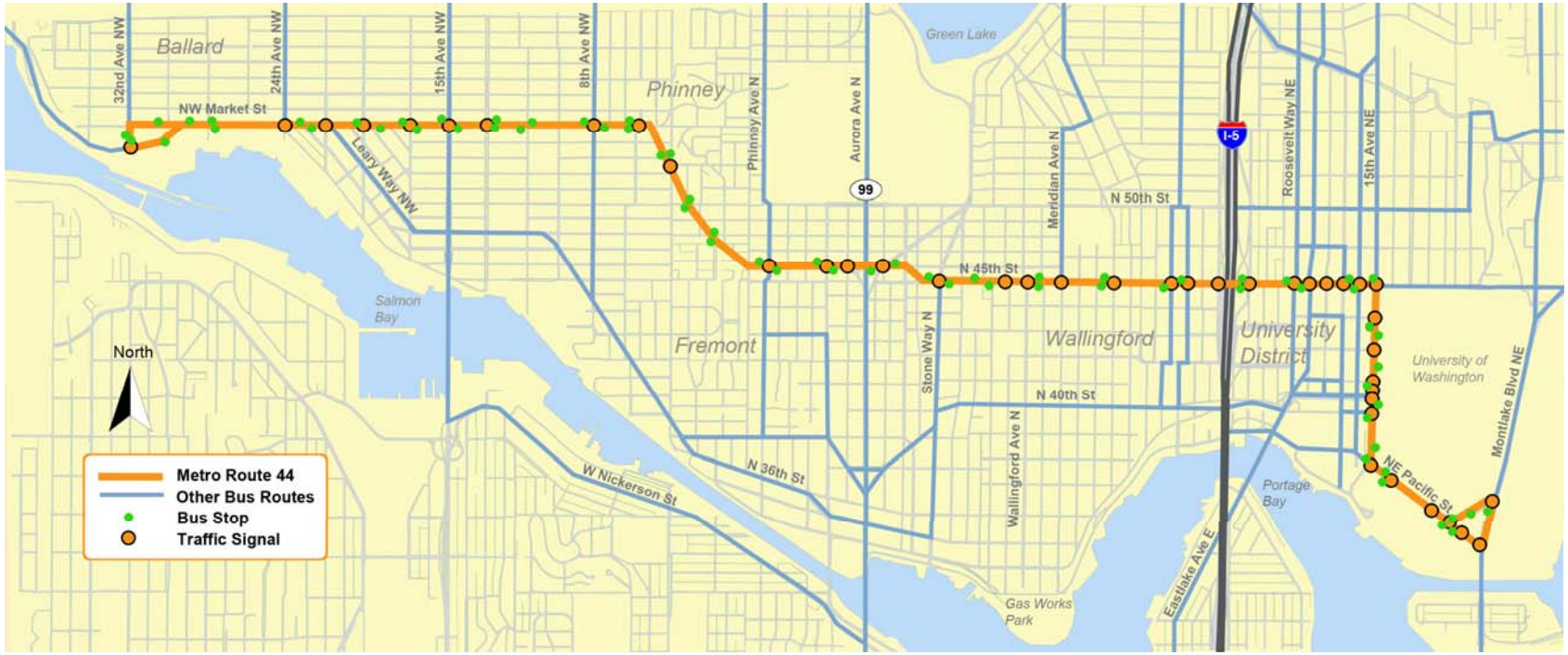


Figure 3
Route 44 Signalized Intersections

Alternatives Screening Approach

Evaluation of the transit priority projects for this corridor was conducted in two levels of screening. A first-level screening considered the traffic operations performance and transit benefits associated with the various transit priority projects. At the second level, an evaluation and screening of the engineering characteristics of projects and project impacts was conducted. Based on the combined performance of each alternative, a recommended package of projects was developed for implementation.

The first level screening relied on several quantitative measures of traffic operations performance prepared in the traffic technical analysis; and planning-level cost estimates. First level screening evaluation criteria were:

- **Travel time benefit to transit** – provides a gauge of the effectiveness of individual or combined transit priority projects
- **Overall intersection operation** – indicates the transit priority impacts on intersection delays for all traffic
- **Queue-related disruption** – addresses adverse impacts of traffic queues on bus movement
- **Diversion impacts** – considers impacts of traffic shifts to other corridors, and the associated adverse impacts to adjacent intersections
- **Cost effectiveness** – provides a comparison of benefits to relative cost of the transit priority projects and packages

Criteria in the second-level screening involved an evaluation of tradeoffs reflected in the proposed design of the individual transit priority projects. For the second-level screening, evaluation criteria were:

- **Conformance to design standards** – considers the engineering characteristics of the proposed design, including potential design exceptions
- **Complete Streets Ordinance** – addresses the adequacy of the project design features in supporting multimodal functions, and reflecting the community context and vision
- **Utilities impacts** – addresses needs and impacts of utility relocations
- **Urban forest cover impacts** – considers the impacts on street trees and corridor aesthetics
- **Parking and access impacts** – addresses the displacement of on-street parking and impacts to driveway access

EXISTING CONDITIONS

Route 44 Description

Metro Route 44 operates along an east-west corridor linking Ballard with the University District and Montlake. The corridor extends about 5½ miles, and comprises parts of NW Market Street, N 46th Street, N Midvale Place, N 45th Street, NE 45th Street, 15th Avenue NE, NE Pacific Street, NE Pacific Place, and Montlake Boulevard NE. Route 44 connects to more than 50 other transit routes at transfer points. The locations of bus stops and signalized intersections are presented on Figure 3.

Transit service is provided on Route 44 at headways of approximately 15 minutes over about 18 hours each day. At these service frequencies and span of service, the route is designated as part of the Urban Village Transit Network (UVTN) in the Seattle Transit Plan. Route 44 directly connects the Ballard, Wallingford, and University District urban villages.

Route 44 served approximately 6,000 weekday boardings during the fall 2008 period. Ridership is heavily influenced by commute travel, with 40 to 60 percent of the daily ridership occurring in the combined AM and PM weekday commute peak periods. Maximum loads are generally observed in the University District and Wallingford areas, where PM ridership reaches 50 persons on each bus in the outbound (westbound) direction. AM loads reach about 40 persons per bus in the inbound (eastbound) direction in these same areas. The lightest loads are observed in the reverse-peak directions of travel (AM outbound and PM inbound), with fewer than 10 persons per bus at many locations during daytime hours.

The busiest transit stops are located in the University District on NE 45th Street at University Way NE and at Brooklyn Avenue NE, each with over 750 patrons boarding and alighting daily. Next busiest are the stops along N 45th Street at Wallingford and Burke Avenues, with about 400 patrons daily. In Ballard, the busiest stops are on NW Market Street at Ballard Avenue and at 15th Avenue NW, with 300 to 400 patrons daily.

Transit Travel Times

Travel times on Route 44 were observed during a two-day period in July 2009. End-to-end travel times were recorded during weekday AM, midday, and PM periods. The scheduled and observed travel times are shown on Table 2. Scheduled travel times range between 33 and 44 minutes, and observed travel times range between 31 and 47 minutes.

Table 2
Average Travel Time – Route 44

Period	Direction	Scheduled Travel Time (minutes)	Measured Travel Time (minutes)	Dwell Delay (minutes)	Total Intersection Delay (minutes)	Top 5 Intersections Delay (minutes)
AM Peak	Inbound	34	36	8	9	4
	Outbound	33	31	5	7	4
Midday	Inbound	36	44	12	12	6
	Outbound	37	37	10	11	5
PM Peak	Inbound	38	44	11	16	9
	Outbound	44	47	10	17	8

Notes: Travel time and delay rounded to the nearest minute
Source: HNTB Corporation, 2009.

Table 2 also indicates the dwell times when riders were boarding and alighting. Cumulative dwell times of up to 11 minutes were observed during the PM peak periods, representing 20 to 25 percent of the total route travel time. Cumulative dwell times are highest for inbound (eastbound) travel during the midday period, reaching almost 12 minutes.

Delays associated with traffic control and queuing at intersections is also substantial, ranging from 7 minutes for outbound (westbound) travel during the AM period to 17 minutes for outbound (westbound) travel during the PM peak period. About half of the intersection delays occur at five locations along the route, varying by direction of travel and time of day.

The intersections where buses most frequently encounter delays are shown on Figure 4. The highest delays are routinely experienced at the N 46th Street/Green Lake Way N/SR 99 NB off-ramp intersection. Other intersections with significant delays include: N 46th Street/Fremont Avenue N, N 45th Street/Wallingford Avenue N, and NE 45th Street/15th Avenue NE. Details of the intersection delay analysis are provided in Appendix A.

Posted speeds are 30 mph for all city streets used by Route 44. End-to-end transit trips requiring 30 to 45 minutes correspond to travel speeds of 7 to 11 mph, with stops and delays included. At these levels, the transit trip is accomplished at 20 to 30 percent of the posted speed. On various sub-segments of the route, observed speeds are reduced to less than 20 percent of the speed limit. A primary goal of the transit priority program is to reduce delays and make transit travel times competitive with private automobile travel.

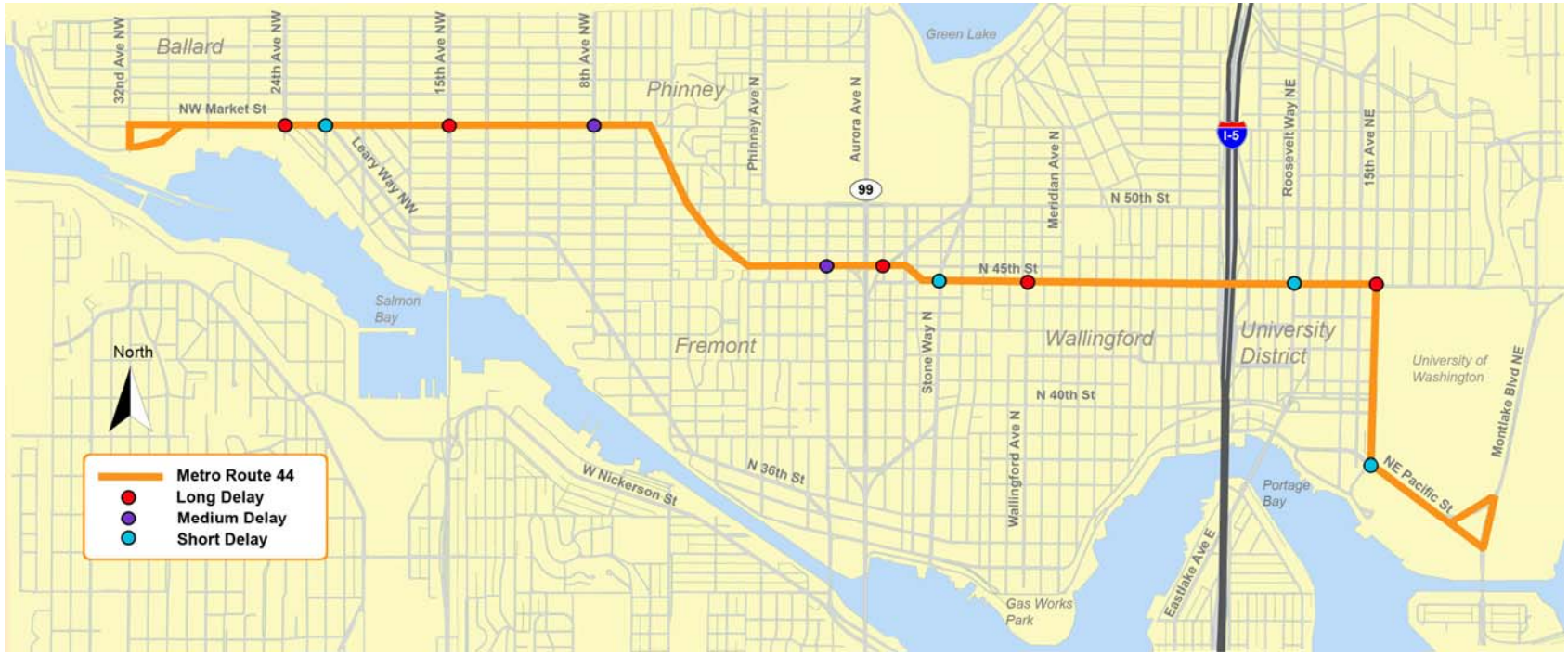


Figure 4
Route 44 Major Sources of Existing Delay

Street Inventory

The streets over which Route 44 operates are part of the City's arterial network serving the movement of automobiles, trucks, buses, bicycles and pedestrians. East-west travel within the corridor is severely limited by topographic constraints, making continuous east-west connections difficult in this part of the City.

Beginning at the west terminus in Ballard, Route 44 originates on NW Market Street at 32nd Avenue NW, where it connects to NW 54th Street. These streets all provide two travel lanes, one in each direction. East of 30th Avenue NW, NW Market Street provides four basic travel lanes, with parking on both sides. The four-lane segment extends east to approximately 6th Avenue NW; no on-street parking is provided east of 9th Avenue NW. NW Market Street turns southeast to climb Phinney Ridge. Two lanes are provided uphill (southeast-bound), but only one lane is provided downhill. N Market Street connects to N 46th Street at Greenwood Avenue N, where four lanes are provided east to Fremont Avenue N. No on-street parking is provided on N Market and N 46th Streets.

At the SR 99 underpass, two eastbound lanes are provided with a single lane extending east onto N Midvale Place. From N Midvale Place, two westbound lanes approach lanes are provided on N 46th Street, but the left lane must turn south onto SR 99, leaving a single westbound lane approaching Fremont Avenue N. On N Midvale Place, a single travel lane is provided in each direction connecting to N 45th Street.

In Wallingford, a single travel lane is provided in each direction, with a continuous center left-turn lane, and parking on both sides. East of Thackeray Place NE, NE 45th Street is comprised of four lanes, with off-peak parking allowed. Additional lanes are provided for turning traffic on the overpass above I-5.

In the University District, NE 45th Street provides four lanes with sections of two-way left turn lane and left-turn lanes at several intersections. Route 44 turns south onto 15th Avenue NE, where three lanes are provided north of NE 42nd Street, and four to five travel lanes south to NE Pacific Street. On NE Pacific Street, four lanes are provided, with auxiliary turning lanes at NE Pacific Place. Two lanes are provided on NE Pacific Place, with a bus layover located on the south side of the street. Montlake Boulevard NE provides four travel lanes adjacent to Husky Stadium, and buses are provided with a southbound auxiliary lane to return to NE Pacific Street.

Traffic Volumes and Patterns

The City's 2006 traffic flow map shows weekday traffic volumes along the Route 44 corridor range from about 20,000 vehicles per day (vpd) in the Ballard business district to 24,500 vpd east of 15th Avenue NW, 24,000 vpd in the Phinney area, and 24,100 vpd in the Wallingford business district. East of I-5, weekday volumes increase to almost 40,000 vpd along NE 45th Street. On 15th Avenue NE, weekday traffic volumes average about 18,000 vpd, and on NE Pacific Street, about 28,000 vpd. Montlake Boulevard NE carries about 45,000 vpd in the vicinity of Husky Stadium.

Peak-hour traffic flows occur during weekday AM and PM peak periods. Figure 5 presents the daily and hourly traffic volumes at several locations in the corridor. The highest hourly volumes

are experienced in the vicinity of I-5 on NE 45th Street, where directional hourly volumes exceed 1,000 vehicles per hour (vph). Directional volumes near 1,000 vph also are observed in the southbound direction on 15th Avenue NE in the AM peak hour, and on eastbound NE Pacific Street during the PM peak hour.

West of I-5, hourly traffic volumes are limited by the two-lane segments on N 45th Street and N Midvale Place. The highest directional hourly volumes approach 900 vph in these areas. Hourly volumes on NW Market Street range above 900 vph eastbound during the PM peak. In the Ballard business district, hourly volumes remain below 600 vph in both directions of travel during peak hours.

Hourly directional volumes of 900 to 1,000 vph generally indicate traffic operations near capacity in a single lane of travel. These maximum volumes typically represent the capacity of bottleneck intersections in the corridor and the resulting queues sometimes extend to disrupt operations at adjacent intersections. These conditions also can occur during midday periods where only a single directional travel lane is available.

Intersection operations in the corridor are characterized by level of service (LOS), defined according to control delay in Synchro Version 7. LOS A represents free flow with minimal delay, and LOS F represents jammed flow with queues. LOS D is considered a stable condition, and LOS E represents operations near capacity. Currently, LOS F is experienced at the NE 45th Street/7th Avenue NE intersection during the PM peak hour, and LOS E is experienced at the NW Market Street/24th Avenue NW, N 46th Street/Green Lake Way N/SR 99 NB off-ramp, and NE 45th Street/15th Avenue NE intersections. Eight intersections currently operate at LOS D.

Trucks represent two to ten percent of hourly traffic flows at most intersections in the corridor. Truck volumes are typically highest during the AM peak and midday periods, with the lowest truck volumes observed during the PM peak period. Intersections with high volumes of truck traffic (over five percent during AM/midday conditions) include NW Market Street/15th Avenue NW, NW Market Street/8th Avenue NW, N 45th Street/Stone Way N, N 45th Street/Wallingford Avenue N, NE 45th Street/15th Avenue NE, and 15th Avenue NE/NE Pacific Street. The higher volumes of heavy vehicles at the NE 45th Street/15th Avenue NE intersection include contributions by deadheading buses.

Route 44 overlaps with other bus routes along various segments of the corridor. Route 44 contributes four to five buses per hour in each direction of travel throughout the day. The overlapping routes contribute an additional five to ten bus trips hourly in Ballard and Wallingford. In the University District, this number expands to about 30 additional buses during the AM and PM periods. This includes several routes operated by Community Transit and Sound Transit.

Traffic Safety

NE 45th Street

Collision data was obtained for the four-year period between 2006 and 2009, inclusive, along NE 45th Street between 7th and 15th Avenues NE. During this period, a total of 285 collisions were reported, with 86 of those (30 percent) involving injuries. There were 98 sideswipe crashes (34

percent), potentially reflecting the narrow lane widths in this corridor. Another 51 crashes (18 percent) were rear-end types, typically associated with congested traffic operations. There were a total of 50 right-angle collisions (17 percent) in the NE 45th Street corridor, including both intersection and midblock locations. Another 21 collisions (7 percent) involved left-turning vehicles.

Intersections with the highest number of collisions include NE 45th Street/11th Avenue NE (29 crashes), NE 45th Street/Roosevelt Way NE (26 crashes), NE 45th Street/7th Avenue NE (18 crashes), and NE 45th Street/Brooklyn Avenue NE (12 crashes). Although none of these locations exceeds the City's current criteria for designation as a high-accident intersection (ten crashes per year), they represent about 30 percent of all collisions in the corridor.

At individual intersections, the highest number of left-turn collisions occurred at the NE 45th Street/Roosevelt Way NE intersection, with seven crashes related to left-turning vehicles. The intersection at NE 45th Street/Brooklyn Avenue NE recorded three left-turn collisions during the analysis period.

In summary, the NE 45th Street corridor is characterized by congested traffic operations and non-standard lane widths. These conditions lead to high levels of rear-end and sideswipe collisions, respectively. At the signalized intersections, protected left-turn phasing is provided, which is generally recognized to reduce collision frequency when left-turn volumes are substantial. The protected left-turn phasing, combined with exclusive left-turn lanes, produces moderate rates of left-turn collisions.

Historical collision data along NE 45th Street was also available from the 1991-1996 period when the corridor operated with the current lane configuration, but without the protected left turns onto the cross streets. At the NE 45th Street/Roosevelt Way NE intersection, there were 9 left-turn collisions with the permissive traffic signal control. At the NE 45th Street/Brooklyn Avenue NE intersection, there were 22 left-turn collisions with the previous control strategy. Thus, the Brooklyn intersection has seen a decrease in left-turn collisions (from 3.7 to 0.75 annually), while the Roosevelt intersection has remained stable (1.5 to 1.75 annually).

NE 50th Street

Collision data was obtained for the NE 50th Street corridor for the six-year period between 2004 and 2009, inclusive, between 7th and 15th Avenues NE. During this period, there were 341 collisions, with 149 of those (44 percent) involving injuries. In this corridor, the predominant collision types are right-angle and left-turn collisions, together accounting for 45 percent of all collisions. Rear-end and sideswipe collisions account for only 21 percent of all collisions in this corridor. Intersections with the highest number of collisions include NE 50th Street/15th Avenue NE (43) crashes), NE 50th Street/Brooklyn Avenue NE (38 crashes), and NE 50th Street/University Way NE (36 crashes). There were 17 left-turn collisions at the NE 50th Street/15th Avenue NE intersection, 15 left-turn collisions at the NE 50th Street/Brooklyn Avenue NE intersection, and 11 left-turn collisions at the NE 50th Street/University Way NE intersection

NE 50th Street provides standard lane widths and experiences less severe congestion compared to NE 45th Street, resulting in fewer sideswipe and rear-end collisions. The frequencies of right-angle and left-turn collisions along NE 50th Street are higher compared to NE 45th Street. These

characteristics may reflect the absence of exclusive left-turn lanes and the application of permissive signal control in this corridor.

Safety Summary

The different collision patterns in the two corridors illustrate the trade-offs between street design parameters and traffic signal operating strategies. NE 45th Street experiences about 75 collisions annually, while NE 50th Street experiences about 55 collisions annually. The NE 45th Street corridor provides exclusive left-turn lanes and protected left-turn signal phasing, with the result that right-angle and left-turn collisions are few. The compromises of lane width produce comparatively higher sideswipe collision frequencies. The protected signal phases produce higher delay at intersections, aggravating congestion, and producing higher frequencies of rear-end collisions. The protected left-turn phasing is required by the relatively higher volumes of left-turning vehicles and their opposing volumes.

The overall lower frequency of collisions along NE 50th Street is related to lower volumes of through traffic and cross street traffic. Lower volumes of left turns make permissive control of left turns possible, but with higher frequencies of right-angle and left-turn collisions. Protected control of left turns would require exclusive left-turn lanes, introducing higher frequencies of sideswipe collisions associated with compromises of lane width. Introduction of protected control also would increase delays and congestion in the corridor, increasing the rates of rear-end collisions.

Figure 5
Existing Traffic Volumes

TRANSIT IMPROVEMENT ALTERNATIVES AND ANALYSIS

Alternatives for improving travel times on Route 44 have been developed using the toolbox of transit priority measures described in the Introduction. These measures are subjected to a detailed traffic analysis to reveal their effectiveness in improving transit travel times in the corridor, and their impacts on general traffic flow at the affected intersections. The alternatives are described and their effects summarized by location, with the University District and Phinney/Wallingford areas highlighted.

University District Potential Transit Priority Projects

Previous studies have evaluated several transit priority concepts along NE 45th Street in the University District. The recommended projects from the University Area Transportation Action Strategy included prohibition of east-west left turns between 8th Avenue NE and University Way NE, and conversion of the lane thus made available to a westbound Business Access and Transit (BAT) lane. In this direction, the BAT lane would respond to the higher level of delay in the outbound direction of Route 44 operation. The Route 44 UVTN Corridor Study investigated the potential for a northbound bus queue jump lane from 15th Avenue NE onto westbound NE 45th Street, and a westbound queue jump lane at 7th Avenue NE. Transit signal priority also was recommended for intersections along NE 45th Street and 15th Avenue NE south to NE Pacific Street.

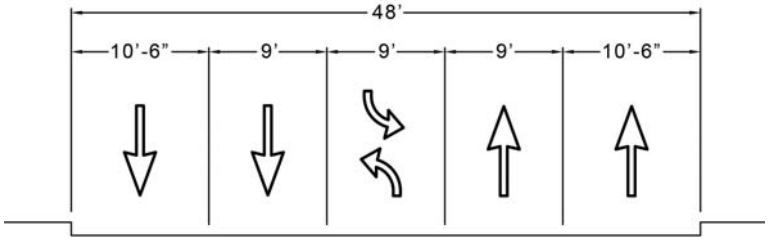
NE 45th Street Cross-Section

The existing width between curbs along NE 45th Street is 48 feet, striped for curb lanes 10.5 feet wide, and three lanes at nine feet in width, as shown on Figure 6. Conversion to a westbound BAT lane would retain the curb lane widths of 10.5 feet, and would place westbound general purpose traffic in two lanes of nine-foot width. This width would be insufficient for the safe operation of trucks, particularly with buses operating in an adjacent lane. Restriping to provide a 10-foot westbound general purpose lane would further reduce curb lane widths to 10 feet. Buses could not operate safely in these conditions, because the width of the bus with mirrors is 9.5 feet.

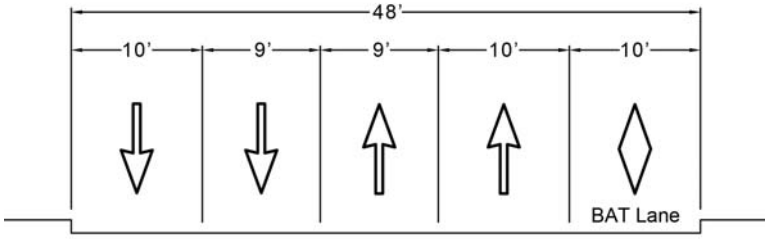
In another variant of this layout, westbound trucks might be allowed to use the curb (BAT) lane, but many trucks are likely destined for southbound I-5, requiring two lane changes downstream. It is not recommended to convert the existing cross-section on NE 45th Street to the proposed BAT lane configuration.

Current City design standards indicate a minimum lane width for through lanes of 10 feet and desirable lane width of 11 feet, and Metro design standards are 11 feet (minimum) or 12 to 13 feet (desirable) for a bus lane. With five lanes in the corridor, application of these standards would result in a widening to provide 53 feet (minimum) or 57 feet (desirable). Sidewalk widths along NE 45th Street, typically 11 feet or less, would not permit roadway widening of five or nine feet. Widening would produce adverse effects on sidewalk capacity and activity, and reduce opportunities for landscape planting. No scenario of continuous widening was carried forward for this segment of NE 45th Street.

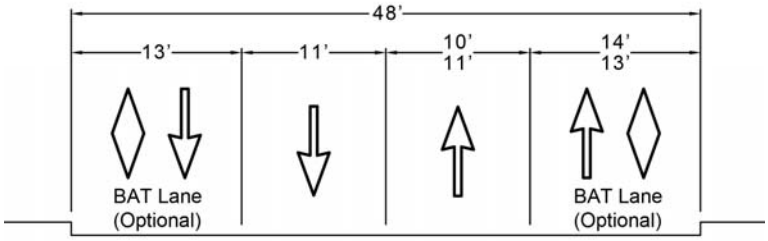
Another option for this area would be to restripe NE 45th Street to four lanes with left turns prohibited. This option is also shown on Figure 6. An advantage of this option is that curb lanes of 13 or 14 feet in width would be created, providing better accommodation for buses, right-turning traffic, and bicycles. The four-lane cross-section is analyzed with and without a reserved lane for BAT operation.



Existing Condition



Five Lane With BAT Lane Westbound



Four Lane With Optional BAT Lane Eastbound And Westbound

Figure 6
NE 45th Street Cross-Section Options (7th to 15th Avenues NE)

NE 45th Street Traffic Diversions and Mitigation

The westbound BAT lane outlined in the UATAS study, or any re-striping of NE 45th Street would result in the prohibition of left turns along NE 45th Street. The left-turn prohibition can be expected to produce diversions of traffic to other corridors.

In the westbound direction, the left turn at 15th Avenue NE would remain, and would absorb about 70 PM peak-hour trips of a total of 250 vph affected. A replacement turning route using northbound 11th Avenue NE and westbound NE 47th Street, onto southbound Roosevelt Way NE would be used by approximately 140 PM peak-hour trips. Eastbound left turns could choose to divert to the I-5 northbound ramp at NE 50th Street, remain on northbound 7th Avenue NE or turn at 15th Avenue NE. Diversion impacts attributable to peak hour left-turn prohibitions are presented in Appendix C.

The traffic analysis considers the impacts of diverted left turns in the individual intersection operations estimates. Overall, a four-lane cross-section along NE 45th Street, with left turns prohibited, provides improved traffic operations along the corridor. It would remove the exclusive left-turn lanes and associated protected left-turn signal phases, with the signal green time reallocated to through movements. The redistribution of signal green time is expected to improve traffic operations both for buses and general traffic. An associated benefit would be a decline in congestion-related rear-end collisions. The use of standard lane widths also may contribute to a decrease in sideswipe collisions.

Several strategies were investigated to balance the traffic operations advantages of prohibiting left-turn movements on NE 45th Street and the access needs for local businesses and residents. These strategies, summarized in Table 3, include: 6 AM to 7 PM turn restrictions, AM and PM peak hour-only turn restrictions, east-west split phase signal operation at the Brooklyn Avenue NE and Roosevelt Way NE intersections, protected left-turn signal operation at the Brooklyn Avenue NE and Roosevelt Way NE intersections, and 24-hour left-turn restrictions on NE 45th Street between 8th Avenue NE and University Way NE.

The use of protected or permissive left turn signalization during peak traffic periods in the four-lane cross-section along NE 45th Street is not recommended. Volumes of through traffic opposing these turns suggests that permissive turn treatment would introduce higher rates of right-angle and left-turn collisions. A protected turn treatment would effectively relinquish the inside lanes to left-turn storage, reducing through capacity to a single lane in each direction. As noted on Table 3, both of these approaches would result in congested operations at intersections potentially selected for protected treatment.

Two left-turn operational strategies could be recommended: the 24-hour left-turn restrictions, or the 6 AM to 7 PM left-turn restriction. These strategies provide the best traffic operations and traveler safety through the NE 45th Street corridor. Specific hours for the overnight left-turns should be reviewed further in the design process. Traffic volumes on NE 45th Street between 7 PM and 8 PM are comparable to the evening peak hour. Traffic volumes in the morning remain low until after 7 AM; a reasonable left-turn restriction could be 7 AM to 8 PM.

Table 3
NE 45th Street Left-Turn Operations Strategies

Strategy	Pros	Cons	Recommendation
4-lane NE 45th St: east-west split phase operation at Brooklyn Ave NE and Roosevelt Way NE	EB and WB left-turn access would be maintained at Brooklyn Ave, along with the WB left-turn at Roosevelt Way	Intersection operations would deteriorate to LOS F at Roosevelt Way, 11th Ave and Brooklyn Ave during the PM peak hour	Not Recommended
4-lane NE 45th St: protected left-turn operation at Brooklyn Ave NE (EB) and Roosevelt Way NE (WB)	Left-turn access would be maintained for EB traffic at Brooklyn Ave and WB traffic at Roosevelt Way	Intersection operations would deteriorate to LOS F at Roosevelt Way and Brooklyn Ave during the PM peak hour	Not Recommended
4-lane NE 45th St: AM and PM peak hour-only turn restrictions	Left-turn access would be maintained for EB traffic at Brooklyn Ave and WB traffic at Roosevelt Way during midday and overnight hours.	Queues would form at Roosevelt Way and Brooklyn Ave, blocking upstream intersections during midday hours.	Not Recommended
4-lane NE 45th St: 6 AM to 7 PM left-turn restrictions between 8th Ave NE and University Way NE.	Left-turn access would be maintained for EB traffic at Brooklyn Ave and WB traffic at Roosevelt Way during overnight hours.	Queues would form at Roosevelt Way and Brooklyn Ave, blocking upstream intersections, until traffic volumes decrease in the evening.	Recommended
4-lane NE 45th St: 24-hour left-turn restrictions between 8th Ave NE and University Way NE.	Intersection levels-of-service generally are improved over existing conditions. Transit and general purpose travel times also improve through the corridor	Left-turning traffic is diverted to adjacent corridors.	Recommended and Preferred

Note: intersection LOS and queuing analysis performed with Synchro 7/SimTraffic software.
Source: HNTB Corporation, 2010.

Delays at intersections affected by diverted traffic generally would increase by fewer than ten seconds per vehicle, and Levels of Service would be affected at two locations outside the study corridor in the PM peak hour. The NE 47th Street/Roosevelt Way NE and NE 50th Street/11th Avenue NE intersections would shift from LOS C to LOS D. Levels of Service would be affected at two locations along the study corridor in the PM peak hour. The NE 45th Street/University Way NE intersection would shift from LOS B to LOS C and the NE 45th Street/15th Avenue NE intersection would shift from LOS E to LOS F. The traffic signals at NE 47th Street/Roosevelt Way NE and NE 50th Street/11th Avenue NE should be retimed to mitigate the impacts of diverted left-turn traffic.

If the northbound left-turn lane at the NE 45th Street/15th Avenue NE intersection is used as a queue jump lane, general purpose traffic would be diverted to adjacent routes. Diversions onto NE 50th Street, NE 47th Street, NE 43rd Street and NE 42nd Street could be expected. The northbound left-turn lane at NE 45th Street/15th Avenue NE is recommended to be an all-day operation of the transit queue jump due to safety and signal operations concerns.

A possible mitigation measure for the increased northbound left-turn demand at the NE 42nd Street/15th Avenue NE intersection would be the construction of a dedicated left-turn lane. A turn pocket length of 100 feet would provide adequate storage for left-turning traffic. Intersection operations would remain at an acceptable level during the PM peak hour with this modification.

Additional diversions would be associated with reserving the curb lanes on NE 45th Street for BAT operation. In this configuration, general purpose traffic would be limited to a single travel lane in each direction. Diversions of up to 300 vph in each direction during the PM peak hour could result from this action. Traffic would be diverted to NE 43rd, NE 47th and NE 50th Streets.

Several of the diversion scenarios would place additional traffic demand at the NE 50th Street/15th Avenue NE intersection. The University Area Transportation Action Strategy considered a project to restripe this intersection to provide east-west left turn lanes and protected left-turn signalization at this location. It also recommended prohibition of on-street parking along 15th Avenue NE north and south of the NE 50th Street intersection. Permanent parking restrictions on the east side of 15th Avenue NE should extend for at least 300 feet south of the intersection, in order to provide a dedicated left-turn lane for this movement. This intersection also experiences left-turn collisions which may be addressed by this proposed mitigation measure.

With a dedicated northbound left-turn lane, delays for this movement would increase about 20 seconds with the combined diversions associated with left-turn prohibitions on NE 45th Street and on 15th Avenue NE northbound at NE 45th Street, providing LOS C for the movement. Delays for the northbound left turn would increase about 40 seconds with the combined diversions associated with BAT operation on NE 45th Street, left-turn prohibitions on NE 45th Street and on 15th Avenue NE northbound at NE 45th Street, providing LOS E for the movement.

To mitigate the increased westbound left-turn demand at the NE 45th Street/15th Avenue NE intersection, the turn pocket could be extended to the east approximately 150 feet, so it is back-to-back with the eastbound left-turn pocket at 17th Avenue NE. This would require prohibiting left-turns into and out of 16th Avenue NE. Turn volumes at 16th Avenue NE are generally light and could be shifted to other locations.

Traffic operations impacts for the diversion scenario including the prohibition of east/west left-turns on NE 45th Street between 8th Avenue NE and University Way NE, and the transit-only use of the northbound left-turn lane at NE 45th Street/15th Avenue NE are shown in Appendix C.

Potential Queue Jump Locations

At the NE 45th Street/15th Avenue NE intersection, three channelization and signal operation options were reviewed to investigate the potential application of a northbound queue jump lane onto westbound NE 45th Street. Delays for buses making the northbound left turn during the PM peak hour reach almost 1½ minutes.

The conceptual channelization and signal operations strategies shown in Figure 7 were evaluated with Synchro. Option A would retain the existing five-lane section on NE 45th Street, Options B and C would extend the four-lane concept to include this intersection. Split-phase signal operation was required in most instances, resulting in distinctly poorer intersection operations compared to existing conditions.

Another potential queue jump could be developed by reserving the northbound left-turn lane at the NE 45th Street/15th Avenue NE intersection for buses only during peak periods. General purpose traffic would be diverted to other routes during these weekday hours. Some diverted left-turn traffic would continue in the northbound through movement to NE 47th or NE 50th Streets. Other vehicles would shift onto NE 42nd or NE 43rd Streets to connect to 11th Avenue NE.

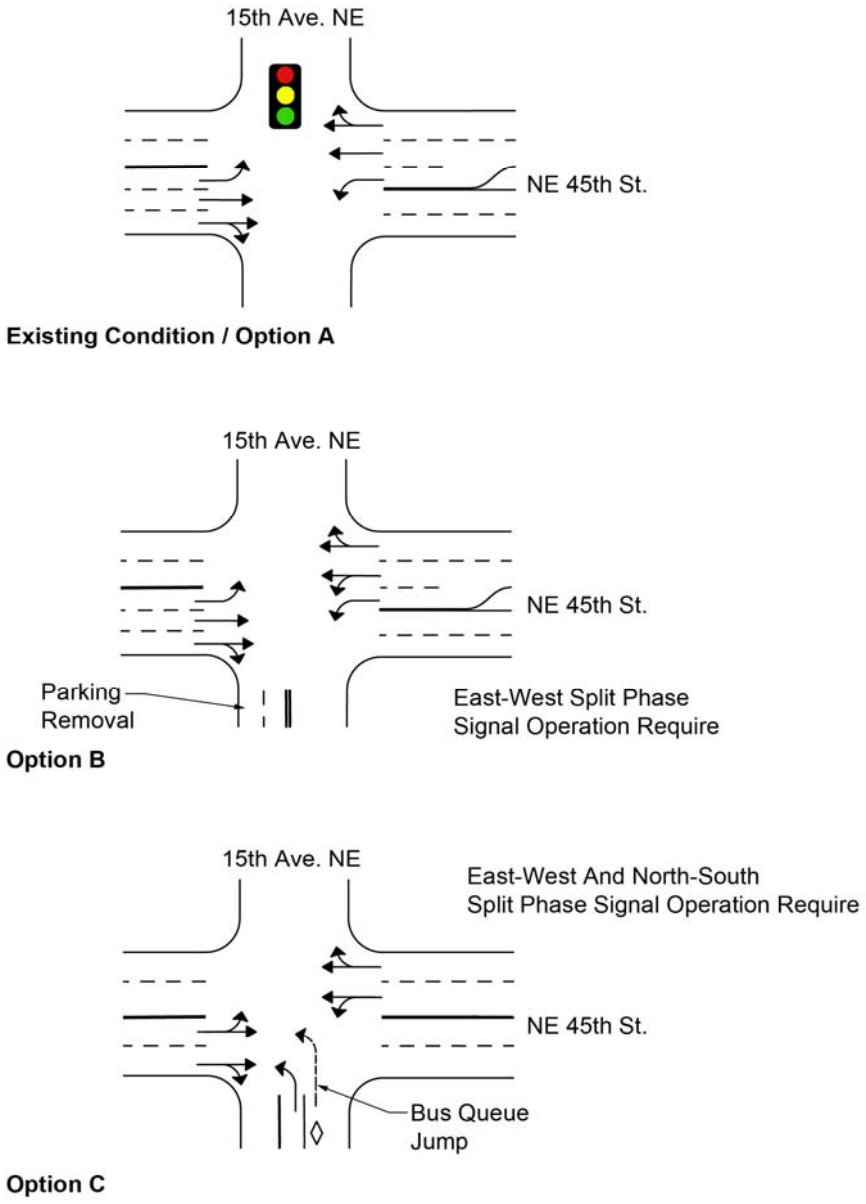


Figure 7
NE 45th Street/15th Avenue NE Intersection Options

One option explored the potential for Route 44 buses to turn left from the northbound through lane on 15th Avenue NE. This operation would require that buses turn concurrently with the northbound left-turn movement, and assumes a single-unit truck would be present among the turning traffic. As shown in the top of Figure 8, the turning envelope for a bus ("A-Bus" design vehicle) would conflict with that of a single unit truck ("SU" design vehicle) in the adjacent lane. Even with a passenger car ("P" design vehicle) turning left in the adjacent lane (bottom of

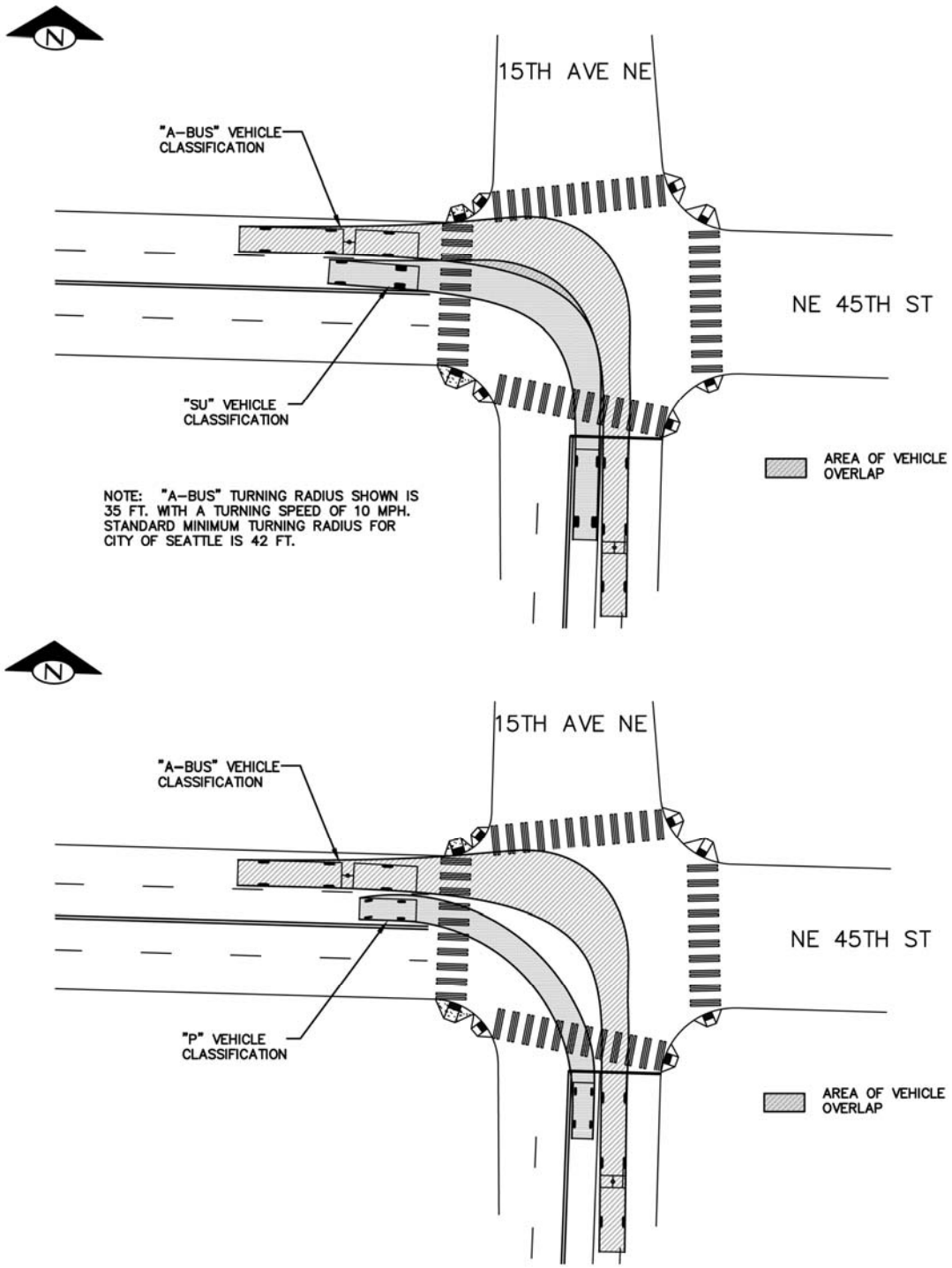


Figure 8
NE 45th Street/15th Avenue NE Turn Template Analysis

Figure 8), the turning paths fail to provide the recommended four feet of clearance between the vehicles. The path of a B Bus (not shown) also would conflict with the SU vehicle turning simultaneously.

These exploratory analyses indicate that channelization modifications at the NE 45th Street/15th Avenue NE intersection to utilize dual left-turn lanes and improve overall operations are not feasible. In the development of alternatives for the University District, the existing channelization and signal operations plan is retained at this intersection.

A queue jump lane for westbound Route 44 buses on NE 45th Street was evaluated at the intersection with 7th Avenue NE. Buses experience about 1½ minutes of delay at this location during the PM peak hour. In the Route 44 UVTN Corridor Study, a concept for modifying the westbound channelization was developed, but it featured a severe offset for the westbound through lanes crossing the intersection. Offsets of four to six feet are considered acceptable in urban settings, but the proposed concept incorporated an offset of over nine feet, representing a full lane width. This design was considered unacceptable for further development.

A westbound queue jump lane at the NE 45th Street/7th Avenue NE intersection would require widening of NE 45th Street to provide the additional lane and to reduce offset to an acceptable level. To effectively bypass existing queues, the widening would extend between 7th and 8th Avenues NE. The widening would reduce sidewalk width on both sides of NE 45th Street to eight feet. It would involve relocation of utility poles and loss of street trees. This alternative was carried forward for conceptual analysis because the benefits for Route 44 could be significant.

University District Alternatives Description

The existing baseline condition and four alternatives were examined for NE 45th Street using the VISSIM simulation software:

- Baseline condition maintains existing channelization and east-west left-turn movements.
- Alternative 1 provides a four-lane cross-section and prohibits east-west left turns along NE 45th Street between Roosevelt Avenue NE and University Way NE. See Figure 9.
- Alternative 2 provides a four-lane cross-section, prohibits left turns, and includes transit signal priority at intersections from 7th to 15th Avenues NE. See Figure 10.
- Alternative 3 provides a four-lane cross-section, prohibits east-west left turns, includes signal priority, and provides a westbound queue jump lane on NE 45th Street at 7th Avenue NE. This alternative requires widening of NE 45th Street between 7th and 8th Avenues NE, narrowing the sidewalks three feet on the north and two feet on the south. See Figure 11.
- Alternative 4 provides a four-lane cross-section, prohibits east-west left turns, includes signal priority, and reserves the curb lanes in both directions for peak-period BAT operation. See Figure 12.

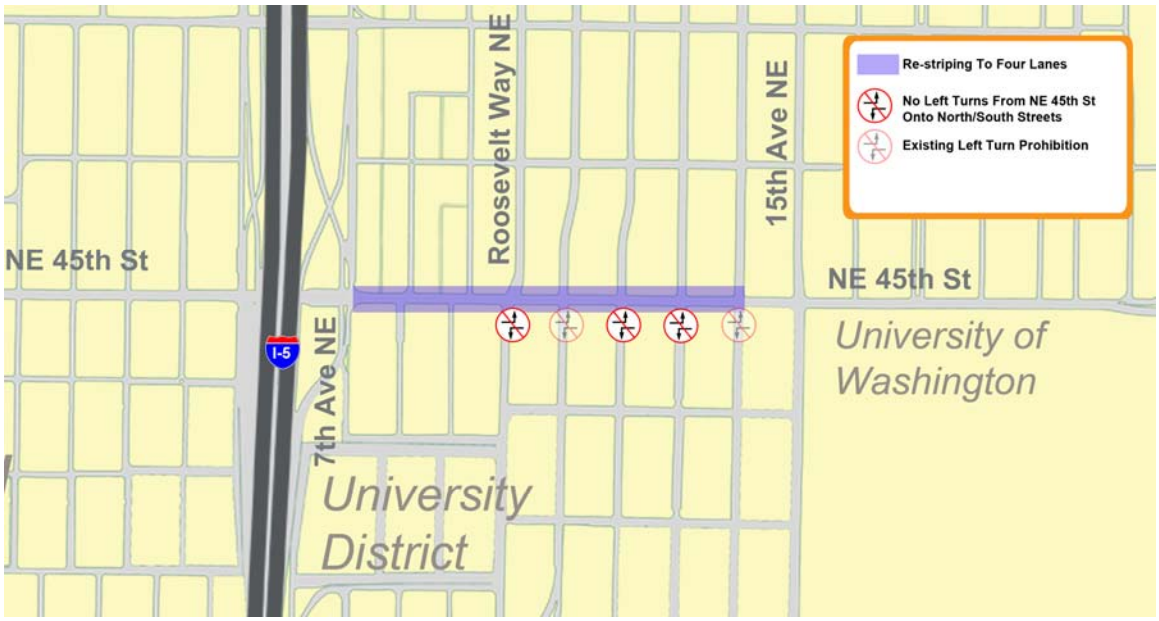


Figure 9
University District Alternative 1

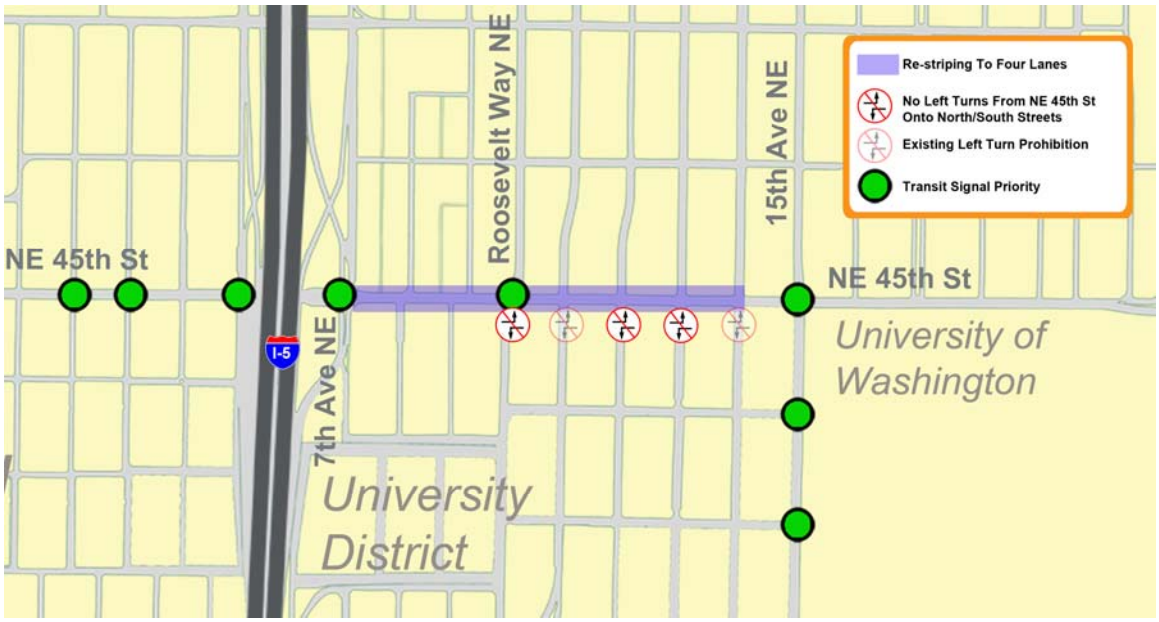


Figure 10
University District Alternative 2

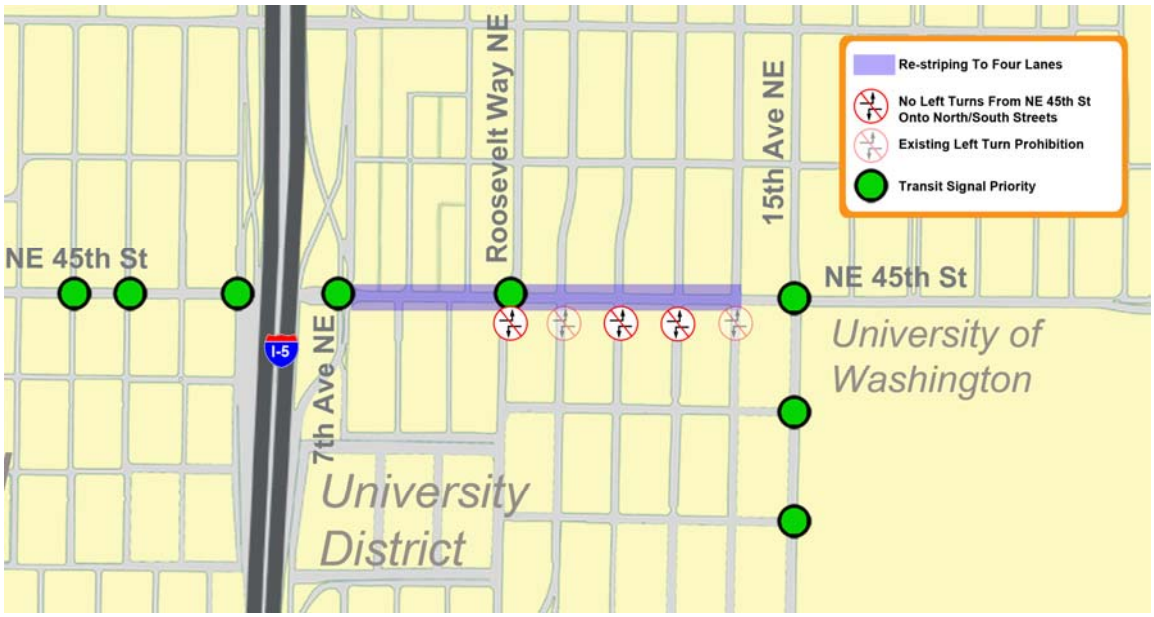


Figure 11
University District Alternative 3

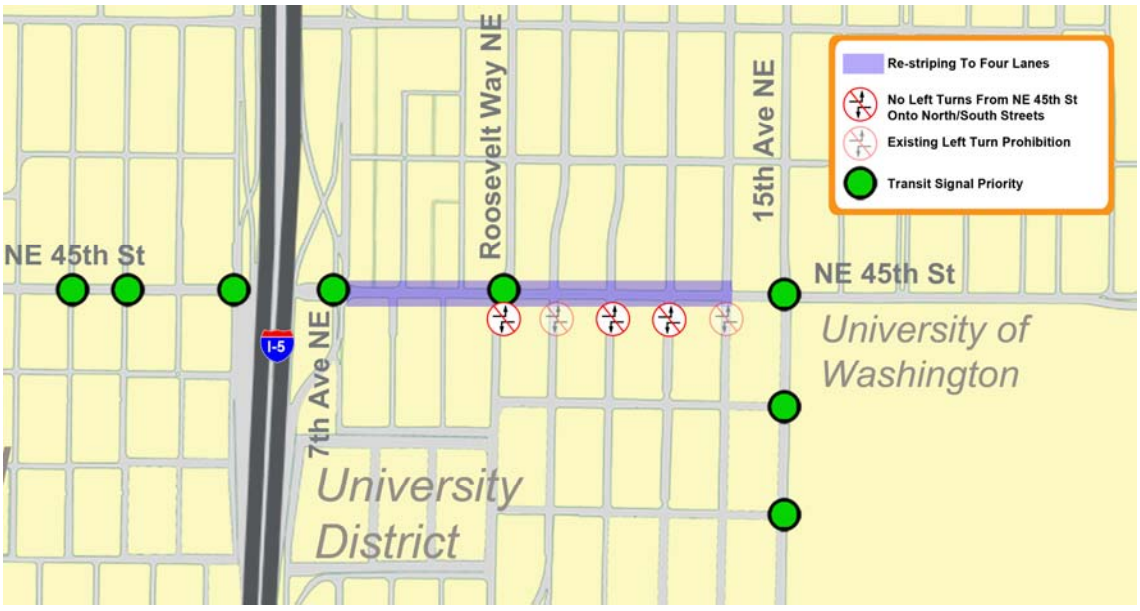


Figure 12
University District Alternative 4

Analysis Results

With the four-lane cross-section, buses would experience improved travel times and operating speeds. Table 4 presents the traffic operations results for the University District alternatives. Travel times are shown for Route 44 between 5th Avenue NE on NE 45th street and NE 43rd Street on 15th Avenue NE. For the University District intersections, overall intersection operations during the PM peak hour would improve to LOS C at the Roosevelt Avenue NE and Brooklyn Avenue NE intersections, compared to LOS D with existing left-turn movements.

In Alternatives 2 through 4, transit signal priority would be implemented for westbound buses at the NE 45th Street/7th Avenue NE intersection, both directions at Roosevelt Avenue NE, and eastbound buses at the NE 45th Street/15th Avenue NE intersection. Other applications of transit signal priority proved to be less effective, particularly for northbound buses at the NE 45th Street/15th Avenue NE intersection.

Overall improvements in bus travel times for the PM peak hour for Alternatives 1, 2, and 3 average about 1½ minutes in the inbound (eastbound) direction and 20 to 30 seconds in the outbound (westbound) direction. Bus delays would be reduced by about 20 seconds for the northbound left turn at the NE 45th Street/15th Avenue NE intersection even without transit signal priority.

Other analysis results include:

- Prohibition of northbound left turns at the NE 45th St/15th Ave NE intersection, for general purpose traffic, would produce a benefit of about 13 seconds for outbound travel in the PM peak hour, with similar benefits for the AM and midday periods.

- At the NE 45th Street/7th Avenue NE intersection, Alternative 3 would produce fewer than 10 seconds of benefit relative to Alternative 2 during the PM peak hour. At other times of day, savings attributable to the added westbound queue jump/right-turn lane would be minimal.

- In Alternative 4, reserved BAT lanes on NE 45th Street would reduce bus travel times in the outbound direction by over 35 seconds, but benefits in the inbound direction would be diminished to fewer than 60 seconds, compared to Alternative 1, 2, and 3.

- Queue lengths of eastbound traffic along NE 45th Street at 7th Avenue NE would be improved by Alternatives 1 through 3. Queues of westbound traffic at 15th Avenue NE would increase about 300 feet, extending back to 17th Avenue NE. In Alternative 4, queues would be reduced at both locations, attributable primarily to the impacts of additional traffic diversion to other corridor.

Table 4
University District Alternatives – Modeled Route 44 Travel Times

	Alternative	Inbound (sec)	Change (sec)	Outbound (sec)	Change (sec)
AM Peak	Baseline	383		281	
	Alternative 1	430	+47	296	+15
	Alternative 2	347	-36	293	+12
	Alternative 3	358	-25	287	+6
	Alternative 4	323	-60	296	+15
Midday	Baseline	335		345	
	Alternative 1	330	-5	350	+5
	Alternative 2	322	-13	346	+1
	Alternative 3	326	-9	332	-13
	Alternative 4	319	-16	335	-10
PM Peak	Baseline	483		426	
	Alternative 1	382	-101	400	-26
	Alternative 2	376	-107	404	-22
	Alternative 3	376	-107	395	-31
	Alternative 4	426	-57	389	-37

Note: Modeled travel times reported from VISSIM are between 5th Avenue NE / NE 45th Street and 15th Avenue NE / NE 43rd Street
Source: HNTB Corporation, 2009.

Alternatives Screening

The various transit priority alternatives for the University District are evaluated in two levels of screening to assess their applicability to the Route 44 corridor. The first-level screening addresses factors associated with traffic operations performance of the various transit priority treatments. The second-level screening addresses conformance with design standards and the City's street design guidelines, community impacts, utility relocation, tree impacts, and effects on parking and local access.

First-level screening results for the University District alternatives are provided in Table 5. Alternatives 1 and 2 provide the best traffic performance relative to their costs for this area. Both include the four-lane cross-section along NE 45th Street, and Alternative 2 includes limited transit signal priority operation. Alternative 3 provides additional operational benefits at the NE 45th Street/7th Avenue NE intersection by virtue of the westbound queue jump/right-turn lane, but at a penalty of additional cost for widening.

Alternative 4, with the reserved BAT lane provides marginal benefits in bus travel times for the University District area, but with additional diversion impacts to other corridors.

The second-level screening in Table 6 gauges the impacts of the alternatives on the adjacent properties and neighborhoods, and compliance with engineering standards and Complete Streets

parameters. Alternative 1 restores standard lane widths with the prohibition of left turns along NE 45th Street, and provides a better environment for bicycle travel. Alternative 2, adding TSP to signal operations at five locations, performs identically to Alternative 1. With Alternative 3, a westbound queue jump lane would be provided at the NE 45th Street/7th Avenue NE intersection, requiring widening of NE 45th Street in the block between 7th and 8th Avenues NE. This widening produces negative impacts related to utility relocation, sidewalk width, and planting strips on both sides of the street. The Alternative 4 BAT lane performs similarly to Alternatives 1 and 2 with regard to the second-level impact criteria.

Overall rankings from the first- and second-level screenings indicate that Alternative 2 provides the optimal combination of positive impacts in the University District. It produces significant travel time benefits for bus movement with a manageable level of traffic diversion to other corridors.

Table 5
University District Alternatives – First Level Screening Matrix

	Travel Time Savings	Overall Intersection Delay	Queue Impacts	Traffic Diversion Impacts	Relative Cost
University District					
Baseline	○	○	○	○	NA
Alternative 1	●	◖	○	○	●
Alternative 2	●	◖	○	○	◖
Alternative 3	●	◖	○	○	○
Alternative 4	●	○	◗	◗	◖

Legend:							
●	Significant Benefit	◖	Positive	○	Neutral / No Effect	◗	Negative

Source: HNTB Corporation, 2009.

Table 6
University District Alternatives – Second Level Screening Matrix

				COMPLETE STREETS PRIMARY DESIGN FEATURES			
University District	Design standard conformance	Parking & access impacts	Utilities Impacts	Wide sidewalks and planting strip	Street trees and landscaping	Signed and/or striped bicycle lanes on designated bicycle routes	Short term, on street parking
Road Classification - Mixed Use and Main Street							
Baseline	○	○	○	○	○	○	○
Alternative 1	●	○	○	○	○	◖	○
Alternative 2	●	○	○	○	○	◖	○
Alternative 3	◖	○	◗	◗	◗	◖	○
Alternative 4	●	○	○	○	○	◖	○

Legend:							
●	Significant Benefit	◖	Positive	○	Neutral / No Effect	◗	Negative

Source: HNTB Corporation, 2009.

Cost Analysis

Planning-level cost estimates were prepared to assess the relative costs of the transit priority alternatives. Cost estimates for the University District transit priority alternatives are included in Table 7.

The cost estimates included in this report are provided for the sole purpose of comparing alternatives. The estimates are not intended to be used for planning or programming budget for the project. These estimates are based on general assumptions regarding the magnitude of work involved for each alternative.

Detailed design elements are not included in the cost estimates. The following contingencies have been applied to the base construction cost estimate for each alternative: 40% miscellaneous item contingency, 10% mobilization, 25% construction engineering and contingencies, 9% sales tax, and 3% inflation to mid-2011 (anticipated year of construction). Estimates were rounded to the nearest thousand dollars.

Table 7
Alternative Cost Estimates – University District

Alt. No.	Description of Improvements	Construction Estimate (2011 $)	PM Peak Total Time Savings (sec)	Cost per Unit Time Savings ($/sec)
1	Rechannelize NE 45th Street from 8th Ave NE to University Way NE to four lanes. Prohibit left turns. Retain five lanes at NE 45th St/7th Ave NE and NE 45th St/15th Ave NE.	$85,000	127	$670
2	Alternative 1 and transit signal priority along NE 45th St at 5th Ave NE, 7th Ave NE, Roosevelt Way NE, 15th Ave NE, and the 15th Ave NE/NE 43rd intersection.	$695,000	129	$5,400
3	Alternative 2 and widening to five lanes on NE 45th St between 7th Ave NE and 8th Ave NE to provide a westbound right turn lane at NE 45th St/7th Ave NE intersection.	$825,000	138	$6,000
4	Alternative 2 with the addition of eastbound and westbound BAT lane reservations between Roosevelt Way NE and University Way NE.	$720,000	94	$7,700

Note: Time/Delay rounded to the nearest second for the PM peak hour
Source: HNTB Corporation, 2009.

Phinney/Wallingford Potential Transit Priority Projects

Previous studies in the Phinney/Wallingford area produced several concepts for providing transit priority along N 45th and N 46th Streets. The Route 44 UVTN Corridor Study proposed a westbound BAT lane on N 46th Street between Phinney and Fremont Avenues N, as shown on Figure 13, reflecting the higher level of delay in the outbound direction of Route 44 operation. The BAT lane would also serve westbound right turns into cross streets and driveways.

N 46th Street is constrained to a single directional lane westbound as it passes under the SR 99 bridge. A second westbound lane is added from the southbound off-ramp from SR 99; the BAT lane would develop from this added (curb) lane. The two westbound lanes merge to a single lane west of Greenwood Avenue N. Curb lanes in this area are 12 feet wide.

Westbound buses encounter about 1½ minutes of delay under the SR 99 bridge. Traffic volume reaches about 950 vph at this location during the PM peak hour. A westbound BAT lane would not reduce delays at the N 46th Street/Fremont Avenue N intersection. The concept for a westbound BAT lane is carried forward for detailed traffic analysis.

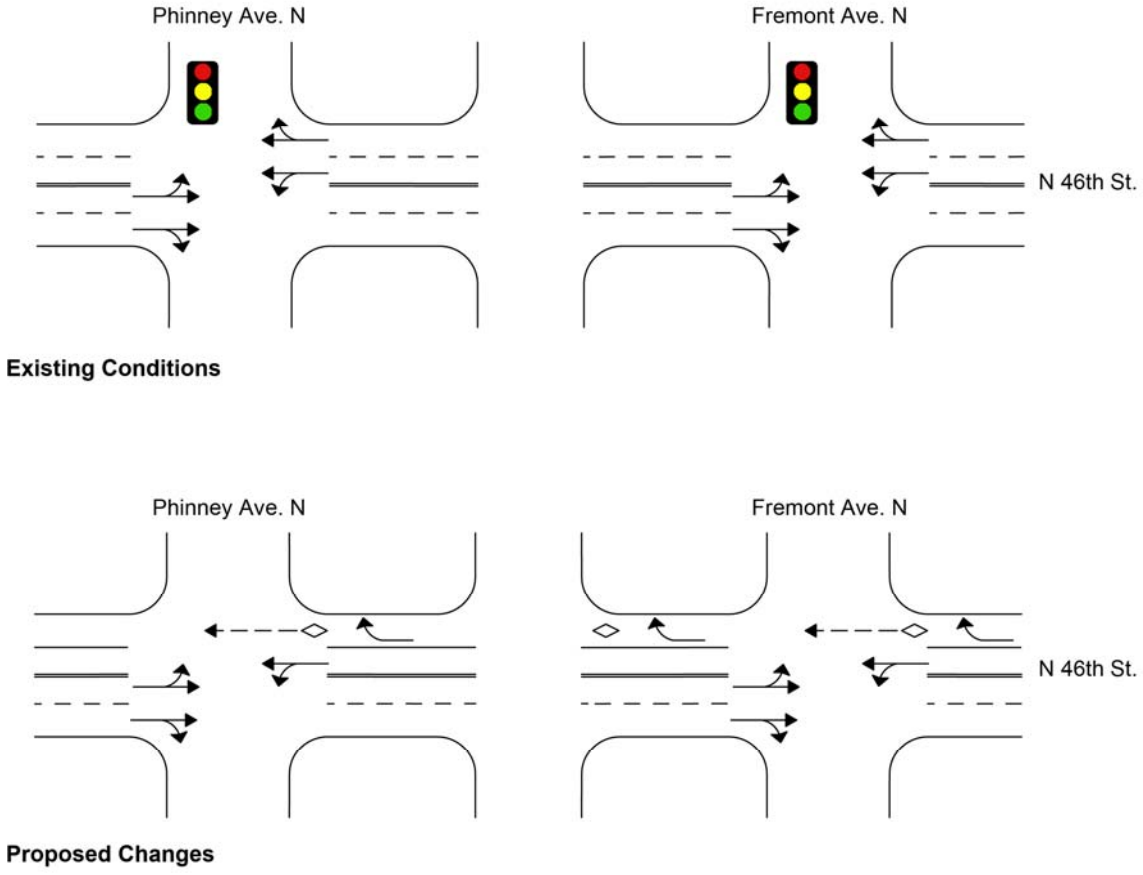


Figure 13
N 46th Street BAT Lane

Potential Queue Jump Locations

SDOT is currently developing a project to provide a westbound queue jump lane on N 45th Street at Wallingford Avenue N. This project would provide an advance green indication for Route 44 buses operating in the curb lane to place them in front of the queue of general purpose traffic. It will be completed under separate funding and is treated as a committed project in the alternatives analysis.

An eastbound queue jump lane at Wallingford Avenue N was considered, but was rejected due to parking impacts and geometric constraints. An eastbound queue jump lane would involve the loss of at eight to ten parking spaces on the south side of N 45th Street between the Wallingford Avenue N and Densmore Avenue N intersections. Lane width would be constrained by the overall 48 feet of curb-to-curb width. These impacts are considered to be fatal flaws for an eastbound queue jump lane at Wallingford Avenue N.

The single highest source of bus delay in the corridor, both in the inbound and outbound directions of bus operation, occurs along N 46th Street at the intersection with Green Lake Way N and the SR 99 northbound off-ramp. Buses encounter two to three minutes of delay in their westbound movement through this intersection during PM peak hour conditions. Limited observation reveals that queues frequently extend along N Midvale Place beyond Stone Way N. Lesser delays are encountered in the inbound (eastbound) direction of travel, but substantial delays also develop during midday conditions.

The bottleneck at the N 46th Street/Green Lake Way N/SR 99 NB off-ramp intersection is related to the single directional lane on the westbound approach and shared left-through lane on the eastbound approach. A second lane develops on the westbound intersection approach to serve left turns downstream of this intersection. Green time allocated to the westbound approach is limited, because the major traffic flows are on other approaches. These factors combine to constrain vehicle throughput, including buses.

Figure 14 shows a concept design for a westbound queue jump lane for Route 44 buses at the N 46th Street/Green Lake Way N/SR 99 NB off-ramp intersection. The lane would require widening along the north side of N Midvale Place, and the south side of N 46th Street. The lane would develop as an extension of an existing transit stop/right-turn lane. An advance green indication would be provided to westbound Route 44 buses to place them ahead of general purpose traffic.

Right turns should be prohibited from the westbound intersection approach given their low volume (less than 5 vph). This configuration is preferable for bus movement, especially if the bus stop must remain in its nearside location.

The westbound queue jump lane on N Midvale Place would require relocation of one trolley-power pole, and would affect the sidewalk and landscaping along the north side of N Midvale Place. In the widened street envelope, curb lanes would be provided at 13-foot widths. The 13-foot curb lanes are considered desirable by Metro. The westbound through lane would be 11 feet wide. Curb lanes of 14-foot widths are recommended in the City's Complete Streets criteria for bicycle use, but because of the high frequency of transit and bicycle traffic in this area, a 13-foot curb lane width is seen as desirable to discourage bicycles from passing buses at transit stops.

The concept design for the added lane would maintain the existing 20 mph design speed. The design also removes the planting strip adjacent to the north sidewalk between Green Lake Way N and Woodland Park Avenue N. About eight on-street parking spaces would be removed from the north side of N Midvale Place between Midvale Avenue N and N 45th Street.

The concept design for the westbound queue jump lane at the N 46th Street/Green Lake Way N intersection will require additional refinement to determine design elements and mitigation potential for the landscaping and utility relocation elements.

Parking Revisions

NE 45th Street east of the Wallingford business district provides two lanes in each direction immediately west of the I-5 ramps. The Route 44 UVTN Corridor Study proposed a project to prohibit daytime parking from the south side of NE 45th Street east of Latona Avenue NE to the I-5 ramps at 5th Avenue NE.

In this area, eastbound traffic is subject to queuing as a result of backups on the ramp entering southbound I-5 during the AM and PM peak periods. This ramp is metered to regulate flow onto I-5, with the result that queues extend to occupy the curb lane on eastbound NE 45th Street in advance of the right turn onto the ramp. These queues are disruptive to bus movement, because buses must remain in the eastbound curb lane to serve transit stops.

Removal of parking from the south side of NE 45th Street would provide additional width for storage of eastbound queued vehicles adjacent to the curb. At the eastbound approach to 5th Avenue NE, however, the additional width disappears because a striped median is provided to shadow the westbound dual left-turn lanes. As a result, the ramp queue would continue to occupy the eastbound curb lane, blocking the passage of buses destined through on NE 45th Street.

A Synchro analysis of this area could not distinguish the benefits associated with parking removal along eastbound NE 45th Street, because the channelization modification would not affect the NE 45th Street/5th Avenue NE intersection approach.

If parking removals are pursued, replacement parking could be provided on the north side of NE 45th Street between Thackeray Place NE and Latona Avenue NE. A bus bulb is proposed along westbound NE 45th Street on the farside of Latona Avenue NE. This bulb would reduce the width of the existing wide curb lane, shadowing an area that could be used for all-day parking west of the bus bulb. Although one-for-one replacement would not be possible, this action would mitigate the proposed parking removals.

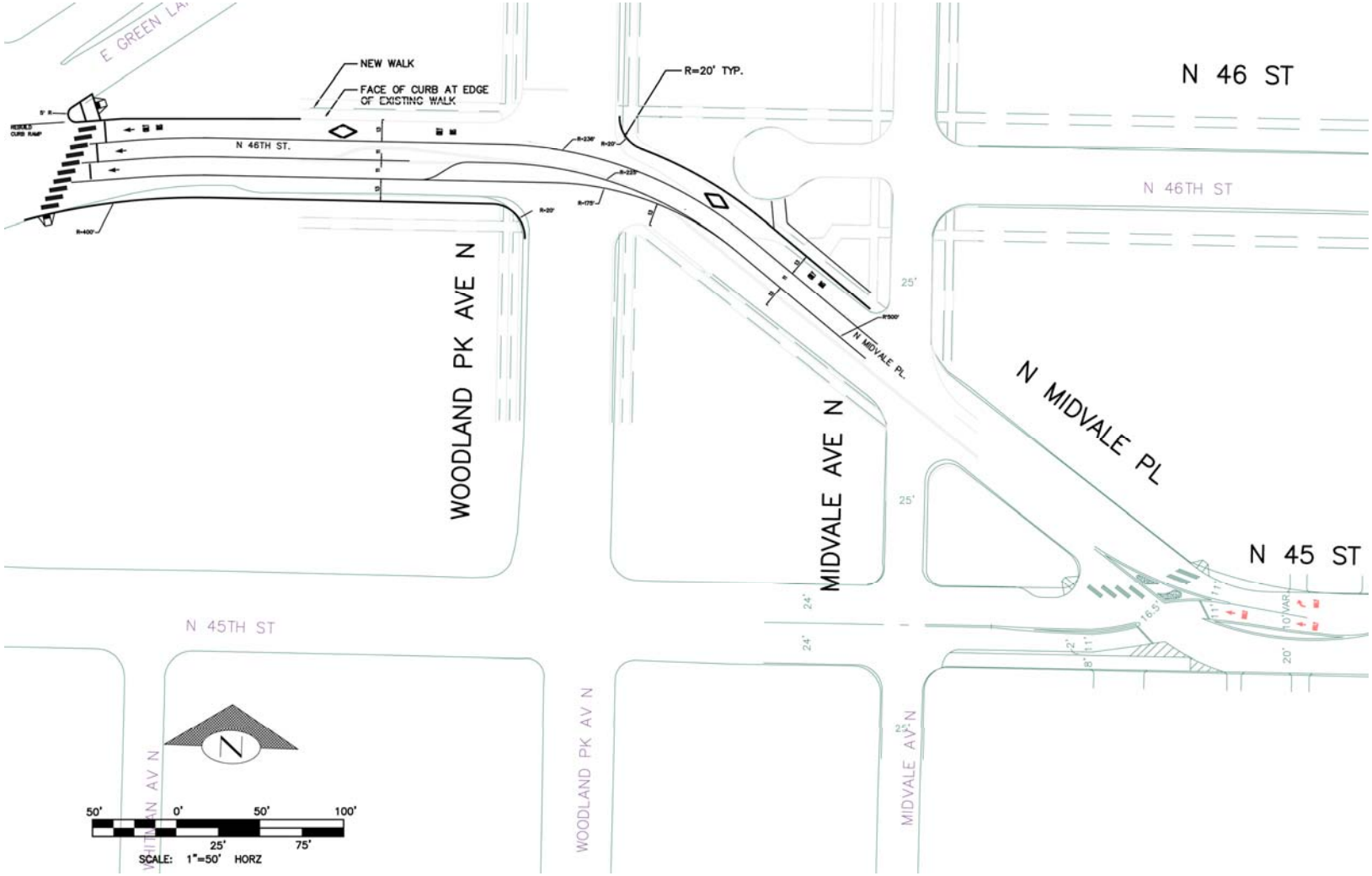


Figure 14
N 46th Street/Green Lake Way N Queue Jump

Phinney/Wallingford Alternatives Description

Three alternatives were developed for analysis in the Phinney/Wallingford area:

- Baseline maintains existing conditions along N 45th and N 46th Streets, with the addition of the westbound queue jump lane at the N 45th St/Wallingford Ave N intersection.

- Alternative 5 includes the committed westbound queue jump lane at the N 45th St/Wallingford Ave N intersection, the westbound queue jump lane along westbound N Midvale Place and eastbound bus bulbs on N 45th Street at Woodlawn Avenue N and Burke Avenue N. See Figure 15.

- Alternative 6 includes the committed queue jump project at Wallingford Avenue N, the westbound queue jump lane along N Midvale Place, transit signal priority at the Fremont Avenue N, Green Lake Way N, Stone Way N, and Wallingford Avenue N intersections, and eastbound bus bulbs on N 45th Street at Woodlawn Avenue N and Burke Avenue N. See Figure 16.

- Alternative 7 includes the committed queue jump lanes at Wallingford Avenue N, the westbound queue jump lane at N Midvale Pace, transit signal priority, eastbound bus bulbs on N 45th Street at Woodlawn Avenue N and Burke Avenue N, and adds the westbound BAT lane along N 46th Street between Fremont and Phinney Avenues N. See Figure 17.

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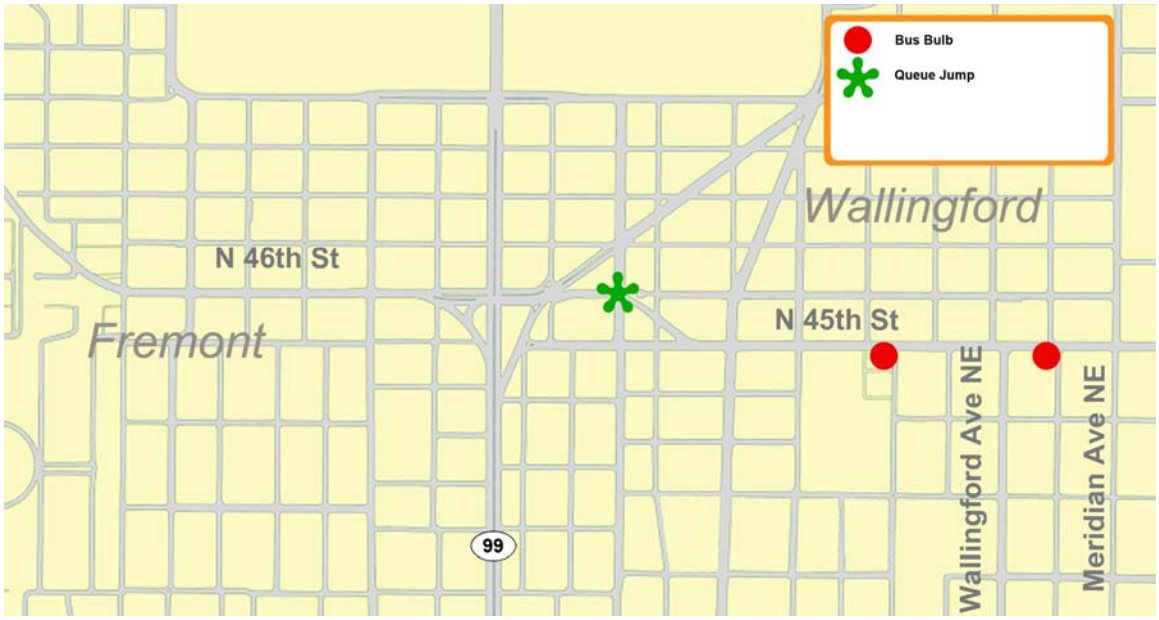

Figure 15
Phinney/Wallingford Area Alternative 5

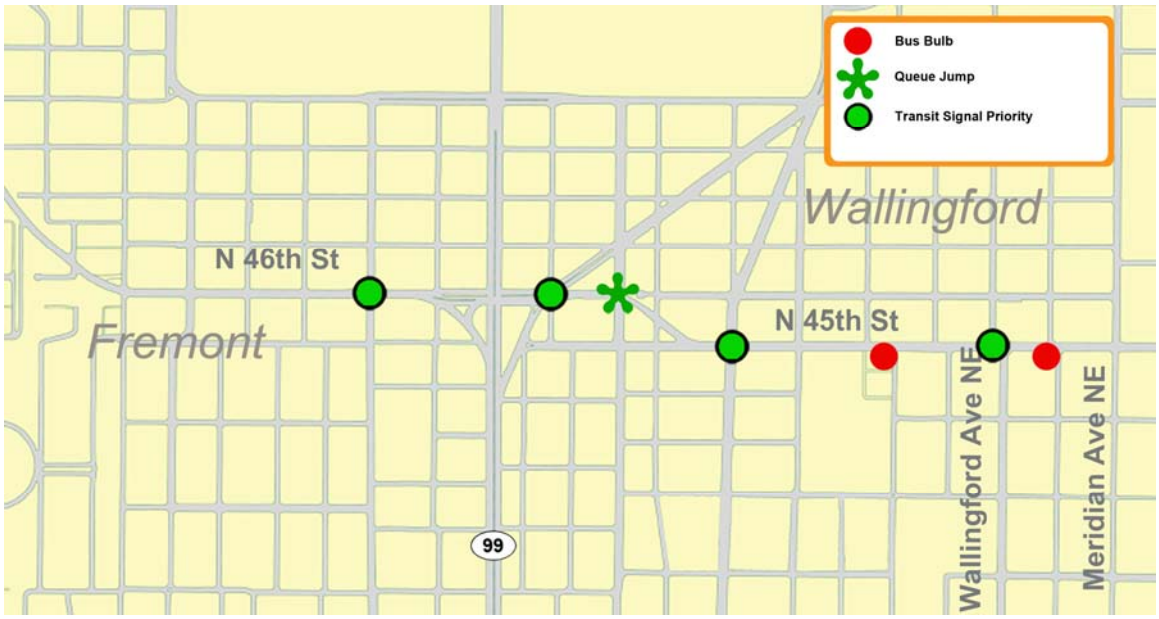

Figure 16
Phinney/Wallingford Area Alternative 6

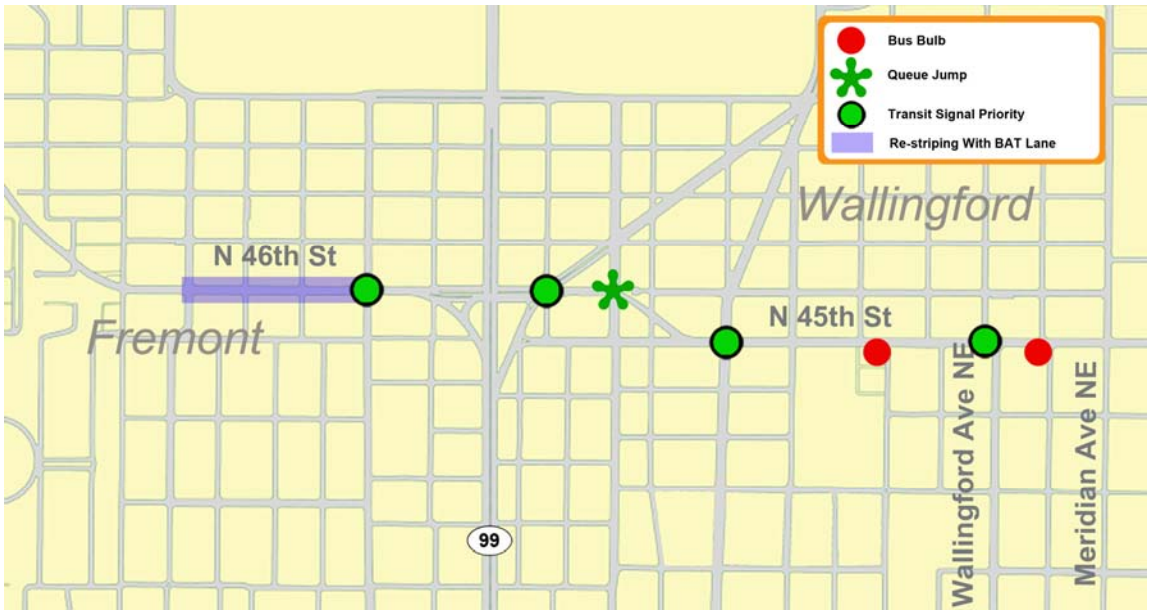

Figure 17
Phinney/Wallingford Area Alternative 7

Analysis Results

VISSIM analysis results for the Phinney/Wallingford alternatives are presented in Table 8. Comparing baseline conditions to collected travel time data shows the committed queue jump project for westbound buses at N 45th Street/Wallingford Avenue N will provide travel time savings estimated at 15 seconds during the PM peak hour. AM savings of 3 seconds are estimated, and midday savings are estimated at 23 seconds.

The proposed queue jump lanes along N Midvale Place in Alternative 5 will allow outbound buses to bypass extensive PM peak hour queues. Cumulative reductions in delay of about 2½ minutes would be experienced by outbound buses during the PM peak hour. Outbound savings also approach or exceed one minute during other times of day.

The addition of signal priority in Alternative 6 would further improve outbound benefits at all times of day. Additional inbound savings would be realized only in the AM peak hour.

A westbound BAT lane on N 46th Street between Fremont Avenue N and Phinney Avenue N would provide incremental benefits only for inbound buses during the midday period, compared to Alternative 6. Its usefulness for outbound travel is limited by the single-lane constraint under the SR 99 bridge in advance of the approach to Fremont Avenue N. It also would cause overall operations at the N 46th Street/Fremont Avenue N intersection to decline to LOS F, compared to LOS D for baseline conditions.

Table 8
Phinney/Wallingford Area Alternatives – Modeled Route 44 Travel Times

	Alternative	Inbound (sec)	Change (sec)	Outbound (sec)	Change (sec)
AM Peak	Baseline	565		451	
	Alternative 5	543	-22	401	-50
	Alternative 6	518	-47	397	-54
	Alternative 7	532	-33	440	-11
Midday	Baseline	671		601	
	Alternative 5	636	-35	524	-77
	Alternative 6	644	-27	521	-80
	Alternative 7	607	-64	541	-60
PM Peak	Baseline	510		666	
	Alternative 5	494	-16	520	-146
	Alternative 6	496	-14	518	-148
	Alternative 7	543	+33	558	-108

Note: Modeled travel times from VISSIM are between Phinney Ave N / N 46th Street & Meridian Ave N / N 45th Street
Source: HNTB Corporation, 2009.

Alternatives Screening

The transit priority alternatives for the Phinney/Wallingford area are evaluated in two levels of screening to assess their applicability to the Route 44 corridor. The first-level screening

addresses factors associated with traffic operations performance of the various transit priority treatments. The second-level screening addresses conformance with design standards and the City's street design guidelines, community impacts, utility relocation, tree impacts, and effects on parking and local access.

In the Phinney/Wallingford areas, first-level screening shows Alternative 5 produces positive impacts on bus travel times with the proposed westbound queue jump lane along N Midvale Place. These benefits are improved marginally with the addition of TSP in Alternative 6. The proposed BAT lane in Alternative 7 provides marginal additional benefit, accompanied by poorer overall operations at the N 46th Street/Fremont Avenue N intersection. See Table 9.

Table 9
Phinney/Wallingford Area Alternatives – First Level Screening Matrix

	Travel Time Savings	Overall Intersection Delay	Queue Impacts	Traffic Diversion Impacts	Relative Cost
Phinney / Wallingford					
Baseline	○	○	○	○	NA
Alternative 5	●	○	●	○	◖
Alternative 6	●	○	●	○	◖
Alternative 7	◖	◗	◗	○	◖

Legend:							
●	Significant Benefit	◖	Positive	○	Neutral / No Effect	◗	Negative

Source: HNTB Corporation, 2009.

The second-level screening gauges the impacts of the alternatives on the adjacent properties and neighborhoods, and compliance with engineering standards and Complete Streets parameters. In the Phinney/Wallingford area, Alternatives 5, 6, and 7 all include the westbound queue jump lane along N Midvale Place, which generates impacts on sidewalk environment, landscaping, and utilities. As a result, the rankings of these alternatives are identical with respect to impacts and engineering characteristics. See Table 10.

The proposed queue jump lane would produce positive impacts on lane widths and roadway geometrics, also improving the bicycle environment. Associated impacts on sidewalk width, planting strips, and utility relocation are negative. The addition of TSP in Alternative 6, and the addition of a BAT lane in Alternative 7 produce no additional neighborhood impacts.

Table 10
Phinney/Wallingford Area Alternatives – Second Level Screening Matrix

				COMPLETE STREETS PRIMARY DESIGN FEATURES	
Phinney / Wallingford	Design standard conformance	Parking & access impacts	Utilities Impacts	Sidewalks buffered from moving traffic by add'l sidewalk width or planting strip	Bicycle access accommodated if parallel route is not feasible
Road Classification - Regional Connector					
Baseline	○	○	○	○	○
Alternative 5	◖	◗	◗	◗	◖
Alternative 6	◖	◗	◗	◗	◖
Alternative 7	◖	◗	◗	◗	◖

Legend:							
●	Significant Benefit	◖	Positive	○	Neutral / No Effect	◗	Negative

Source: HNTB Corporation, 2009.

The Phinney/Wallingford area alternatives indicate that the addition of the westbound queue jump lane, combined with TSP (Alternative 6), provides the greatest positive impacts on bus travel times. The addition of a westbound BAT lane provides a marginal positive impact on bus travel, but a distinct negative impact on general purpose traffic.

Cost Analysis

Planning-level cost estimates were prepared to assess the relative costs of the transit priority alternatives. Cost estimates in Table 11 include the various transit priority alternatives in the Phinney/Wallingford area.

The cost estimates included in this report are provided for the sole purpose of comparing alternatives. The estimates are not intended to be used for planning or programming budget for the project. These estimates are based on general assumptions regarding the magnitude of work involved for each alternative.

Detailed design elements are not included in the cost estimates. The following contingencies have been applied to the base construction cost estimate for each alternative: 40% miscellaneous item contingency, 10% mobilization, 25% construction engineering and contingencies, 9% sales tax, and 3% inflation to mid-2011 (anticipated year of construction). Estimates were rounded to the nearest thousand dollars.

Table 11
Alternative Cost Estimates – Phinney/Wallingford Area

Alt. No.	Description of Improvements	Construction Estimate (2011 $)	PM Peak Total Time Savings (sec)	Cost per Unit Time Savings ($/sec)
5	Westbound queue jump lane on N Midvale Pl and bus bulbs on eastbound N 45th St at Woodlawn Ave N and Wallingford Ave N	$430,000	162	$2,650
6	Alternative 5 and the addition of transit signal priority at the Fremont Ave N, Green Lake Way N, Stone Way N, and Wallingford Ave N intersections.	$1,050,000	162	$6,500
7	Alternative 6 and the addition of a westbound BAT lane restriction on N 46th St between Fremont Ave and Phinney Ave.	$1,065,000	75	$14,200

Note: Time/Delay rounded to the nearest second for the PM peak hour.
Source: HNTB Corporation, 2009.

Ballard Potential Transit Priority Projects

The primary source of Route 44 bus delay along NW Market Street occurs at the signalized intersection with 24th Avenue NW. This signal operates in split phase configuration for all east-west and north-south movements, operating at LOS E during PM peak-hour conditions. Delays for buses reach one to two minutes during several periods of the day.

Ballard Alternatives Description

Two lanes are currently provided both eastbound and westbound at the NW Market Street/24th Avenue NW intersection, with left turns occurring from the left through lane. Right-turn volumes are high in both directions, onto Shilshole Avenue NW from eastbound NW Market Street, and onto 24th Avenue NW from westbound NW Market Street.

These patterns suggest the curb lanes could be converted to dedicated right-turn lanes, and serve as queue jump lanes for through movements by Route 44 buses. General traffic could make right turns on red, but may be impeded by buses waiting for a through movement. Signing would indicate the right lanes must turn right, except transit. A green-arrow signal indication for east-west right turns could not be used because conflicting pedestrian movements occur simultaneously. Also, overlap phases for east-west right turns are not recommended because through buses would interrupt right-turn flows in this operation.

To the east, at the NW Market Street/17th Avenue NW intersection, potential restriping of NW Market Street would provide in-line transit stops in the relocated curb lanes in both directions. The space created in the median would be used for east-west left-turn pockets. Left-turn volumes remain below 45 vph at all times of day, so exclusive left-turn phases would not be warranted. A flashing yellow indication could be added in accordance with City guidelines. This modification would yield benefits both to buses and general traffic by reducing turbulence associated with lane changing maneuvers. Parking prohibitions east and west of 17th Avenue NW may be associated with the restriping.

Transit signal priority (TSP) is proposed along NW Market Street at both the 24th and 17th Avenue NW intersections. At the 24th Avenue NW intersection, the presence of split phase operation for east-west traffic would produce a situation where TSP calls may be received on conflicting approaches. Traffic signals typically require two signal cycles to recover from a TSP pre-emption call. Some TSP requests would be denied during these recovery cycles. Alternatively, TSP could be applied only in the eastbound direction, because the highest delays for Route 44 occur for inbound buses during AM peak operations.

TSP also could be applied at the NW Market Street/15th Avenue NW intersection, where Route 44 crosses the route of the proposed Metro RapidRide operation. RapidRide would be provided with transit signal priority in the north-south direction. Metro has indicated that signal priority for east-west buses should not be implemented at this location.

The Ballard transit priority projects are shown schematically on Figure 18.

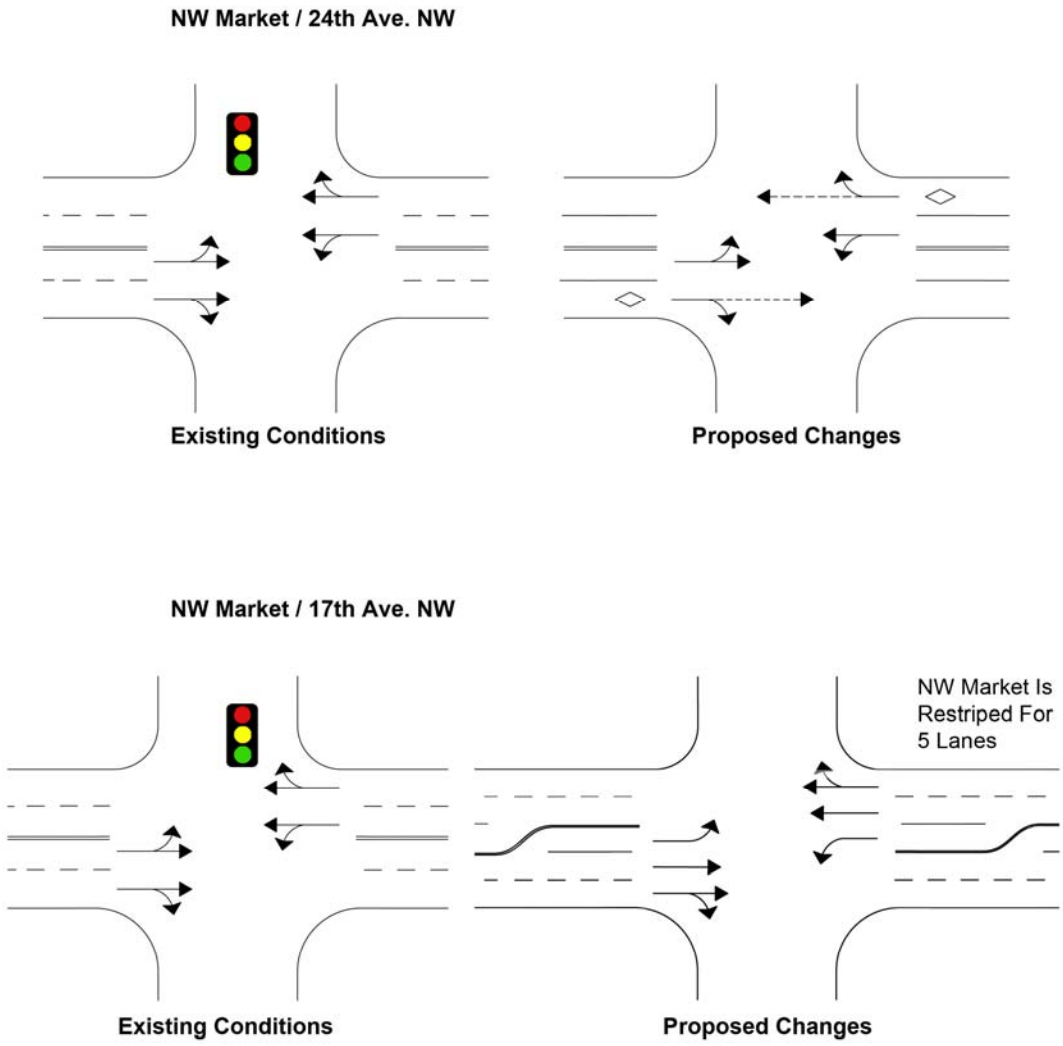

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Figure 18
Ballard Area Potential Transit Priority Projects

Analysis Results

At the NW Market Street/24th Avenue NW intersection, overall intersection operations would remain at LOS E, with a minor improvement in delay. Travel times for east-west bus movements would benefit by 5 to 9 seconds during the PM peak hour with the rechannelization and TSP improvements.

At the NW Market Street/17th Avenue NW intersection, overall operations would remain at LOS B, with a negligible improvement in delay. Travel times for east-west bus movements would benefit by 1 to 3 seconds. Rechannelization is not recommended given these limited benefits.

15th Avenue NE, NE Pacific Street and NE Pacific Place Potential Transit Priority Projects

In the eastern limits of the project, candidate priority treatments are limited to the application of transit signal priority at the following intersections:

- 15th Avenue NE/NE 42nd Street
- 15th Avenue NE/NE 41st Street
- 15th Avenue NE/NE 40th Street
- 15th Avenue NE/NE Pacific Street
- NE Pacific Street/NE Pacific Place

A project to repave the 15th Avenue corridor is in the early design stage, with construction scheduled for 2011. This project includes channelization revisions that would provide northbound left-turn lanes at the NE 41st and NE 42nd Street intersections. These turn lanes would accommodate a portion of the diversion traffic created by transit priority actions along the NE 45th Street corridor. The 15th Avenue NE/NE 41st Street and 15th Avenue NE/NE 42nd Street intersections operate at LOS A and B during peak hours, indicating that rechannelization would not adversely affect traffic operations.

The 15th Avenue NE/NE 50th Street intersection also would be included in the paving project. Earlier UATS studies had investigated the potential for east-west dedicated turn lanes with protected left-turn signals at this location, but turning volumes in the AM and midday periods do not support this action. With the proposed diversion traffic created by transit priority actions along the NE 45th Street corridor, the northbound left turn is likely to experience increased vehicular volume. A dedicated left-turn lane would be required, potentially extending 200 to 300 feet. On-street parking would need to be removed to serve northbound through and right-turn traffic. With a dedicated northbound left-turn lane, a protected signal phase could be added, depending on the levels of traffic diverted to this intersection.

The UATAS studies also addressed the potential for creating two southbound lanes on 15th Avenue NE south of NE 45th Street, where 12 to 15 parking spaces would be removed on the west side of the street. Parking removal also is planned on the west side of the street in the vicinity of NE 41st and 42nd Street to allow for the planned northbound left-turn lanes.

The paving project would remove a northbound right-turn lane from 15th Avenue NE at NE 41st Street. This action would allow for sidewalk widening over a two-block area in the vicinity of the northbound transit stop, and contribute to an improved pedestrian environment.

On NE Pacific Street, transit operations could be improved by re-striping and signing the existing HOV lane, as a transit only lane. Currently, three-person carpools are eligible to use the lane and to receive an advanced green indication to make a right turn at the NE Pacific Street/Montlake Boulevard NE intersection. Although Route 44 is not included in this movement, changes affecting the intersection operation could affect upstream operation of Route 44.

PM peak hour violation rates for automobiles are high at this location, and numerous transit routes are included in this movement. Synchro analysis shows a six second decrease in delay at the NE Pacific Street/Montlake Boulevard NE queue jump signal, if carpools are shifted to general purpose lanes. Signal delay in the eastbound general purpose lanes was not significantly impacted; Synchro reported a one second increase.

Bus Bulb Applications

Implementation of bus bulbs will provide for in-line bus stops at about 22 locations in the corridor. The bus bulbs will eliminate delays associated with buses merging into traffic at existing bus pullouts. The bus bulb analysis was conducted using the existing locations of bus stops in the corridor and without considering consolidation, relocation or closure of bus stops. SDOT and Metro have identified stops to be closed, independent of this corridor project.

In the University District and Phinney/Wallingford study areas, the analysis of bus bulbs is embedded together with other transit priority features, so the impact of individual bus bulb locations cannot be determined. An independent bus bulb analysis, using the Metro methodology with the Synchro software, is provided in Appendix E.

The results indicate that bus bulbs would contribute roughly 1 to 1½ minutes of travel time savings in each direction of travel for Route 44 during the PM peak hour. Lesser time savings are estimated for the AM and midday periods. Each bus bulb results in time savings up to 15 seconds.

The number of bus bulbs included in the design phase will vary from the 22 locations analyzed in this report, reflecting consolidation or closure of some bus stops. Bus bulb construction may be determined to be infeasible due to considerations of length, driveway interruption, or residential setting.

Bus Bulb Cost Analysis

Planning-level cost estimates for the potential bus bulbs were prepared to assess their relative costs. The cost estimates included in Table 12 are provided for the sole purpose of comparing alternatives. The estimates are not intended to be used for planning or programming budget for the project. These estimates are based on general assumptions regarding the magnitude of work involved for each improvement alternative. Detailed design elements are not included in the cost estimates. The following contingencies have been applied to the base construction cost estimate for each alternative: 40% miscellaneous item contingency, 10% mobilization, 25% construction engineering and contingencies, 9% sales tax, and 3% inflation to mid-2011 (anticipated year of construction). Estimates were rounded to the nearest thousand dollars.

Table 12
Route 44 Bus Bulb Cost/Benefit Comparison

Intersection	Type of Transit Stop Improvement	Construction Estimate	PM Peak Total Time Savings (sec)	Cost per Unit Time Savings
30th Ave NW and NW Market	*Bus Bulb (WB)*	*$60,000*	*7.7*	*$7,800*
30th Ave NW and NW 54th Street	Bus Bulb (EB)	$60,000	6.2	$9,700
28th Ave NW and NW Market	Bus Bulb (WB)	$75,000	5.9	$12,700
28th Ave NW and NW Market	Bus Bulb (EB)	$75,000	5.2	$14,400
26th Ave NW and NW Market	*Bus Bulb (WB)*	*$75,000*	*7.0*	*$10,700*
26th Ave NW and NW Market	*Bus Bulb (EB)*	*$75,000*	*3.6*	*$20,800*
17th Ave NW and NW Market	*Bus Bulb (WB)*	*$75,000*	*7.9*	*$9,500*
17th Ave NW and NW Market	*Bus Bulb (EB)*	*$75,000*	*5.0*	*$15,000*
11th Ave NW and NW Market	Bus Bulb (EB)	$75,000	5.2	$14,400
11th Ave NW and NW Market	Bus Bulb (WB)	$75,000	4.4	$17,000
3rd Ave NW and NW Market	Mid block (WB)	$60,000	8.2	$7,300
50th St NW and NW Market	*Bus Bulb (WB)*	*$60,000*	*4.0*	*$15,000*
48th St NW and NW Market	Bus Bulb (WB)	$60,000	7.3	$8,200
Stone Way N and N 45th Street	*Bus Bulb (EB)*	*$75,000*	*11.1*	*$6,800*
Woodlawn Ave N and N 45th Street	Bus Bulb (EB)	$75,000	10.0	$7,500
Wallingford Ave N and N 45th Street	Bus Bulb (EB)	$75,000	11.7	$6,400
Sunnyside Ave N and N 45th Street	Mid block (WB)	$60,000	14.6	$4,100
Thackeray Pl N and N 45th Street	Bus Bulb (EB)	$60,000	10.2	$5,900
Latona Ave NE and NE 45th Street	Bus Bulb (WB)	$60,000	10.5	$5,700
7th Ave NE and NE 45th Street	*Bus Bulb (WB)*	*$60,000*	*8.7*	*$6,900*
NE 43rd Street and 15th Ave NE	Bus Bulb (SB)	$60,000	8.1	$7,400
NE 40th Street and 15th Ave NE	Bus Bulb (NB)	$60,000	9.1	$6,600
Total	**22 Bus Bulbs**	**$1,485,000**	**171.6**	**$8,650**

Note: Travel time savings derived using King County Metro methodology and Synchro 7 software.
Bus Bulbs shown in italics are unlikely to progress beyond this conceptual study, due to design issues or potential stop closure.
Source: HNTB Corporation, 2009.

OVERALL BUS TRAVEL TIME IMPROVEMENTS

A program of transit priority projects would consist of a selection of an alternative (1, 2, 3 or 4) in the University District, an alternative (5, 6 or 7) for the Phinney/Wallingford area, and selected projects in the outlying areas.

Combining Alternatives 2 and 6 provides travel time savings during the AM peak hour exceeding eight percent in both directions (Table 13). At midday hours, travel time improvements in the outbound direction approach the ten percent objective, but total less than five percent in the inbound direction (Table 14). Transit priority improvements in the corridor are sufficient to achieve a ten percent reduction in outbound transit travel times during the PM peak period, but only eight percent in the inbound direction (Table 15).

Table 13
AM Peak Route 44 Travel Time Savings

Location	Build Description	Inbound Time Savings (sec)	Outbound Time Savings (sec)
30th Avenue NW & NW Market Street	*Bus Bulb*	*5.6*	*2.6*
28th Avenue NW & NW Market Street	Bus Bulb	5.6	2.1
26th Avenue NW & NW Market Street	*Bus Bulb*	*4.0*	*1.3*
24th Avenue NW & NW Market Street	Channelization, TSP	4.9	42.0
17th Avenue NW & NW Market Street	*Bus Bulb*	*5.2*	*4.7*
11th Avenue NW & NW Market Street	Bus Bulb	6.0	4.2
3rd Avenue NW & NW Market Street	Prohibit WB Left-turns, TSP	16.0	28.4
52nd Avenue NW & NW Market Street	Bus Bulb	-	2.2
50th Avenue NW & NW Market Street	*Bus Bulb*	-	*0.7*
48th Avenue NW & NW Market Street	Bus Bulb	-	1.4
Phinney/Wallingford Area	Alternative 6	47.0	54.0
Sunnyside Avenue N & N 45th Street	Bus Bulb	-	4.4
Thackeray Place N & N 45th Street	Bus Bulb, TSP	11.0	-
Latona Avenue NE & NE 45th Street	Bus Bulb, TSP	1.1	8.2
7th Avenue NE & NE 45th Street	*Bus Bulb*	-	*5.7*
University District	Alternative 2	35.6	-12.8
15th Avenue NE & NE 43rd Street	Bus Bulb	9.3	-
15th Avenue NE & NE 42nd Street	TSP	1.4	1.2
15th Avenue NE & NE 41st Street	TSP	0.9	3.4
15th Avenue NE & NE 40th Street	Bus Bulb, TSP	4.7	7.1
15th Avenue NE & NE Pacific Street	TSP	8.1	1.0
Total Time Savings		**166.4**	**161.8**
Total Time Savings (minutes)		**2.8**	**2.7**
Percent of Total Travel Time		**8.2%**	**8.2%**

Note: Time savings for intersections outside the VISSIM study areas are from Synchro 7.
Bus Bulbs shown in italics are unlikely to progress beyond this conceptual study, due to design issues or potential stop closure.
Source: HNTB Corporation, 2009.

Table 14
Midday Route 44 Travel Time Savings

Location	Build Description	Inbound Time Savings (sec)	Outbound Time Savings (sec)
30th Avenue NW & NW Market Street	*Bus Bulb*	*5.3*	*5.0*
28th Avenue NW & NW Market Street	Bus Bulb	5.2	3.2
26th Avenue NW & NW Market Street	*Bus Bulb*	*3.8*	*3.7*
24th Avenue NW & NW Market Street	Channelization, TSP	-1.8	28.1
17th Avenue NW & NW Market Street	*Bus Bulb*	*4.5*	*7.4*
11th Avenue NW & NW Market Street	Bus Bulb	6.2	4.6
3rd Avenue NW & NW Market Street	Prohibit WB Left-turns, TSP	9.4	15.1
52nd Avenue NW & NW Market Street	Bus Bulb	-	3.3
50th Avenue NW & NW Market Street	*Bus Bulb*	-	*1.6*
48th Avenue NW & NW Market Street	Bus Bulb	-	1.8
Phinney/Wallingford Area	Alternative 6	27.0	80.0
Sunnyside Avenue N & N 45th Street	Bus Bulb	-	11.3
Thackeray Place N & N 45th Street	Bus Bulb, TSP	12.1	-
Latona Avenue NE & NE 45th Street	Bus Bulb, TSP	1.0	14.3
7th Avenue NE & NE 45th Street	*Bus Bulb*	-	*9.9*
University District	Alternative 2	13.2	-1.4
15th Avenue NE & NE 43rd Street	Bus Bulb	9.2	-
15th Avenue NE & NE 42nd Street	TSP	1.8	6.1
15th Avenue NE & NE 41st Street	TSP	1.6	4.5
15th Avenue NE & NE 40th Street	Bus Bulb, TSP	3.1	12.8
15th Avenue NE & NE Pacific Street	TSP	0.3	1.2
Total Time Savings		**101.9**	**212.5**
Total Time Savings (minutes)		**1.7**	**3.5**
Percent of Total Travel Time		**4.7%**	**9.6%**

Note: Time savings for intersections outside the VISSIM study areas are from Synchro 7.
Bus Bulbs shown in italics are unlikely to progress beyond this conceptual study, due to design issues or potential stop closure.
Source: HNTB Corporation, 2009.

Table 15
PM Peak Route 44 Travel Time Savings

Location	Build Description	Inbound Time Savings (sec)	Outbound Time Savings (sec)
30th Avenue NW & NW Market Street	*Bus Bulb*	*6.2*	*7.7*
28th Avenue NW & NW Market Street	Bus Bulb	5.2	5.9
26th Avenue NW & NW Market Street	*Bus Bulb*	*3.6*	*7.0*
24th Avenue NW & NW Market Street	Channelization, TSP	5.0	8.8
17th Avenue NW & NW Market Street	*Bus Bulb*	*5.0*	*7.9*
11th Avenue NW & NW Market Street	Bus Bulb	5.2	4.4
3rd Avenue NW & NW Market Street	Prohibit WB Left-turns, TSP	-2.6	21.1
52nd Avenue NW & NW Market Street	Bus Bulb	-	8.2
50th Avenue NW & NW Market Street	*Bus Bulb*	-	*4.0*
48th Avenue NW & NW Market Street	Bus Bulb	-	7.3
Phinney/Wallingford Area	Alternative 6	14.0	148.0
Sunnyside Avenue N & N 45th Street	Bus Bulb	-	14.6
Thackeray Place N & N 45th Street	Bus Bulb, TSP	14.5	4.0
Latona Avenue NE & NE 45th Street	Bus Bulb, TSP	2.2	11.6
7th Avenue NE & NE 45th Street	*Bus Bulb*	-	*8.7*
University District	Alternative 2	107.3	22.0
15th Avenue NE & NE 43rd Street	Bus Bulb	8.1	-
15th Avenue NE & NE 42nd Street	TSP	2.9	10.0
15th Avenue NE & NE 41st Street	TSP	0.6	3.8
15th Avenue NE & NE 40th Street	Bus Bulb, TSP	5.6	14.7
15th Avenue NE & NE Pacific Street	TSP	2.7	0.9
Total Time Savings		**185.5**	**320.6**
Total Time Savings (minutes)		**3.1**	**5.3**
Percent of Total Travel Time		**8.1%**	**12.1%**

Note: Time savings for intersections outside the VISSIM study areas are from Synchro 7.
Bus Bulbs shown in italics are unlikely to progress beyond this conceptual study, due to design issues or potential stop closure.
Source: HNTB Corporation, 2009.

IMPACTS TO GENERAL PURPOSE TRAFFIC

The implementation of transit priority measures can be expected to produce impacts on the movement of general purpose traffic in the corridor. These impacts are presented in Tables 16, 17, and 18 for the AM, midday, and PM periods, respectively. At most locations, delays for general purpose traffic change by fewer than five seconds, and Levels of Service remain unchanged. Where delays are reduced for general purpose travel, it is an ancillary effect of revised channelization or the added green time produced by TSP.

Locations where general purpose traffic would experience a change in the letter grade of Level of Service include the NE 45th Street/15th Avenue NE intersection (LOS D to E in AM peak hour), N 45th Street/Stone Way N intersection (LOS D to E during midday hour), and the NE 45th Street/5th Avenue NE intersection (LOS C to D during PM peak hour).

Table 16
AM Peak Intersection LOS and Average Delay (Sec/Veh)

Intersection	Baseline	Build	Delay Change (sec/veh)
24th Avenue NW & NW Market Street	C (33.0)	C (33.8)	+0.8
3rd Avenue NW & NW Market Street	C (33.6)	C (23.1)	-10.5
Phinney Avenue N & N 46th Street	A (8.4)	A (8.4)	0.0
Fremont Avenue N & N 46th Street	D (39.4)	D (39.2)	-0.2
Green Lake Way N & N 46th Street	C (25.3)	C (24.7)	-0.6
Stone Way N & N 45th Street	C (21.1)	C (32.8)	+11.7
Wallingford Avenue N & N 45th Street	C (29.0)	C (32.8)	+3.8
Thackeray Place N & N 45th Street	B (13.6)	B (12.1)	-1.5
Latona Avenue NE & NE 45th Street	A (7.4)	A (7.1)	-0.3
5th Avenue NE & NE 45th Street	C (24.1)	C (30.3)	+6.2
7th Avenue NE & NE 45th Street	C (23.1)	C (27.0)	+3.9
Roosevelt Way NE & NE 45th Street	D (35.4)	C (25.9)	-9.5
11th Avenue NE & NE 45th Street	B (11.1)	B (10.4)	-0.7
12th Avenue NE & NE 45th Street	B (10.2)	A (6.9)	-3.3
Brooklyn Avenue NE & NE 45th Street	B (16.2)	B (14.7)	-1.5
University Way NE & NE 45th Street	B (16.9)	B (17.2)	+0.3
15th Avenue NE & NE 45th Street	D (45.5)	E (57.5)	+12.0
15th Avenue NE & NE 43rd Street	B (12.3)	A (8.8)	-3.5
15th Avenue NE & NE 42nd Street	A (4.8)	A (3.6)	-1.2
15th Avenue NE & NE 41st Street	A (5.1)	A (4.4)	-0.7
15th Avenue NE & NE 40th Street	B (11.9)	B (12.0)	+0.1
15th Avenue NE & NE Pacific Street	C (33.6)	C (30.9)	-2.7

Note: Delay values for intersections outside the VISSIM study areas are from Synchro 7. See Table 13 for a description of intersection improvements in the Build condition.
Source: HNTB Corporation, 2009.

Table 17
Midday Intersection LOS and Average Delay (Sec/Veh)

Intersection	Baseline	Build	Delay Change (sec/veh)
24th Avenue NW & NW Market Street	D (36.2)	D (43.4)	+7.2
3rd Avenue NW & NW Market Street	C (33.2)	C (23.8)	-9.4
Phinney Avenue N & N 46th Street	A (7.4)	A (7.3)	-0.1
Fremont Avenue N & N 46th Street	D (39.2)	D (35.9)	-3.3
Green Lake Way N & N 46th Street	C (32.5)	D (38.0)	+5.5
Stone Way N & N 45th Street	D (41.6)	E (60.2)	+18.6
Wallingford Avenue N & N 45th Street	E (61.1)	E (60.1)	-1.0
Thackeray Place N & N 45th Street	B (12.2)	B (11.2)	-1.0
Latona Avenue NE & NE 45th Street	A (6.6)	A (6.2)	-0.4
5th Avenue NE & NE 45th Street	B (16.3)	B (17.0)	+0.7
7th Avenue NE & NE 45th Street	B (19.8)	B (20.0)	+0.2
Roosevelt Way NE & NE 45th Street	B (12.0)	B (10.5)	-1.5
11th Avenue NE & NE 45th Street	B (10.9)	B (12.1)	+1.2
12th Avenue NE & NE 45th Street	B (10.9)	A (6.9)	-4.0
Brooklyn Avenue NE & NE 45th Street	B (18.8)	B (11.7)	-7.1
University Way NE & NE 45th Street	B (12.7)	B (10.4)	-2.3
15th Avenue NE & NE 45th Street	C (26.7)	C (29.0)	+2.3
15th Avenue NE & NE 43rd Street	A (9.5)	A (7.6)	-1.9
15th Avenue NE & NE 42nd Street	A (7.0)	A (4.1)	-2.9
15th Avenue NE & NE 41st Street	A (7.2)	A (5.5)	-1.7
15th Avenue NE & NE 40th Street	B (11.8)	B (13.2)	+1.4
15th Avenue NE & NE Pacific Street	C (29.0)	C (29.1)	+0.1

Note: Delay values for intersections outside the VISSIM study areas are from Synchro 7. See Table 13 for a description of intersection improvements in the Build condition.
Source: HNTB Corporation, 2009.

Table 18
PM Peak Intersection LOS and Average Delay (Sec/Veh)

Intersection	Baseline	Build	Delay Change (sec/veh)
24th Avenue NW & NW Market Street	E (66.9)	E (65.4)	-1.5
3rd Avenue NW & NW Market Street	D (52.6)	C (45.4)	-7.2
Phinney Avenue N & N 46th Street	B (11.7)	B (12.0)	+0.3
Fremont Avenue N & N 46th Street	E (66.7)	E (63.5)	-3.2
Green Lake Way N & N 46th Street	D (50.8)	D (53.3)	+2.5
Stone Way N & N 45th Street	D (40.6)	D (38.1)	-2.5
Wallingford Avenue N & N 45th Street	D (43.2)	D (47.7)	+4.5
Thackeray Place N & N 45th Street	B (17.1)	B (13.7)	-3.4
Latona Avenue NE & NE 45th Street	A (9.6)	A (9.3)	-0.3
5th Avenue NE & NE 45th Street	C (28.0)	D (39.6)	+11.6
7th Avenue NE & NE 45th Street	C (34.2)	C (34.3)	+0.1
Roosevelt Way NE & NE 45th Street	D (37.1)	C (21.4)	-15.7
11th Avenue NE & NE 45th Street	C (21.5)	C (20.1)	-1.4
12th Avenue NE & NE 45th Street	C (27.2)	B (13.1)	-14.1
Brooklyn Avenue NE & NE 45th Street	D (35.7)	C (23.4)	-12.3
University Way NE & NE 45th Street	B (13.0)	B (15.9)	+2.9
15th Avenue NE & NE 45th Street	D (47.7)	D (45.0)	-2.7
15th Avenue NE & NE 43rd Street	B (11.1)	B (11.1)	0.0
15th Avenue NE & NE 42nd Street	B (11.6)	A (6.3)	-5.3
15th Avenue NE & NE 41st Street	A (8.2)	A (8.4)	+0.2
15th Avenue NE & NE 40th Street	B (14.7)	B (19.1)	+4.4
15th Avenue NE & NE Pacific Street	D (40.5)	D (45.6)	+5.1

Notes: Delay values for intersections outside the VISSIM study areas are from Synchro 7.
See Table 13 for a description of intersection improvements in the Build condition.
Source: HNTB Corporation, 2009.

RECOMMENDATIONS

An array of transit priority projects were determined to provide positive impacts on bus travel times for Metro Route 44. In the University District, Alternative 2 is recommended for advancement to the design stage. This project would prohibit left turns from NE 45th Street between 7th Avenue NE and University Way NE, resulting in diversion of left-turn traffic to other routes. With a four-lane cross-section in this portion of NE 45th Street, lane widths will be improved to meet design standards, providing benefits for all modes, including bicycles. Alternative 2 also includes TSP at several critical intersections in the University District.

Mitigation of traffic diversion impacts can be addressed with signal retiming along diversion routes, addition of left-turn lanes on northbound 15th Avenue at NE 42nd and NE 50th Streets, removal of on-street parking along the east side of 15th Avenue NE near NE 50th Street, and on the west side between NE 43rd and NE 45th Streets, and lengthening of the westbound left-turn storage lane at the NE 45th Street/15th Avenue NE intersection.

In the Phinney/Wallingford area, Alternative 6 is recommended for further design development. It includes the westbound queue jump lane along N Midvale Place, which is critical to the attainment of bus travel time benefits in the corridor. Further refinement of this design is recommended to reduce adverse impacts to landscaping and the pedestrian environment. Alternative 6 also includes TSP at several critical intersections along the route.

Bus bulbs provide benefits throughout the corridor by shifting stops to an in-line position and reducing delays related to buses merging into traffic lanes from existing bus pullouts. The bus bulb benefits are estimated for all existing bus stops without regard to future consolidation or relocation of bus stops. Additional travel time savings may be demonstrated with the consolidation or closure of bus stops in separate actions by SDOT and Metro.

Rechannelization at intersections in outlying areas also provides benefits to bus movement. These actions include the NW Market Street/24th Avenue NW intersection, and the Latona Avenue NE and Thackeray Place N intersections along NE 45th Street.

Removal of on-street parking would occur at the westbound queue jump lane along N Midvale Place, the Latona Avenue NE and Thackeray Place N intersections along NE 45th Street, and at several bus bulb locations.

The selected alternatives provide the required improvements in bus travel times for outbound travel during the PM peak period, but fall short of the ten percent improvement needed at other time periods. Additional travel time improvements are likely to be realized with consolidation or closure of bus stops. The transit priority actions are expected to attract additional patronage to Route 44 by virtue of the improved travel times.

APPENDICES

Appendix A: Bus Delay – Top Five Intersections

	Inbound Intersection	Delay (sec)	Outbound Intersection	Delay (sec)
AM Peak	N 46th Street & Fremont Avenue N	59.3	N 46th Street & Green Lake Way N	54.3
	NE 45th Street & Roosevelt Way NE	50.0	NW Market Street & 24th Avenue NW	45.8
	NE Pacific Street & 15th Avenue NE	45.7	N 45th Street & Wallingford Avenue N	44.8
	NW Market Street & 15th Avenue NW	42.3	15th Avenue N & NE 45th Street	40.0
	N 45th Street & Stone Way N	37.0	N 45th Street & Stone Way N	31.3
Midday	NW Market Street & 24th Avenue NW	125.5	N 45th Street & Wallingford Avenue N	128.5
	NW Market Street & 15th Avenue NW	74.0	N 46th Street & Fremont Avenue N	65.5
	N 46th Street & Green Lake Way N	70.0	N 45th Street & Stone Way N	53.0
	N 45th Street & Wallingford Avenue N	47.5	NW Market Street & 22nd Avenue NW	47.0
	N 45th Street & Stone Way N	43.0	NW Market Street & 24th Avenue NW	34.5
PM Peak	N 46th Street & Green Lake Way N	108.5	N 46th Street & Green Lake Way N	149.0
	NW Market Street & 15th Avenue NW	106.0	15th Avenue N & NE 45th Street	108.5
	NW Market Street & 24th Avenue NW	77.0	NW Market Street & Ballard Avenue NW	93.5
	N 46th Street & Fremont Avenue N	73.0	N 45th Street & Wallingford Avenue N	64.5
	NW Market Street & 8th Avenue NW	68.0	N 46th Street & Fremont Avenue N	60.0

Note: Delay data collected in July, 2009.
Source: HNTB Corporation, 2009.

Appendix B: University District – VISSIM Analysis Output

AM Peak VISSIM Output

AM Peak	Bus Travel Time (5th Ave to 15th & 43rd) - sec			
	Inbound	Outbound	Inbound delta	outbound delta
Baseline Conditions	382.9	280.5		
Alternative 1	429.7	295.9	46.7	15.4
Alternative 2	347.3	293.3	-35.6	12.8
Alternative 3	358.4	286.7	-24.6	6.2
Alternative 4	323.2	295.9	-59.8	15.4
Alt 1 + 45th/15th transit only NBL	379.3	306.3	-3.6	25.9
Alt 1 + 45th/15th transit only NBL and EBR restripe	538.1	328.4	155.2	47.9

AM Peak	GP Travel Time (5th Ave to 15th & 43rd) - sec			
	Inbound	Outbound	Inbound delta	outbound delta
Baseline Conditions	297.1	244.6		
Alternative 1	323.0	251.3	25.8	6.7
Alternative 2	272.0	255.2	-25.2	10.6
Alternative 3	254.3	274.9	-42.9	30.3
Alternative 4	253.3	253.9	-43.9	9.3
Alt 1 + 45th/15th transit only NBL	279.7	NA	-17.4	
Alt 1 + 45th/15th transit only NBL and EBR restripe	466.3	NA	169.1	

AM Peak	Queuing			
	Eastbound, east of 7th		Westbound, east of 15th	
	avg (ft)	max (ft)	avg (ft)	max (ft)
Baseline Conditions	220	760	50	390
Alternative 1	190	680	40	320
Alternative 2	130	590	810	1440
Alternative 3	150	620	870	1430
Alternative 4	110	550	920	1490
Alt 1 + 45th/15th transit only NBL	110	600	30	300
Alt 1 + 45th/15th transit only NBL and EBR restripe	522	829	31	279

AM Peak	Intersection Delay (sec/veh)						
	Baseline Conditions	Alt 1	Alt 2	Alt 3	Alt 4	Alt 1 + 45th/15th transit only NBL	Alt 1 + 45th/15th transit only NBL and EBR restripe
Node 17: 5th Ave NE	24.1	31.9	30.3	30.9	27.7	31.1	42.8
Node 19: 7th Ave NE	23.1	28.3	27.0	25.7	23.4	25.9	48.6
Node 20: Roosevelt Way NE	35.4	25.2	25.9	24.2	24.6	23.0	35.0
Node 21: 11th Ave NE	11.1	11.5	10.4	10.6	9.7	9.7	22.2
Node 22: 12th Ave NE	10.2	10.3	6.9	7.1	6.4	5.6	29.0
Node 18: Brooklyn Ave NE	16.2	19.9	14.7	13.9	8.6	12.2	36.3
Node 23: University Way NE	16.9	22.0	17.2	41.1	12.9	19.7	22.6
Node 24: 15th Ave NE	45.5	49.1	57.5	57.4	59.8	42.9	42.9
Node 25: 43rd Street NE	12.3	10.0	8.8	18.0	8.4	9.5	9.0

AM Peak	Bus Movement Delay (s)						
Movement	Baseline Conditions	Alt 1	Alt 2	Alt 3	Alt 4	Alt 1 + 45th/15th transit only NBL	Alt 1 + 45th/15th transit only NBL and EBR restripe
7th Ave WBT	20.4	32.9	29.6	27.8	23.4	29.8	22.9
7th Ave EBT	19.6	25.0	19.5	21.0	16.4	22.4	68.0
15th Ave EBR	37.5	10.3	37.0	34.2	33.6	42.6	43.8
15th Ave NBL	46.7	77.2	58.2	59.9	67.1	71.7	68.1

AM Peak	Midblock Volumes (vph)						
	Baseline Conditions	Alt 1	Alt 2	Alt 3	Alt 4	Alt 1 + 45th/15th transit only NBL	Alt 1 + 45th/15th transit only NBL and EBR restripe
EB b/w Brooklyn & University	955	962	982	977	843	978	865
WB b/w Brooklyn & University	763	717	644	614	586	645	645
WB b/w 7th Ave & Roosevelt	721	700	658	641	614	644	642
EB b/w 7th Ave & Roosevelt	1289	1266	1274	1268	1068	1281	1139

Midday VISSIM Output

Mid Day	Bus Travel Time (5th Ave to 15th & 43rd) - sec			
	Inbound	Outbound	Inbound delta	outbound delta
Baseline Conditions	335.0	344.9		
Alternative 1	330.0	350.1	-5.0	5.2
Alternative 2	321.8	346.3	-13.2	1.4
Alternative 3	326.3	331.9	-8.8	-13.0
Alternative 4	319.0	335.2	-16.1	-9.7
Alt 1 + 45th/15th transit only NBL	329.0	338.9	-6.0	-6.0
Alt 1 + 45th/15th transit only NBL and EBR restripe	355.3	348.4	20.2	3.5

Mid Day	GP Travel Time (5th Ave to 15th & 43rd) - sec			
	Inbound	Outbound	Inbound delta	outbound delta
Baseline Conditions	230.8	281.7		
Alternative 1	216.1	272.7	-14.8	-9.0
Alternative 2	220.2	271.2	-10.7	-10.5
Alternative 3	217.7	261.5	-13.1	-20.2
Alternative 4	223.4	265.2	-7.4	-16.5
Alt 1 + 45th/15th transit only NBL	219.5	NA	-11.3	
Alt 1 + 45th/15th transit only NBL and EBR restripe	265.0	NA	34.2	

Mid Day	Queuing			
	Eastbound, east of 7th		Westbound, east of 15th	
	avg (ft)	max (ft)	avg (ft)	max (ft)
Baseline Conditions	38	319	51	360
Alternative 1	26	251	35	232
Alternative 2	24	221	35	236
Alternative 3	24	235	36	232
Alternative 4	32	348	52	394
Alt 1 + 45th/15th transit only NBL	25	259	34	242
Alt 1 + 45th/15th transit only NBL and EBR restripe	53	379	33	230

Mid Day	Intersection Delay (sec/veh)						
	Baseline Conditions	Alt 1	Alt 2	Alt 3	Alt 4	Alt 1 + 45th/15th transit only NBL	Alt 1 + 45th/15th transit only NBL and EBR restripe
Node 17: 5th Ave NE	16.3	16.9	17.0	16.8	16.3	16.8	16.7
Node 19: 7th Ave NE	19.8	20.4	20.0	20.2	20.8	19.9	20.2
Node 20: Roosevelt Way NE	12.0	10.8	10.5	10.5	10.6	10.6	14.2
Node 21: 11th Ave NE	10.9	12.1	12.1	12.1	12.3	12.1	15.5
Node 22: 12th Ave NE	10.9	7.0	6.9	7.0	9.3	7.0	15.5
Node 18: Brooklyn Ave NE	18.8	11.3	11.7	11.5	12.8	11.8	20.7
Node 23: University Way NE	12.7	10.1	10.4	10.3	9.0	10.4	22.6
Node 24: 15th Ave NE	26.7	29.0	29.0	28.4	28.0	28.2	30.4
Node 25: 43rd Street NE	9.5	7.7	7.6	7.6	7.6	7.7	7.4

Mid Day	Bus Movement Delay (s)						
Movement	Baseline Conditions	Alt 1	Alt 2	Alt 3	Alt 4	Alt 1 + 45th/15th transit only NBL	Alt 1 + 45th/15th transit only NBL and EBR restripe
7th Ave WBT	28.0	25.2	22.4	16.5	27.4	23.6	24.1
7th Ave EBT	15.8	14.5	15.3	14.7	14.5	14.6	14.5
15th Ave EBR	25.4	19.8	21.1	20.7	15.6	21.0	24.8
15th Ave NBL	46.5	44.5	44.7	44.3	44.5	41.9	41.4

Mid Day	Midblock Volumes (vph)						
	Baseline Conditions	Alt 1	Alt 2	Alt 3	Alt 4	Alt 1 + 45th/15th transit only NBL	Alt 1 + 45th/15th transit only NBL and EBR restripe
EB b/w Brooklyn & University	923	936	937	935	850	936	933
WB b/w Brooklyn & University	716	663	663	662	640	638	636
WB b/w 7th Ave & Roosevelt	1040	1073	1073	1076	911	1054	1055
EB b/w 7th Ave & Roosevelt	1148	1113	1113	1113	1001	1111	1110

PM Peak VISSIM Output

PM Peak	Bus Travel Time (5th Ave to 15th & 43rd) - sec			
	Inbound	Outbound	Inbound delta	outbound delta
Baseline Conditions	483.2	426.2		
Alternative 1	381.9	400.4	-101.3	-25.8
Alternative 2	375.9	404.2	-107.3	-22.0
Alternative 3	376.0	395.2	-107.2	-31.0
Alternative 4	426.3	389.2	-56.9	-37.0
Alt 1 + 45th/15th transit only NBL	382.9	387.4	-100.3	-38.8
Alt 1 + 45th/15th transit only NBL and EBR restripe	592.3	393.1	109.1	-33.1

PM Peak	GP Travel Time (5th Ave to 15th & 43rd) - sec			
	Inbound	Outbound	Inbound delta	outbound delta
Baseline Conditions	345.1	275.1		
Alternative 1	266.1	248.9	-79.0	-26.2
Alternative 2	246.9	251.6	-98.2	-23.5
Alternative 3	250.3	243.5	-94.7	-31.6
Alternative 4	277.4	249.1	-67.6	-25.9
Alt 1 + 45th/15th transit only NBL	231.0	NA	-114.0	
Alt 1 + 45th/15th transit only NBL and EBR restripe	463.6	NA	118.5	

PM Peak	Queuing			
	Eastbound, east of 7th		Westbound, east of 15th	
	avg (ft)	max (ft)	avg (ft)	max (ft)
Baseline Conditions	480	830	320	850
Alternative 1	130	580	440	1100
Alternative 2	100	470	490	1190
Alternative 3	100	470	530	1200
Alternative 4	410	790	290	1020
Alt 1 + 45th/15th transit only NBL	89	475	754	1433
Alt 1 + 45th/15th transit only NBL and EBR restripe	582	833	837	1430

PM Peak	Intersection Delay (sec/veh)						
	Baseline Conditions	Alt 1	Alt 2	Alt 3	Alt 4	Alt 1 + 45th/15th transit only NBL	Alt 1 + 45th/15th transit only NBL and EBR restripe
Node 17: 5th Ave NE	28.0	33.6	39.6	34.2	51.8	29.5	32.9
Node 19: 7th Ave NE	34.2	32.2	34.3	33.7	40.9	27.9	44.0
Node 20: Roosevelt Way NE	37.1	23.4	21.4	23.2	27.5	22.3	44.2
Node 21: 11th Ave NE	21.5	22.8	20.1	21.2	25.6	20.3	37.9
Node 22: 12th Ave NE	27.2	17.8	13.1	14.1	14.6	11.6	37.9
Node 18: Brooklyn Ave NE	35.7	25.6	23.4	24.4	17.0	23.6	32.9
Node 23: University Way NE	13.0	16.5	15.9	16.3	12.4	16.0	22.9
Node 24: 15th Ave NE	47.7	44.3	45.0	44.6	43.1	45.0	47.4
Node 25: 43rd Street NE	11.1	10.9	11.1	11.3	13.3	12.5	12.3

PM Peak	Bus Movement Delay (s)						
Movement	Baseline Conditions	Alt 1	Alt 2	Alt 3	Alt 4	Alt 1 + 45th/15th transit only NBL	Alt 1 + 45th/15th transit only NBL and EBR restripe
7th Ave WBT	18.7	25.1	27.3	16.9	27.9	24.1	21.6
7th Ave EBT	24.8	30.8	31.4	31.5	60.8	15.7	61.7
15th Ave EBR	20.2	25.8	24.6	24.7	17.6	25.9	27.0
15th Ave NBL	68.5	46.1	47.9	46.6	47.4	50.7	49.4

PM Peak	Midblock Volumes (vph)						
	Baseline Conditions	Alt 1	Alt 2	Alt 3	Alt 4	Alt 1 + 45th/15th transit only NBL	Alt 1 + 45th/15th transit only NBL and EBR restripe
EB b/w Brooklyn & University	1087	1108	1107	1113	836	1111	963
WB b/w Brooklyn & University	729	744	745	740	657	598	608
WB b/w 7th Ave & Roosevelt	1170	1120	1119	1121	912	1000	993
EB b/w 7th Ave & Roosevelt	1212	1145	1134	1143	908	1140	996

Appendix C: University District – Traffic Diversions

University District Traffic Diversion Impacts - AM Peak Hour

		7th Ave NE		Roosevelt Way NE		11th Ave NE		12th Ave NE		Brooklyn Ave NE		University Way NE		15th Ave NE	
		LOS	Delay (sec)	LOS	Delay (sec)	LOS	Delay (sec)	LOS	Delay (sec)	LOS	Delay (sec)	LOS	Delay (sec)	LOS	Delay (sec)
	Base	B	19.8	C	31.5	B	17.0	A	4.6	A	7.0	B	11.8	B	12.7
50th	**Opt 2**	C	21.3	D	38.4	B	14.7	A	3.7	A	6.6	B	12.1	B	13.6
	Δ		+1.5		+6.9		-2.3		-0.9		-0.4		+0.3		+0.9
	Base			A	7.1	A	8.7	A	8.2	A	9.7	A	8.5	A	7.0
47th	**Opt 2**			B	18.6	A	8.0	A	8.4	A	9.8	A	8.4	A	7.3
	Δ				+11.5		-0.7		+0.2		+0.1		-0.1		+0.3
	Base	C	21.7	C	33.0	A	8.8	A	8.2	B	14.7	A	5.2	D	36.2
45th	**Opt 2**	C	23.2	C	27.2	B	12.3	A	9.4	B	12.4	A	7.6	C	34.1
	Δ		+1.5		-5.8		+3.5		+1.2		-2.3		+2.4		-2.1
	Base					A	7.5	A	9.4	B	10.5	A	7.3	B	10.3
43rd	**Opt 2**					A	7.9	B	10.4	B	10.2	A	8.1	A	9.9
	Δ						+0.4		+1.0		-0.3		+0.8		-0.4
	Base			A	4.9	B	11.1	A	8.9	A	9.6	A	8.3	A	7.6
42nd	**Opt 2**			A	4.6	B	11.5	A	9.0	A	9.7	A	8.7	A	9.9
	Δ				-0.3		+0.4		+0.1		+0.1		+0.4		+2.3

Option 2 includes east/west left turn prohibitions on NE 45th Street (Roosevelt Way NE to University Way NE) and a Transit Only NBL at 45th/15th.

note: intersection delay values are reported from Synchro 7 software

University District Traffic Diversion Impacts - Midday

		7th Ave NE		Roosevelt Way NE		11th Ave NE		12th Ave NE		Brooklyn Ave NE		University Way NE		15th Ave NE	
		LOS	Delay (sec)	LOS	Delay (sec)	LOS	Delay (sec)	LOS	Delay (sec)	LOS	Delay (sec)	LOS	Delay (sec)	LOS	Delay (sec)
	Base	B	18.7	B	17.7	B	15.3	A	2.2	A	7.3	B	10.5	A	9.1
50th	**Opt 2**	B	19.0	B	18.8	B	15.0	A	2.0	A	7.5	B	11.0	B	10.2
	Δ		+0.3		+1.1		-0.3		-0.2		+0.2		+0.5		+1.1
	Base			B	10.0	A	6.4	A	8.3	A	9.8	B	10.4	A	7.2
47th	**Opt 2**			B	14.4	A	6.5	A	8.3	A	9.7	B	10.3	A	7.5
	Δ				+4.4		+0.1		+0.0		-0.1		-0.1		+0.3
	Base	C	27.1	B	11.0	A	8.5	A	7.6	B	14.0	A	7.9	C	26.0
45th	**Opt 2**	C	23.3	B	12.5	B	12.4	A	7.6	B	10.1	A	9.8	C	21.7
	Δ		-3.8		+1.5		+3.9		+0.0		-3.9		+1.9		-4.3
	Base					A	5.8	A	6.5	B	10.1	A	9.0	B	13.8
43rd	**Opt 2**					A	6.1	A	7.0	B	10.5	B	10.7	B	15.9
	Δ						+0.3		+0.5		+0.4		+1.7		+2.1
	Base			A	7.2	A	3.1	A	8.5	A	9.8	A	8.5	A	4.6
42nd	**Opt 2**			A	7.2	A	3.2	A	8.8	B	10.1	A	8.2	A	4.1
	Δ				+0.0		+0.1		+0.3		+0.3		-0.3		-0.5

Option 2 includes east/west left turn prohibitions on NE 45th Street (Roosevelt Way NE to University Way NE) and a Transit Only NBL at 45th/15th.

note: intersection delay values are reported from Synchro 7 software

University District Traffic Diversion Impacts - PM Peak Hour

		7th Ave NE		Roosevelt Way NE		11th Ave NE		12th Ave NE		Brooklyn Ave NE		University Way NE		15th Ave NE	
		LOS	Delay (sec)	LOS	Delay (sec)	LOS	Delay (sec)	LOS	Delay (sec)	LOS	Delay (sec)	LOS	Delay (sec)	LOS	Delay (sec)
	Base	D	35.8	B	13.7	C	32.2	A	2.1	B	19.3	B	10.1	B	14.2
50th	**Opt 2**	D	38.2	B	15.5	D	48.4	A	1.7	B	19.4	B	10.4	B	14.5
	Δ		+2.4		+1.8		+16.2		-0.4		+0.1		+0.3		+0.3
	Base			C	25.6	C	20.2	A	9.5	B	14.5	B	16.7	B	14.2
47th	**Opt 2**			D	51.9	C	21.5	A	9.4	B	13.9	B	16.6	B	13.9
	Δ				+26.3		+1.3		-0.1		-0.6		-0.1		-0.3
	Base	F	97.9	D	50.9	D	39.2	A	7.7	D	48.8	B	16.7	E	60.4
45th	**Opt 2**	F	84.2	D	36.9	D	40.5	A	8.0	C	31.3	C	21.0	F	80.6
	Δ		-13.7		-14.0		+1.3		+0.3		-17.5		+4.3		+20.2
	Base					B	14.9	A	7.9	C	16.3	B	16.3	B	10.2
43rd	**Opt 2**					B	15.8	A	9.3	C	16.0	B	18.6	B	12.2
	Δ						+0.9		+1.4		-0.3		+2.3		+2.0
	Base			A	7.2	A	4.5	A	9.3	B	11.6	B	10.6	B	11.6
42nd	**Opt 2**			A	7.4	A	5.1	A	9.6	B	12.3	B	10.7	B	15.7
	Δ				+0.2		+0.6		+0.3		+0.7		+0.1		+4.1

Option 2 includes east/west left turn prohibitions on NE 45th Street (Roosevelt Way NE to University Way NE) and a Transit Only NBL at 45th/15th.

note: intersection delay values are reported from Synchro 7 software

Appendix D: Phinney/Wallingford Area – VISSIM Analysis Output

AM Peak VISSIM Output

AM Peak	Bus Travel Times (sec)					
	Inbound			**Outbound**		
	Phinney to Stone	Stone to Meridian	delta	Meridian to Stone	Stone to Phinney	delta
Baseline Conditions	297.5	267.0		177.7	273.7	
Alternative 5	338.5	204.9	-21.0	178.5	222.7	-50.2
Alternative 6	312.7	205.7	-46.1	168.1	229.2	-54.2
Alternative 7	328.3	203.6	-32.5	170.4	269.3	-11.7
Alt 5 + Green Lake stop consolidation	297.8	199.4	-67.3	178.9	222.2	-50.3

AM Peak	GP Travel Times (sec)					
	Inbound			**Outbound**		
	Phinney to Stone	Stone to Meridian	delta	Meridian to Stone	Stone to Phinney	delta
Baseline Conditions	181.4	154.4		120.7	207.8	
Alternative 5	202.4	166.2	32.8	118.1	177.2	-33.2
Alternative 6	178.7	175.2	18.1	118.2	207.8	-2.5
Alternative 7	192.1	176.0	32.3	115.4	251.3	38.2
Alt 5 + Green Lake stop consolidation	190.0	178.7	32.9	120.4	172.4	-35.7

AM Peak	Queuing			
	Westbound, east of Stone Way		Eastbound, west of Green Lake Way	
	Avg (ft)	Max (ft)	Avg (ft)	Max (ft)
Baseline Conditions	28	320	43	293
Alternative 5	23	289	64	321
Alternative 6	22	295	38	258
Alternative 7	23	283	48	413
Alt 5 + Green Lake stop consolidation	23	294	58	331

AM Peak	Volumes (vph)				
	Baseline Conditions	Alt 5	Alt 6	Alt 7	Alt 5 + Green Lake stop consolidation
WB west of Meridian	457	447	449	453	453
EB west of Meridian	517	515	511	514	517
WB east of Stone	507	500	503	505	504
EB east of Stone	475	472	470	472	476
WB Midvale	306	297	298	299	298
EB Midvale	348	345	345	345	349
WB Fremont input	737	736	739	740	735
EB Fremont input	928	928	927	927	930
WB west of Phinney	657	655	657	656	657
EB west of Phinney	873	872	872	872	873

AM Peak	Intersection Delay (sec/veh)				
	Baseline Conditions	Alt 5	Alt 6	Alt 7	Alt 5 + Green Lake stop consolidation
Node 17: Phinney	8.4	8.4	8.4	8.6	8.4
Node 18: Fremont	39.4	38.7	39.2	45.4	36.0
Node 19: Green Lake	25.3	27.9	24.7	30.9	27.6
Node 20: Stone	21.1	21.2	32.8	32.4	20.9
Node 21: Densmore	12.7	17.1	15.6	14.3	16.2
Node 22: Wallingford	29.0	33.7	32.8	32.0	33.7
Node 23: Meridian	12.5	12.9	12.2	12.0	13.2

AM Peak	Bus Movement Delay (sec/veh)				
	Baseline Conditions	Alt 5	Alt 6	Alt 7	Alt 5 + Green Lake stop consolidation
Wallingford Ave WBT	20.0	22.5	25.2	24.2	26.1
Wallingford Ave EBT	17.9	22.7	22.1	21.6	21.4
Green Lake Way WBT	53.3	38.0	38.3	43.1	27.2
Green Lake Way EBR	21.0	21.5	11.7	22.9	20.5

Midday VISSIM Output

Mid Day	Bus Travel Times (sec)					
	Inbound			**Outbound**		
	Phinney to Stone	Stone to Meridian	delta	Meridian to Stone	Stone to Phinney	delta
Baseline Conditions	290.5	380.3		283.1	317.4	
Alternative 5	341.1	295.2	-34.5	258.2	266.2	-76.1
Alternative 6	341.2	302.7	-26.9	257.1	263.4	-80.0
Alternative 7	307.4	299.9	-63.5	249.0	291.7	-59.7
Alt 5 + Green Lake stop consolidation	318.2	309.1	-43.5	246.8	263.3	-90.4

Mid Day	GP Travel Times (sec)					
	Inbound			**Outbound**		
	Phinney to Stone	Stone to Meridian	delta	Meridian to Stone	Stone to Phinney	delta
Baseline Conditions	194.0	288.3		207.9	230.4	
Alternative 5	204.6	276.0	-1.7	207.9	204.3	-26.1
Alternative 6	201.0	262.1	-19.2	190.1	203.8	-44.4
Alternative 7	215.1	342.1	74.9	236.6	224.9	23.2
Alt 5 + Green Lake stop consolidation	206.7	268.3	-7.3	196.3	206.3	-35.7

Mid Day	Queuing			
	Westbound, east of Stone Way		Eastbound, west of Green Lake Way	
	Avg (ft)	Max (ft)	Avg (ft)	Max (ft)
Baseline Conditions	76	566	70	397
Alternative 5	77	547	100	473
Alternative 6	109	607	115	615
Alternative 7	58	445	75	580
Alt 5 + Green Lake stop consolidation	83	522	91	471

Mid Day	Volumes (vph)				
	Baseline Conditions	Alt 5	Alt 6	Alt 7	Alt 5 + Green Lake stop consolidation
WB west of Meridian	487	530	516	489	537
EB west of Meridian	559	585	554	563	574
WB east of Stone	584	633	611	582	640
EB east of Stone	510	532	500	505	521
WB Midvale	416	440	428	401	442
EB Midvale	384	400	383	379	398
WB Fremont input	843	860	853	788	862
EB Fremont input	802	808	799	793	807
WB west of Phinney	593	602	598	532	600
EB west of Phinney	734	735	734	733	734

Mid Day	Intersection Delay (sec/veh)				
	Baseline Conditions	Alt 5	Alt 6	Alt 7	Alt 5 + Green Lake stop consolidation
Node 17: Phinney	7.4	7.3	7.3	8.6	7.5
Node 18: Fremont	39.2	37.3	35.9	44.3	34.8
Node 19: Green Lake	32.5	37.5	38.0	37.7	36.4
Node 20: Stone	41.6	44.7	60.2	58.7	51.2
Node 21: Densmore	36.9	36.6	38.8	38.9	38.2
Node 22: Wallingford	61.1	61.0	60.1	60.8	57.9
Node 23: Meridian	47.2	41.5	40.7	39.0	38.8

Mid Day	Bus Movement Delay (sec/veh)				
	Baseline Conditions	Alt 5	Alt 6	Alt 7	Alt 5 + Green Lake stop consolidation
Wallingford Ave WBT	54.1	42.1	44.3	35.7	33.6
Wallingford Ave EBT	26.6	27.7	27.8	27.7	27.8
Green Lake Way WBT	64.5	45.5	41.6	41.4	46.1
Green Lake Way EBR	28.2	28.5	29.4	25.8	28.1

PM Peak VISSIM Output

PM Peak	Bus Travel Times (sec)					
	Inbound			**Outbound**		
	Phinney to Stone	Stone to Meridian	delta	Meridian to Stone	Stone to Phinney	delta
Baseline Conditions	279.9	229.9		226.3	440.1	
Alternative 5	308.6	185.3	-16.0	213.7	306.0	-146.7
Alternative 6	317.8	178.5	-13.5	208.6	309.8	-148.1
Alternative 7	363.3	179.6	33.0	233.3	324.4	-108.8
Alt 5 + Green Lake stop consolidation	281.8	202.6	-25.5	210.4	282.2	-173.8

PM Peak	GP Travel Times (sec)					
	Inbound			**Outbound**		
	Phinney to Stone	Stone to Meridian	delta	Meridian to Stone	Stone to Phinney	delta
Baseline Conditions	188.9	130.5		158.5	375.0	
Alternative 5	198.0	161.6	40.1	165.2	314.8	-53.5
Alternative 6	206.0	154.6	41.2	167.1	286.3	-80.1
Alternative 7	238.7	150.4	69.6	184.0	364.7	15.1
Alt 5 + Green Lake stop consolidation	215.1	175.9	71.6	173.7	277.7	-82.1

PM Peak	Queuing			
	Westbound, east of Stone Way		Eastbound, west of Green Lake Way	
	Avg (ft)	Max (ft)	Avg (ft)	Max (ft)
Baseline Conditions	148	752	51	315
Alternative 5	132	702	62	352
Alternative 6	114	559	99	589
Alternative 7	198	727	202	766
Alt 5 + Green Lake stop consolidation	117	609	94	509

PM Peak	Volumes (vph)				
	Baseline Conditions	Alt 5	Alt 6	Alt 7	Alt 5 + Green Lake stop consolidation
WB west of Meridian	671	690	652	670	631
EB west of Meridian	573	569	571	565	565
WB east of Stone	675	691	660	672	643
EB east of Stone	566	562	568	560	564
WB Midvale	381	393	380	379	371
EB Midvale	420	417	419	413	421
WB Fremont input	1017	1000	1001	789	989
EB Fremont input	944	942	943	953	958
WB west of Phinney	799	784	786	613	789
EB west of Phinney	898	899	899	899	899

PM Peak	Intersection Delay (sec/veh)				
	Baseline Conditions	Alt 5	Alt 6	Alt 7	Alt 5 + Green Lake stop consolidation
Node 17: Phinney	11.7	11.8	12.0	18.9	11.5
Node 18: Fremont	66.7	63.9	63.5	78.7	60.8
Node 19: Green Lake	50.8	56.2	53.3	114.5	56.4
Node 20: Stone	40.6	39.8	38.1	40.5	39.4
Node 21: Densmore	16.2	23.2	22.0	21.7	25.6
Node 22: Wallingford	43.2	44.9	47.7	46.7	50.6
Node 23: Meridian	35.2	33.7	40.9	35.6	44.6

PM Peak	Bus Movement Delay (sec/veh)				
	Baseline Conditions	Alt 5	Alt 6	Alt 7	Alt 5 + Green Lake stop consolidation
Wallingford Ave WBT	44.1	36.5	39.1	42.0	40.3
Wallingford Ave EBT	18.6	23.1	22.3	22.7	24.4
Green Lake Way WBT	153.1	49.4	39.1	39.2	41.7
Green Lake Way EBR	21.0	28.4	35.3	47.0	38.7

Appendix E: Bus Bulb Time Savings

AM Peak Bus Bulb Synchro Analysis

Metro Zone Number	Bus Bulb Location	Stop Use	Stop Delay (sec/veh)	Time Savings (sec/veh)
Inbound				
18090	NW 54th Street & 30th Avenue NW, Nearside	54%	10.5	5.6
18100	NW Market Street & 28th Avenue NW, Farside	54%	10.5	5.6
18110	*NW Market Street & 26th Avenue NW, Farside*	*38%*	*10.5*	*4.0*
29214	*NW Market Street & 17th Avenue NW, Farside*	*55%*	*9.4*	*5.2*
29217	NW Market Street & 11th Avenue NW, Farside	56%	10.6	6.0
29231	*N 45th Street & Stone Way N, Farside*	*91%*	*11.4*	*10.4*
29232	N 45th Street & Woodlawn Avenue N, Nearside	68%	10.9	7.5
17410	N 45th Street & Wallingford Avenue N, Farside	93%	11.4	10.6
29236	NE 45th Street & Thackeray Place NE, Nearside	89%	12.3	11.0
10912	15th Avenue NE & NE 43rd Street, Farside	93%	10.0	9.3
	Total Inbound Time Savings			**75.2**
Outbound				
29440	15th Avenue NE & NE 40th Street, Farside	53%	10.0	5.3
29470	*NE 45th Street & 7th Avenue NE, Farside*	*62%*	*9.2*	*5.7*
29480	NE 45th Street & Latona Avenue NE, Farside	53%	12.7	6.8
29500	N 45th Street & Sunnyside Avenue N, Farside	38%	11.6	4.4
29620	NW Market Street & NW 48th Street	13%	10.5	1.4
29630	*NW Market Street & NW 50th Street, Farside*	*7%*	*10.1*	*0.7*
29640	NW Market Street & 3rd Avenue NW, Farside	22%	10.1	2.2
29680	NW Market Street & 11th Avenue NW, Farside	47%	9.0	4.2
29710	*NW Market Street & 17th Avenue NW, Farside*	*52%*	*9.1*	*4.7*
18750	*NW Market Street & 26th Avenue NW, Nearside*	*14%*	*9.3*	*1.3*
18760	NW Market Street & 28th Avenue NW, Nearside	23%	9.3	2.1
18785	*NW Market Street & 30th Avenue NW, Farside*	*27%*	*9.3*	*2.6*
	Total Outbound Time Savings			**41.4**

Note: Stop use percentages from Metro's Fall 2008 APC data
Bus Bulbs shown in italics are unlikely to progress beyond this conceptual study, due to design issues or potential stop closure.
Source: HNTB Corporation, 2009.

Midday Bus Bulb Synchro Analysis

Metro Zone Number	Bus Bulb Location	Stop Use	Stop Delay (sec/veh)	Time Savings (sec/veh)
Inbound				
18090	NW 54th Street & 30th Avenue NW, Nearside	53%	10.1	5.3
18100	NW Market Street & 28th Avenue NW, Farside	52%	10.1	5.2
18110	*NW Market Street & 26th Avenue NW, Farside*	*37%*	*10.1*	*3.8*
29214	*NW Market Street & 17th Avenue NW, Farside*	*44%*	*10.2*	*4.5*
29217	NW Market Street & 11th Avenue NW, Farside	54%	11.4	6.2
29231	*N 45th Street & Stone Way N, Farside*	*97%*	*11.5*	*11.1*
29232	N 45th Street & Woodlawn Avenue N, Nearside	80%	9.2	7.4
17410	N 45th Street & Wallingford Avenue N, Farside	99%	12.6	12.4
29236	NE 45th Street & Thackeray Place NE, Nearside	82%	14.7	12.1
10912	15th Avenue NE & NE 43rd Street, Farside	95%	9.7	9.2
	Total Inbound Time Savings			**77.2**
Outbound				
29440	15th Avenue NE & NE 40th Street, Farside	89%	9.7	8.6
29470	*NE 45th Street & 7th Avenue NE, Farside*	*78%*	*12.7*	*9.9*
29480	NE 45th Street & Latona Avenue NE, Farside	85%	16.4	14.0
29500	N 45th Street & Sunnyside Avenue N, Farside	71%	15.9	11.3
29620	NW Market Street & NW 48th Street	17%	10.4	1.8
29630	*NW Market Street & NW 50th Street, Farside*	*12%*	*13.2*	*1.6*
29640	NW Market Street & 3rd Avenue NW, Farside	25%	13.2	3.3
29680	NW Market Street & 11th Avenue NW, Farside	51%	8.9	4.6
29710	*NW Market Street & 17th Avenue NW, Farside*	*71%*	*10.4*	*7.4*
18750	*NW Market Street & 26th Avenue NW, Nearside*	*35%*	*10.6*	*3.7*
18760	NW Market Street & 28th Avenue NW, Nearside	30%	10.6	3.2
18785	*NW Market Street & 30th Avenue NW, Farside*	*47%*	*10.6*	*5.0*
	Total Outbound Time Savings			**74.4**

Note: Stop use percentages from Metro's Fall 2008 APC data

Bus Bulbs shown in italics are unlikely to progress beyond this conceptual study, due to design issues or potential stop closure.

Source: HNTB Corporation, 2009.

PM Peak Bus Bulb Synchro Analysis

Metro Zone Number	Bus Bulb Location	Stop Use	Stop Delay (sec/veh)	Time Savings (sec/veh)
Inbound				
18090	NW 54th Street & 30th Avenue NW, Nearside	62%	10.0	6.2
18100	NW Market Street & 28th Avenue NW, Farside	52%	10.0	5.2
18110	*NW Market Street & 26th Avenue NW, Farside*	*36%*	*10.0*	*3.6*
29214	*NW Market Street & 17th Avenue NW, Farside*	*50%*	*10.0*	*5.0*
29217	NW Market Street & 11th Avenue NW, Farside	46%	11.1	5.2
29231	*N 45th Street & Stone Way N, Farside*	*92%*	*12.1*	*11.1*
29232	N 45th Street & Woodlawn Avenue N, Nearside	81%	12.3	10.0
17410	N 45th Street & Wallingford Avenue N, Farside	96%	12.2	11.7
29236	NE 45th Street & Thackeray Place NE, Nearside	77%	13.2	10.2
10912	15th Avenue NE & NE 43rd Street, Farside	85%	9.5	8.1
	Total Inbound Time Savings			**76.3**
Outbound				
29440	15th Avenue NE & NE 40th Street, Farside	96%	9.4	9.1
29470	*NE 45th Street & 7th Avenue NE, Farside*	*87%*	*10.1*	*8.7*
29480	NE 45th Street & Latona Avenue NE, Farside	99%	10.6	10.5
29500	N 45th Street & Sunnyside Avenue N, Farside	88%	16.6	14.6
29620	NW Market Street & NW 48th Street	40%	18.1	7.3
29630	*NW Market Street & NW 50th Street, Farside*	*22%*	*18.1*	*4.0*
29640	NW Market Street & 3rd Avenue NW, Farside	57%	14.4	8.2
29680	NW Market Street & 11th Avenue NW, Farside	48%	9.2	4.4
29710	*NW Market Street & 17th Avenue NW, Farside*	*79%*	*10.0*	*7.9*
18750	*NW Market Street & 26th Avenue NW, Nearside*	*59%*	*11.8*	*7.0*
18760	NW Market Street & 28th Avenue NW, Nearside	50%	11.8	5.9
18785	*NW Market Street & 30th Avenue NW, Farside*	*65%*	*11.8*	*7.7*
	Total Outbound Time Savings			**95.3**

Note: Stop use percentages from Metro's Fall 2008 APC data

Bus Bulbs shown in italics are unlikely to progress beyond this conceptual study, due to design issues or potential stop closure.

Source: HNTB Corporation, 2009.