

# Greenwood Avenue

85th Street to 105th Street



Transit Corridor Plan

November 2012  
City of Seattle





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## Appendix

Appendix A. Proposed Corridor Design Drawings



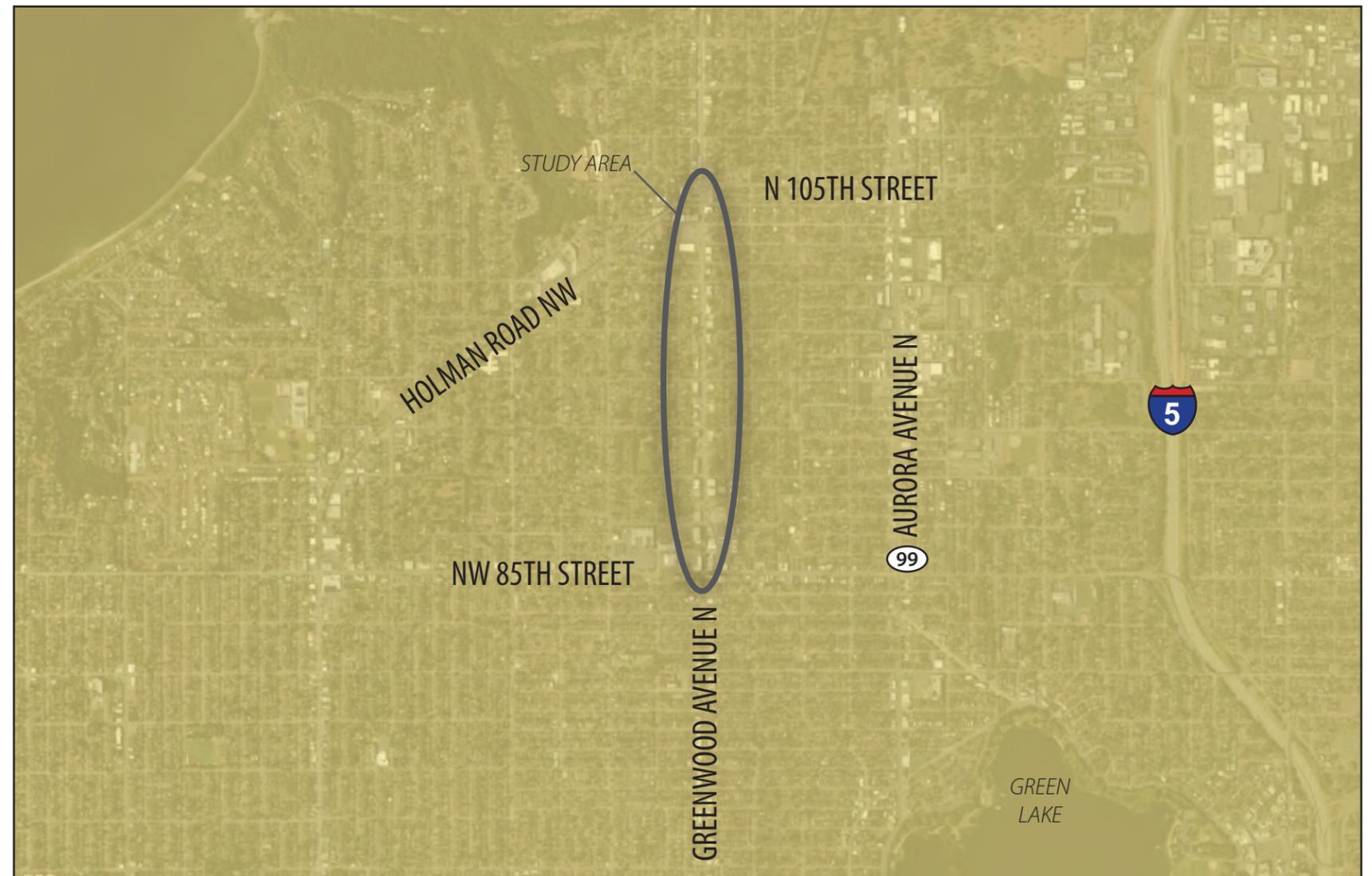
# Introduction

The City of Seattle is developing a long-term transit priority concept plan for Greenwood Avenue. The focus of this plan is to improve transit stops and nearby nonmotorized connections between N 85th Street and N 105th Street. The objective for this section of Greenwood Avenue is to improve transit speed and reliability in a manner consistent with Seattle’s Complete Streets policy.

An assessment of corridor conditions was completed to identify ideal stop locations in coordination with King County Metro (Metro). This ensures bus stops along the corridor are constructed in locations deemed most beneficial to maximize transit speed and reliability for bus operations. Also, opportunities to enhance pedestrian connections to bus stops and attain approximately 1/4-mile spacing between bus stops per King County Metro and Seattle Department of Transportation (SDOT) policies was considered.

This project developed preliminary design plans of the proposed bus stop locations, which includes curb lines, curb bulb locations, and the sidewalk/landscaping areas of improvement. The design assessed existing conditions to determine areas of insufficient passenger waiting surface, such as no sidewalk with vegetation, and other right of way uses. Improvements are targeted to be constructed within the existing roadway right of way to reduce impact to adjacent properties.

Traffic operations at 105th Street were also evaluated to determine if transit operations through this busy and complex intersection at the north end of the study area could be improved.



# Existing Conditions

## Greenwood Avenue Bus Stops

Greenwood Avenue is a primary north-south arterial in north Seattle. Adjacent land uses are a mix of low single family and multifamily residences and mixed commercial uses. The area has benefited from recent improvements to Greenwood Avenue north of 105th Street.

There are 7 existing bus stops on Greenwood Avenue from 85th Street to 105th Street. The highest number of people using the bus are at either ends of the corridor (near 85th Street and

105th Street) and near the middle of the corridor (97th Street).

Greenwood is a three-lane roadway with on-street parking and sidewalks between 85th Street and 92nd Street. The area near 85th Street has the highest concentration of commercial development and is zoned as an incentive area by the City of Seattle.

North of 92nd Street, Greenwood Avenue is generally a three lane arterial with bike lanes. On-street parking and sidewalks are not continuous.



*Existing Bus Stop Space and Peaking Boardings and Disembarkings*

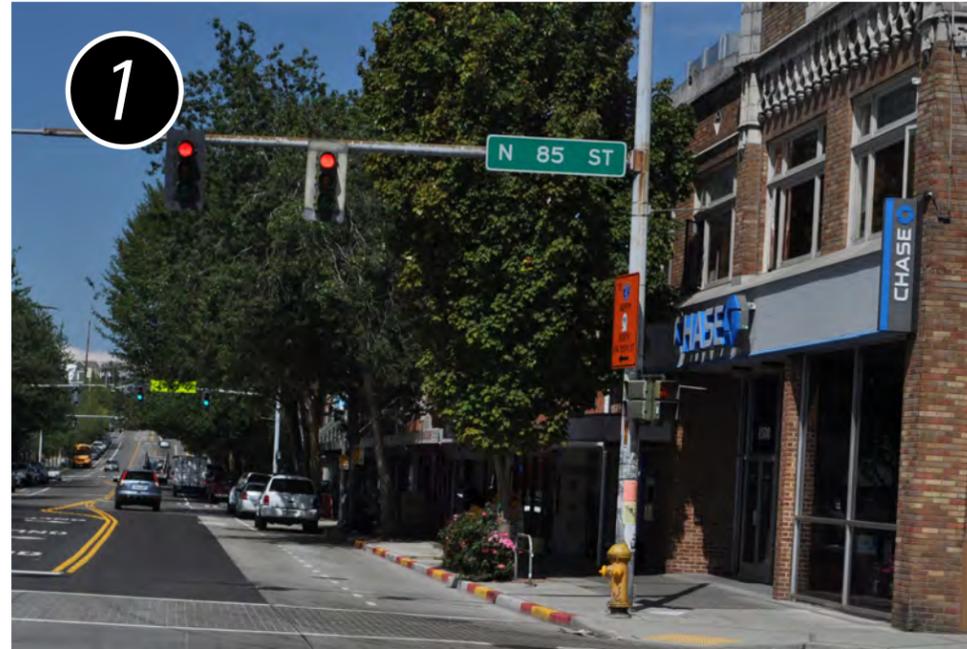


*Looking north along Greenwood Avenue: The southbound bus stop has been improved with a shelter, but the northbound bus stop lacks sidewalks and ADA accessibility. A signalized midblock crossing at 97th Street is provided, but there is no pedestrian connection to the east.*

Bus stops along the Greenwood Avenue corridor include shelters with amenities (photo #3), but are mostly flag stops (photo #4). The quality of sidewalk conditions varies by location, although sidewalks exist along most of Greenwood Avenue. ADA accessibility is not well accommodated.

Bus stops generally operate as pull-outs; the bus must leave the vehicle travel lane and cross the bike lane (where provided) and maneuver parallel to the curb. This adds some delay to buses because bus drivers must find an appropriate gap in vehicle traffic and bicycles to merge into the traffic flow after serving the bus stop.

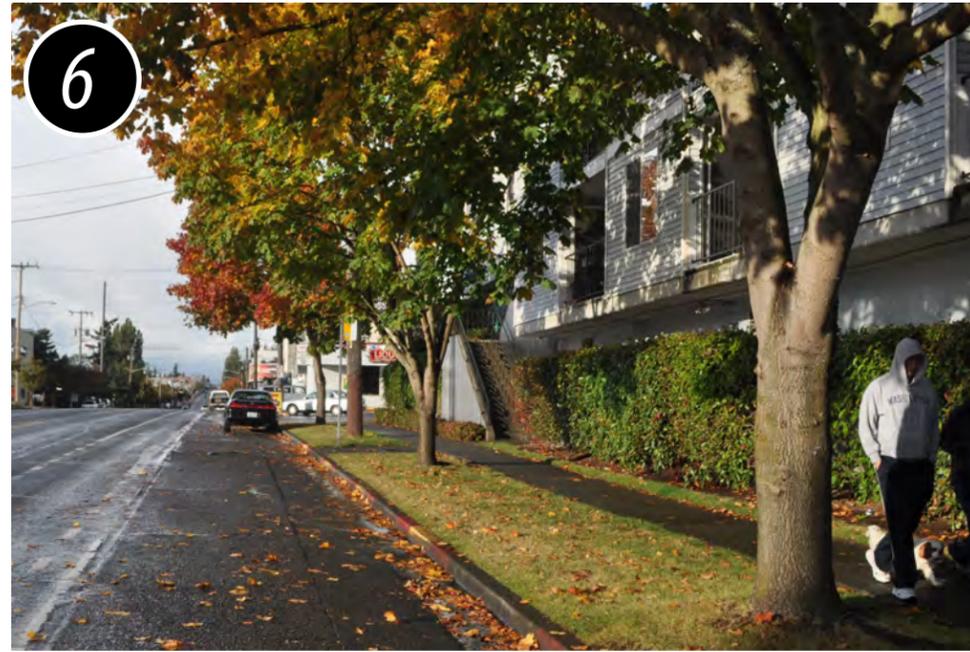
*(Continued on next page)*



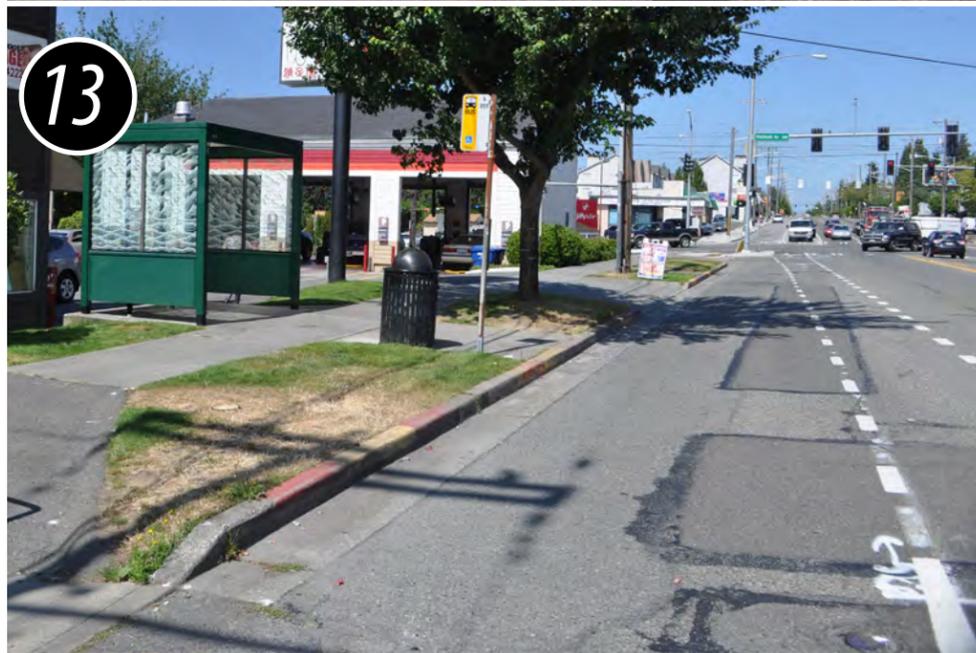
1. East side bus stop north of 85th Street, 2. East side bus stop north of 87th Street, 3. West side bus stop north of 87th Street, 4. East side bus stop north of 90th Street, 5. West side bus stop north of 90th Street

## Existing Conditions

Bus stops at locations without curbs, such as the west side stop south of 100th Street, the east side stop south of 97th Street, and the east side stop north of 100th Street, are poorly defined and offer no dedicated space for waiting passengers. Bus drivers often choose to remain partially or completely in the travel lane at bus stop areas with inadequate shoulders.



6. East side bus stop north of 92nd Street, 7. West side bus stop south of 95th Street, 8. East side bus stop south of 97th Street, 9. West side bus stop south of 97th Street, 10. East side bus stop north of 100th Street



11. West side bus stop south of 100th Street, 12. East side bus stop north of 103rd Street, 13. West side bus stop south of 105th Street

## Existing Conditions (Continued)

### Parking and Driveways

Vehicle parking in the right of way along Greenwood Avenue varies. It includes parking configurations such as parking lots, shoulder parking, and on-street parking (see adjacent photos).

Many of the off-street parking spaces are currently accessed directly from the roadway with no defined driveway. This type of parking increases the potential conflict points for vehicles and pedestrians. There are locations where there is no defined pedestrian area (see photo #1, #2, and #4).

Side streets along the corridor generally provide on-street parking. They also provide parking lot access for some of the properties. A detailed assessment of parking space requirements for property was not completed for this study.



Along Greenwood Avenue: 1. Looking west near 100th Street, 2. Looking northeast near Greenwood Circle, 3. Looking north near 85th Street, 4. Looking northwest near Greenwood Circle

# Plan Development

The City of Seattle coordinated with King County Metro in the development of this corridor plan for Greenwood Avenue. Improvements are organized into five categories, which describe the methods and considerations used when developing the conceptual improvements for the corridor. They include the following:

- 1. Bus Stop Placement
- 2. Sidewalks, Parking, and Roadway
- 3. Bicycle Facilities
- 4. Bus Stop Design
- 5. Greenwood Avenue and 105th Street

# Bus Stop Placement

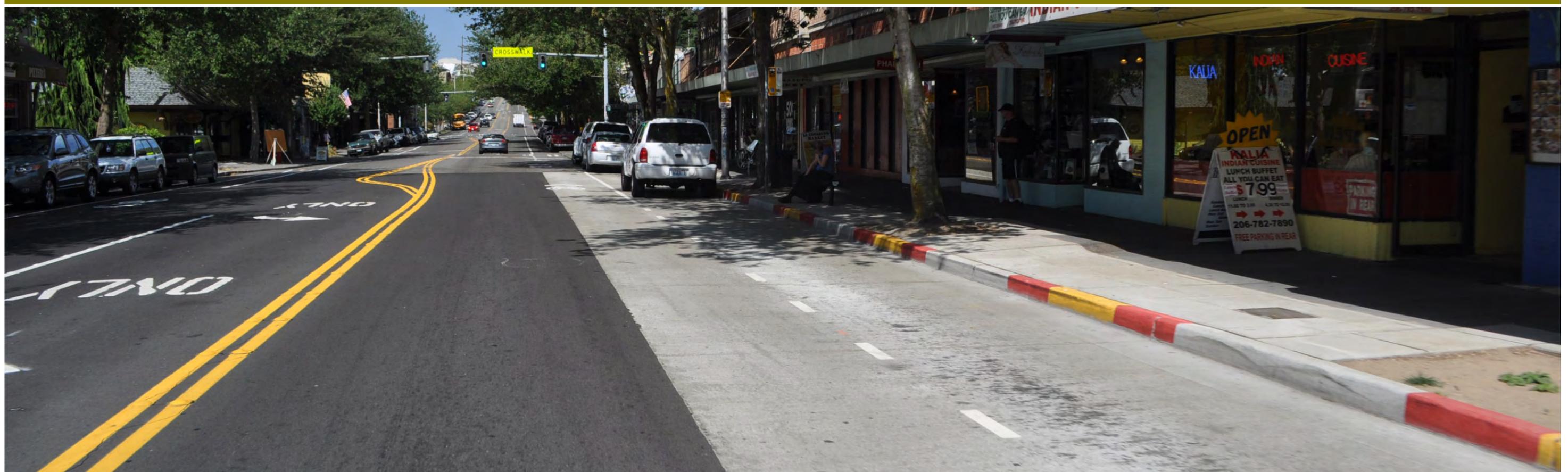
The objective of consolidating bus stops along the Greenwood Avenue corridor is to improve bus travel time and reliability. Because 85th Street and 105th Street are connection points to other service not running along Greenwood Avenue, these bus stops were not considered for consolidation. These stops also have some of the highest number of people using bus stops in the corridor. Two bus stop location strategies were developed as follows:

## Bus Stop Location Strategy #1

This strategy reduces the number of bus stops from 7 to 4. On average, it takes buses approximately 20 to 30 seconds to serve a bus stop. This time is significantly longer if the accessible ramp is deployed or a lot of people board and disembark the bus. Reducing the number of bus stops would reduce bus travel time through the corridor. This strategy would have bus stop with approximately 1/3-mile distance along Greenwood Avenue between them (also known as bus stop spacing).

## Bus Stop Location Strategy #2

This strategy consolidates 2 bus stop locations. The distance between bus stop locations along Greenwood Avenue would be approximately 1/4-mile. This could reduce the walk distance bus patrons have to their bus stop (compared to 1/3-mile bus stop spacing).



# Bus Stop Placement Summary

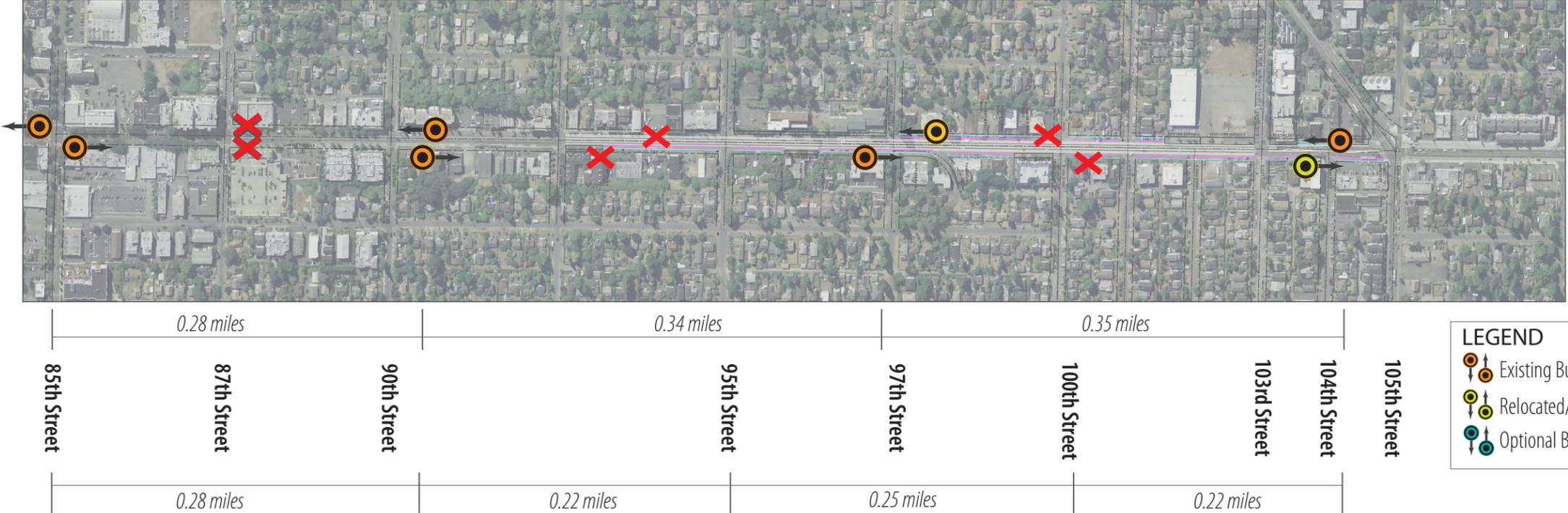
- Removing bus stops reduces bus travel time through the corridor.
- Longer spacing between bus stops makes access more difficult for some riders.

- Signal at 90th Street provides safer crossing locations for bus patrons.
- Near-side southbound stop could incur slight delay from patrons using signal to cross Greenwood Avenue

- Signal at 97th Street provides safer crossing locations for bus patrons, but does not serve neighborhood to the east of Greenwood Avenue.
- Near-side northbound stop could incur slight delay from patrons using signal to cross Greenwood Avenue.

- Near-side northbound bus stop at 105th Street could be impacted by right-turning vehicle queues.

## Strategy #1 1/3-mile stop spacing



**LEGEND**

- Orange circle with arrow: Existing Bus Stops
- Yellow circle with arrow: Relocated/New Bus Stops
- Teal circle with arrow: Optional Bus Stops

## Strategy #2 1/4-mile stop spacing



- Shorter bus stop spacing improves access for some riders.

- Bus zone has connections to neighborhoods to the east and west of Greenwood Avenue.
- Pedestrian signal may be desirable.

- Bus zone has connections to neighborhoods to the east and west of Greenwood Avenue.
- Pedestrian signal may be desirable.

- Near-side northbound bus stop between 105th Street and 104th Street would be expanded to occupy entire block. This moves the stop as close to 105th Street as possible and could reduce the impact from right-turn vehicle queues at 105th Street.

- Optional bus zone north of 105th Street does not provide desirable passenger waiting area (see page 13 discussion).

# Sidewalks, Parking, and Roadway

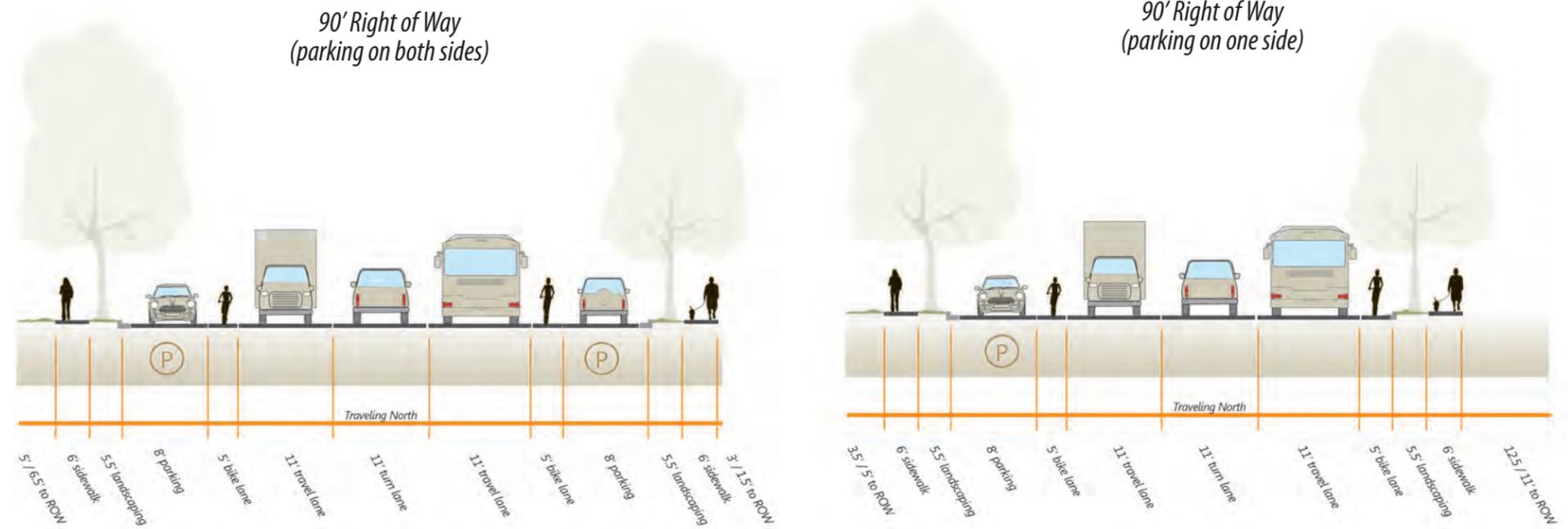
The Greenwood Avenue roadway configuration would remain in its current configurations (see adjacent representative existing sections) including existing turn lanes at intersections. Continuous sidewalks with landscaping would be provided on both sides of the street. Where feasible, on-street parking would be provided. In some instances, deviations from the proposed cross sections are considered.

For example, on-street parking could be removed near 97th Street. This is because the steep east side slope could require construction of a retaining wall and potentially slope stabilization work. Because the apartment building adjacent to the bus stop appears to have sufficient off-street parking, on-street parking could be excluded from this side. This would reduce the cost of constructing expensive retaining walls.

Where the existing sidewalks are in good to fair condition, the proposed design would match the existing sidewalks. This would help to reduce construction costs for the project.

At street crossings, curb ramps compliant with the American with Disabilities Act (ADA) would be furnished. Curb bulbs could be provided at some locations. These features improve pedestrian safety by reducing the crossing length for pedestrians and providing a better sight line for pedestrians and drivers.

## Greenwood Avenue – Existing Sections



Images 1 and 2. Looking south along Greenwood Avenue at the 97th Street bus stops; the east side bus stop would require sidewalk and bus stop improvement while the west side is in good condition.

# Bicycle Facilities

Currently, Greenwood Avenue has dedicated bicycle lanes adjacent to the vehicle travel lanes (see photos #1 and #2). The cross section on the previous page is representative of existing conditions where there is parking and bike lanes on both sides of the street.

To reduce the impact of roadway improvements on neighboring properties, the existing roadway width was maintained where possible (the existing curb and sidewalks typically remain where they are currently located).

## Alternative Bicycle Facilities

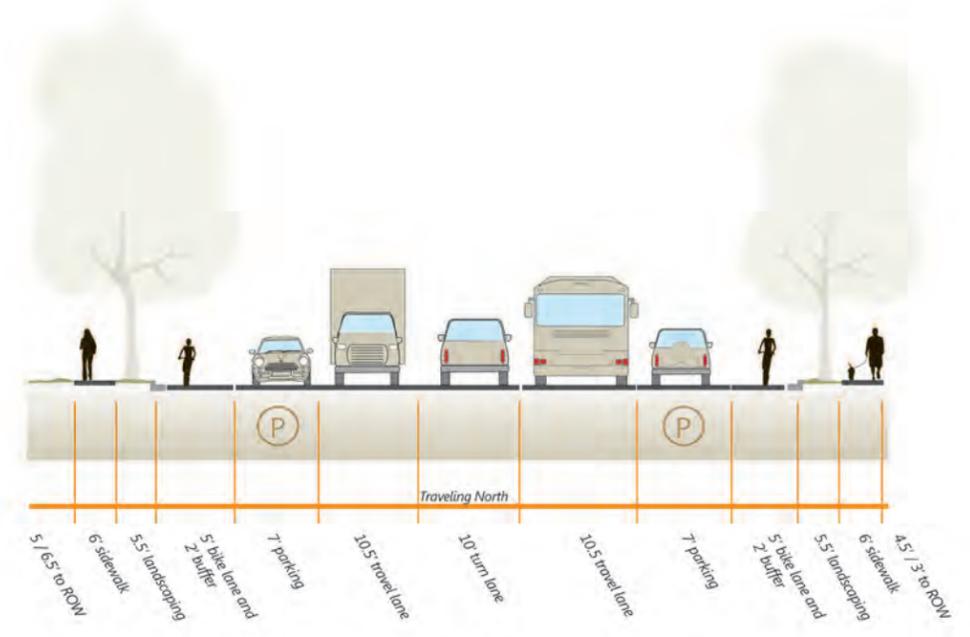
Cycle tracks could be considered along the Greenwood Avenue corridor. Cycle tracks are dedicated bicycle facilities that are further separated from vehicle travel lanes compared to bike lanes. Separation could be provided using features such as on-street parking and a buffer (image #3), landscaping, a barrier, and a slightly elevated profile from the roadway. Generally, cycle tracks provide a more comfortable facility to all rider groups

and could serve bicyclists who may not use bike lanes.

One goal of this project is to maintain the existing roadway and sidewalks where possible. A cycle track consideration for this corridor could be simply moving the bike lane to the curb and placing the parallel parking as a buffer between cyclists and vehicles. A striped buffer is desirable to protect cyclists from car door openings. The adjacent cycle track section illustrates alternative striping widths for the outside cycle track while maintaining existing curb locations.

## Greenwood Avenue - Cycle Track Section

90' Right of Way  
(parking on both sides)



1. Example of transition to bike lanes along Greenwood Avenue, 2. Bike lanes are provided on both sides of Greenwood Avenue along most of the corridor, 3. Example of cycle track with buffer located between the sidewalk and on-street parking.

# Bus Stop Design

The vision for Greenwood Avenue is to provide bus stops where the bus stops in the vehicle travel lane. This reduces the bus travel time and delay associated with pull-out bus stops. With in-lane bus stops, buses block both the vehicle travel lane and the bike lane. This can create potential conflicts because some drivers and cyclists could attempt to pass the stopped bus by using part of the travel lane and/or center turn lane.

Specific bus stop placement at an intersection should carefully address the safety of pedestrians and motorists. Generally, on two-lane roads stops should be located on the far side of a non-signalized intersection but on the near side of a signalized intersection. As this corridor moves into the design phase, improvements suggested in the pedestrian master plan should be considered as they relate to the bus stop locations and intersection improvements.

This section provides bus stop design considerations to address these potential conflicts.

## In-Lane Bus Stop with Shared Use Roadway

For buses to be able to stop in-lane at locations where on-street parking or a wide shoulder is provided, the curb can be extended. This improvement is commonly referred to as a curb bulb or bus bulb-out. A curb bulb provides additional space for bus stop amenities and permits buses to remain in the vehicle travel lane when serving a bus stop. As shown in the adjacent illustration, the curb bulb is extended to the cross-street when the bus stop is in close proximity. This also provides additional safety to people crossing at this location because it shortens the crossing distance and provides better sight lines around parked vehicles.

*Illustration of in-lane bus stop with curb bulb and bike lane transition to shared use through the bus zone.*



Bike lanes are not provided through typical bus stops; instead the bike lane transitions to a shared use roadway with the travel lane widened to 14-feet through the bus stop. Bicyclists are alerted to changed roadway conditions when the solid bike lane stripe changes to a dashed stripe and eventually the sharrow paint marking. With this configuration, bikes would either stop behind the bus or pass a stopped bus, creating a conflict.

Small islands can be placed in the center lane to prevent vehicles from passing a stopped bus (see illustration). These islands make road maintenance and snow removal difficult.



*1. Example of shared use roadway at bus stop.*

## In-Lane Bus Stop with Bike Lane Behind Bus Stop

This improvement would still provide a curb bulb for buses to be able to stop in-lane, but would provide a space behind the bus stop for the bike lane (see photo #1). As shown in the adjacent illustration, the bike lane is not replaced with a shared use roadway as shown in the illustration on the previous page. This allows cyclists to stay in the bike lane and eliminates this conflict point between cyclists and a bus.

As shown in photo #2, the bike lane could be designed to slow the speed of cyclists as they approach and travel through the bus stop area. The vehicle travel lane does not widen at this location. Some cyclists may prefer to share the roadway with vehicular traffic to avoid going behind the bus stop.

A median island, as shown in photo #3 could be provided to stop drivers from using the center lane to pass buses stopped at bus stops. The placement of center lane islands at bus stops close to intersections should consider the need for left-turn lanes and street maintenance.

Advantages of this configuration compared to In-Lane bus stop with shared use roadways include:

- A continuous bike lane running the length of the corridor.
- Potential bus-bike conflicts are significantly reduced.
- Areas with potential bike-pedestrian conflicts are designed to significantly slow the speed of cyclists.

Illustration of in-lane bus stop with curb bulb and bike lane behind bus zone.



1. Dexter Avenue bike lane and bus stop treatment in Seattle



2. Example of bike lane behind a bus stop in Portland-Oregon



3. Improvements along 45th Street in Seattle showing bus bulb and center lane island.

# Greenwood Avenue and 105th Street

The intersection of Greenwood Avenue and 105th Street is a complicated intersection which can cause considerable delay to bus travel time and bus passenger connection times. This master plan evaluated the placement of bus stops in the vicinity of this intersection and the vehicle operations at the intersection.

## Bus Stop Placement

The existing southbound Greenwood Avenue bus stop is located south of 105th Street. This is the preferred location because of the two right-turn lanes from Greenwood Avenue to Holman Road, which impact the ability to have the near side bus stop in close proximity to the intersection. Also, far-side bus stops often improve transit speed and reliability because buses do not have to exit the flow of traffic to serve a bus stop and then potentially miss the green light; instead buses travel through the intersection with vehicle traffic. Traffic signal priority (TSP) is typically more effective and less costly to implement at far-side stops because less bus detection equipment is needed.

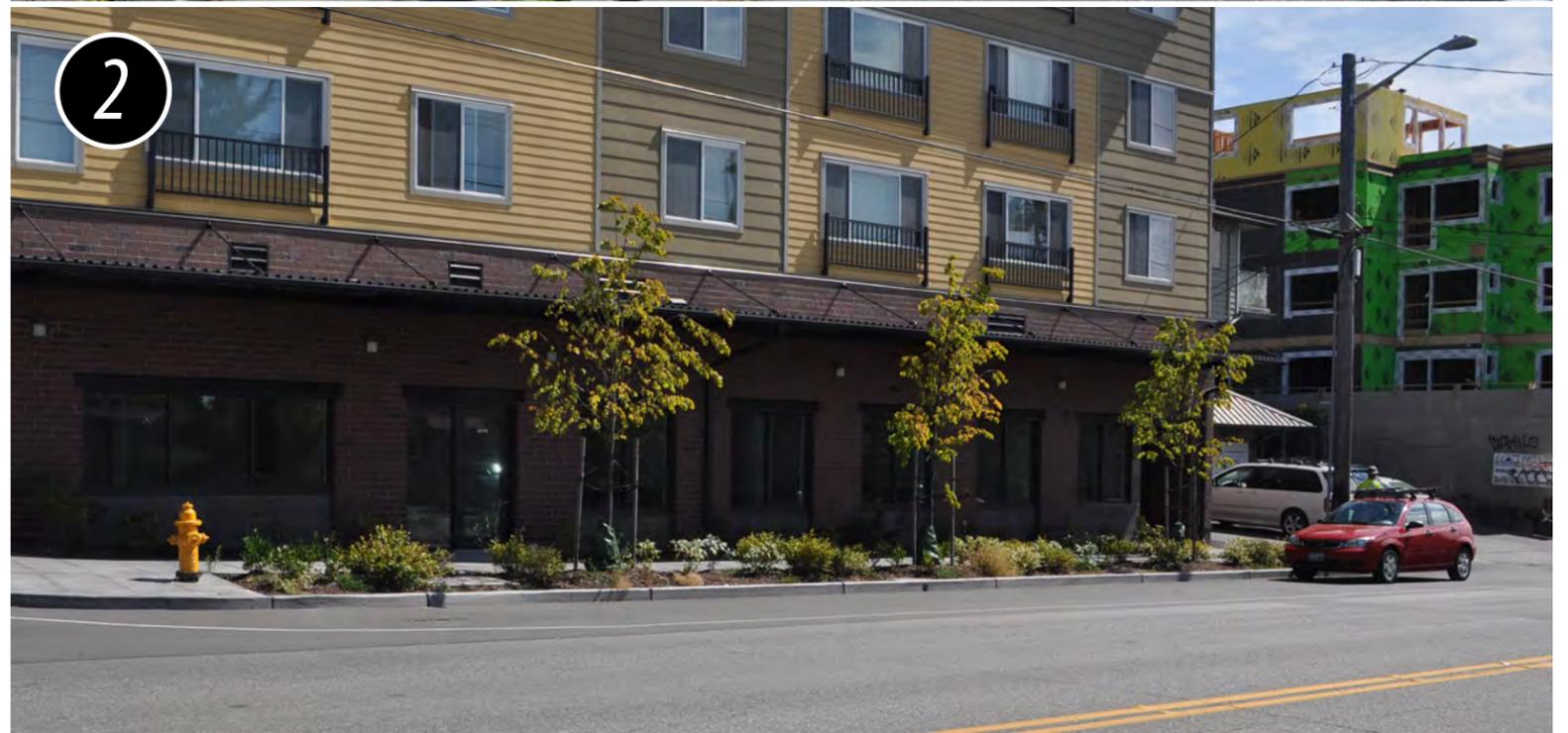
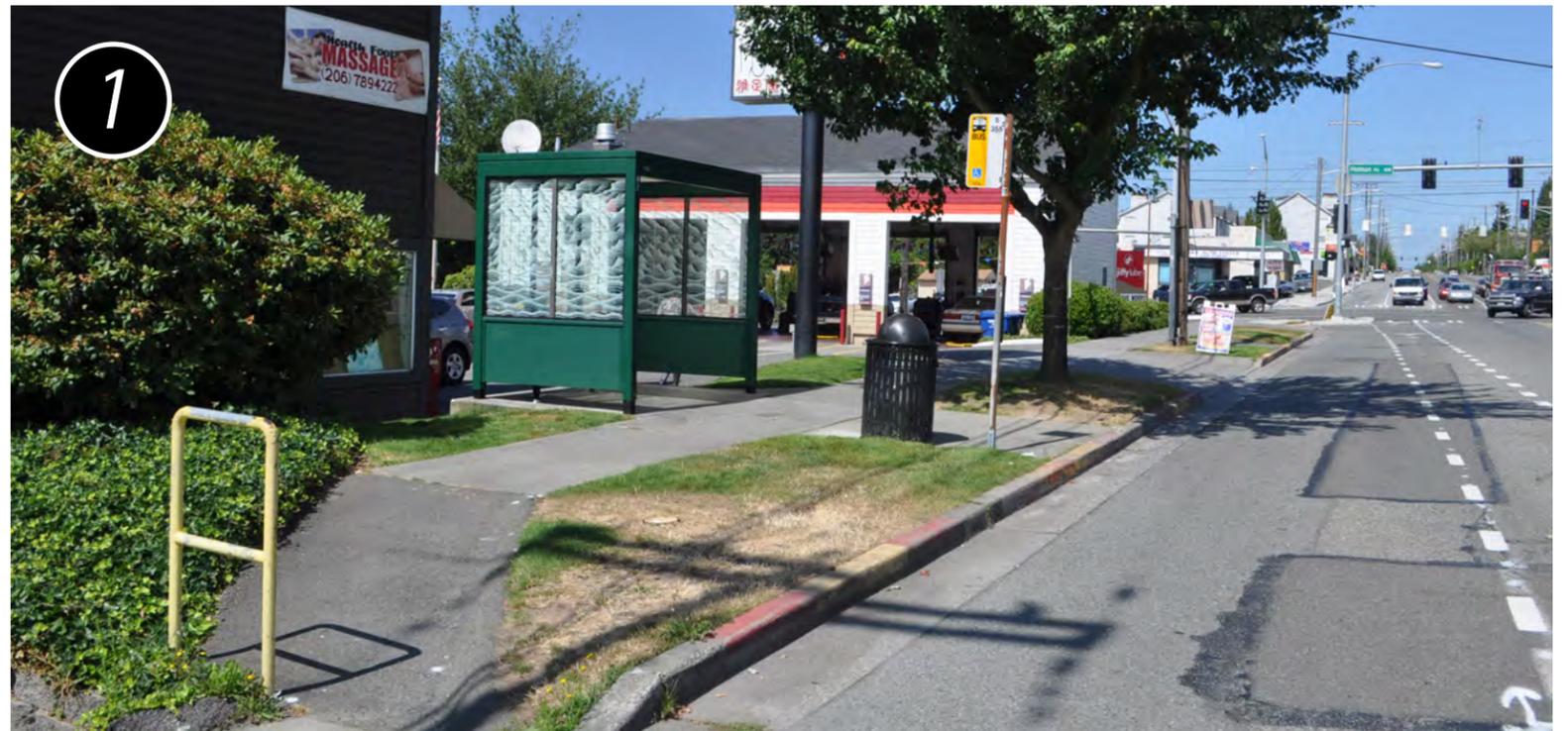
The existing northbound Greenwood Avenue bus stop is situated on the far side of N 103rd Street. It has no passenger waiting area or amenities. For the northbound Greenwood

Avenue bus stop, there are two options proposed: move the current location to near side 104th Street or relocate the bus stop to north of 105th Street.

### Option One: 104th Street Bus Stop

This option would move the bus stop to the near side of 104th Street. A bus only lane could be provided between 103rd Street and 104th Street; this would alleviate concerns of traffic queues from the 105th Street traffic signal blocking bus access to the bus stop. The bus only lane would require removal of approximately 3 on-street parking/loading zone space. Buses leaving the proposed bus stop would be able to merge into a northbound through lane. This would reduce delay from northbound right-turn vehicle queues and provide additional space for buses to access the bus stop. This location would provide a landscaping strip and sidewalk. Buildings adjacent the bus stop currently have awnings, which would provide protection from the elements for passengers. There would be sufficient space to provide an ADA loading zone.

Locating the bus stop at the far side of 104th Street is not recommended because of vehicles queuing from the signalized intersection at 105th Street. See the *Intersection Operations* description on Page 15 for more information.



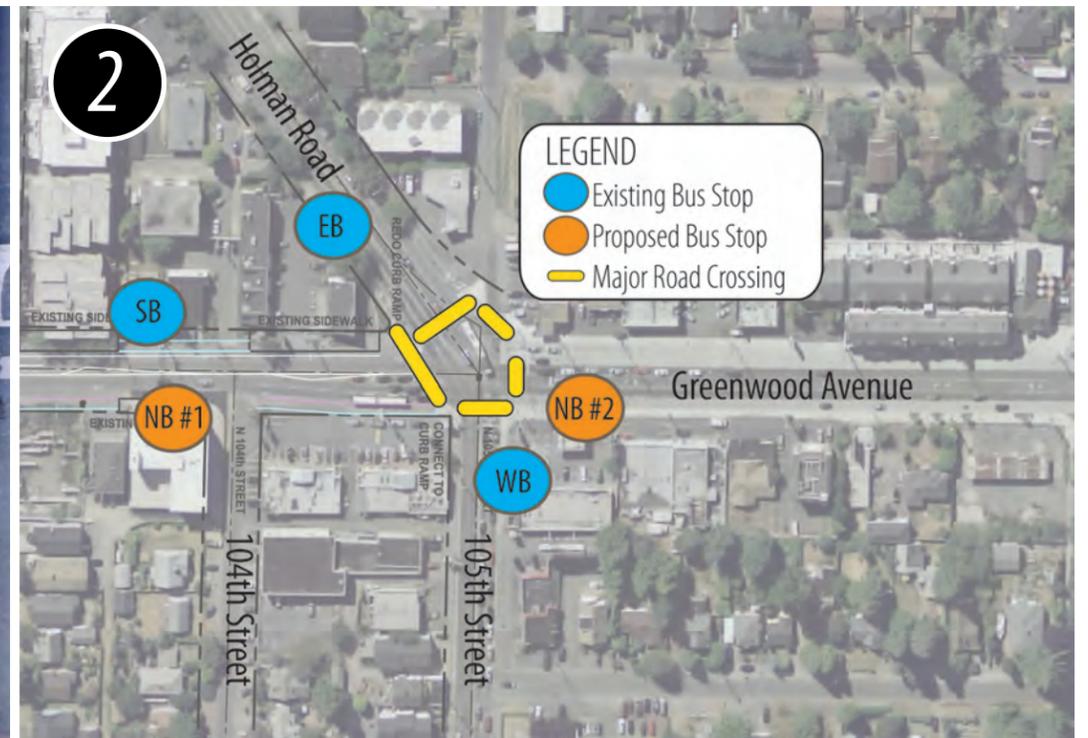
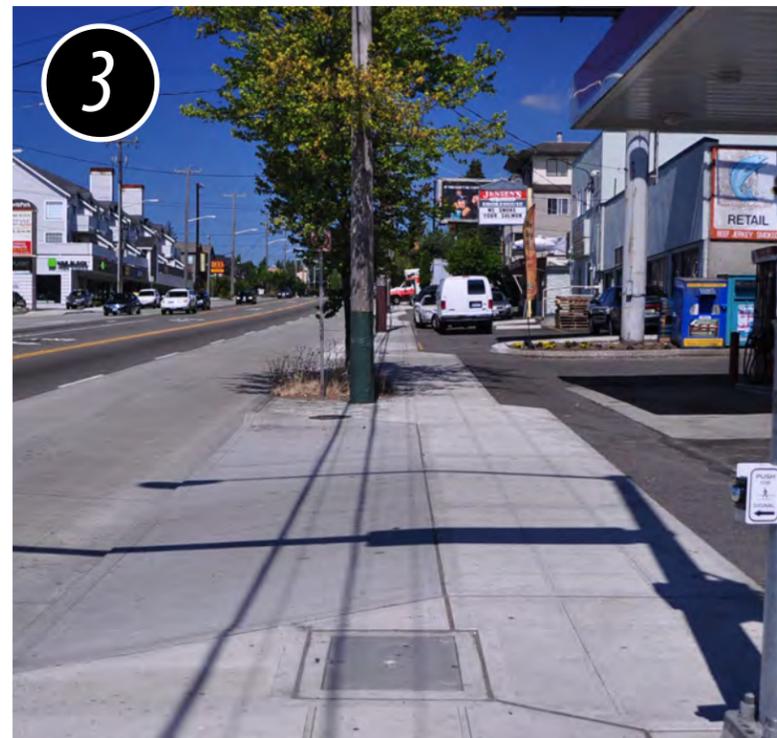
1. Existing southbound bus stop south of 105th Street, 2. Existing northbound bus stop north of 103rd Street.

### Option Two: Far Side 105th Street Bus Stop

This option would relocate the bus stop to the far side of 105th Street along Greenwood Avenue. This location would provide no protection from the elements and lacks a landscaping strip to provide a barrier from the sidewalk to the roadway. There are also local business parking lots at the back of sidewalk and closely spaced driveways further degrading the passenger waiting area. This makes it difficult to find sufficient space for an ADA compliant loading zone space. The curb, gutter and sidewalk are newly constructed for this portion of Greenwood Avenue. The far side 105th Street bus stop would be in-lane, and could potentially affect traffic signal operations due to the relative closeness to the intersection. However, it would be consistent with SDOT bus stop location policy.

### Comparison of Passenger Connections

The two options proposed provide different passenger connection consideration which are summarized in the adjacent illustration. Because no change is proposed to the southbound bus stop, the passenger connections to Holman Road service are the same. The northbound bus stop in Option One is proposed to be south of 104th Street and the connections would be the same as existing service. Option Two, would locate the bus stop to the far side and would eliminate passenger having to cross a road to connect from westbound to northbound service. However, connections from eastbound to northbound would require passenger to make two roadway crossings. All of these crossing would occur at a signalized intersection.



1. and 2. Proposed Option Two bus stop location north of 105th Street, 3. Illustration of bus stop locations and major road crossing in the vicinity of 105th Street

## Intersection Operations

105th Street, Greenwood Avenue, and Holman Road form a 5-legged intersection as shown in the adjacent illustration. The highest number of vehicles were observed making the following movements:

- Southbound right-turn from Greenwood Avenue to Holman Road
- Westbound left-turn from Holman Road to Greenwood Avenue
- Westbound thru from 105th Street to Holman Road

The existing signal time was used to conduct a comparative analysis for options to improve the intersection for transit operations. Synchro software was used to calculate the delay vehicles would experience at the intersection and the extent vehicles could queue back from the intersection. This intersection currently operates at a level of service F, which indicates an average of 91 seconds of delay for each vehicle and represents severely congested conditions.

With the existing configuration, buses can generally access the bus stop without entering the vehicle queue. After serving the bus stop, buses would enter the existing vehicle queue, which extends from the intersection to midway between 103rd Street and 104th Street (approximately 350 feet long).

### Signal Timing Adjustment

Adjusting the existing signal timing could improve intersection operations to a level of service E, which indicates an average of 77 seconds of delay for each vehicle. This would reduce queue lengths by approximately 1 to 2 vehicles. Adjustments included shortening the amount of time to the northbound and southbound movements. This was because it appeared extra signal time was allotted to these during the PM Peak. However, before timing adjustment are considered additional information about signal operations may be needed such as additional traffic counts and signal controller specifics.



*105th Street, Greenwood Avenue, and Holman Road create a complex intersection in the study area. Buses operate on all approaches.*

### Re-Stripe Northbound Greenwood Avenue (Queue Jump)

A potential improvement would be to re-stripe the northbound approach (Greenwood Avenue) to convert the curb side shared thru/right-turn lane to right-turn only. This could provide a queue jump for buses. Northbound buses on Greenwood Avenue would be able to use the right-turn only lane to cross 105th Street. Adjusting the lane configurations at this intersection would increase the overall intersection delay by approximately 2 seconds per vehicle (from 91 to 93 seconds, but both are considered level of service F).

With the re-striping, buses would encounter the vehicle queue from the intersection prior to serving the bus stop. The vehicle queue would increase to over 650 feet, which is almost south to 102nd Street. Buses would be in this vehicle queue for approximately 300 feet before accessing

the bus stop and would encounter approximately 70 feet of vehicle queuing after leaving the bus stop at the intersection (vehicles queuing for the right turn).

Bus travel time is likely better when access to the bus stop is unimpeded by vehicle queues. This is because a bus entering the back of a queue would have to wait for the vehicle queue to clear to access the bus stop.

# Recommendations

The Transit Corridor Plan was reviewed internally by City of Seattle staff and was presented to the public on November 28th, 2012. Based on the comments received, the following improvements are recommended in this corridor.

## Bus Stop Placement

A variation of strategy #1 and #2 should be incorporated into this corridor development. Bus stop locations are based on the existing ridership, bus stop spacing, and existing pedestrian crossings of Greenwood Avenue. Bus stops are recommended at 85th, 87th, 92nd, 97th, and 104th as shown in the adjacent figure.

## Bike Facilities

Cycle tracks would be preferred along this corridor but initial evaluation shows right of way and existing street improvements do not allow for cycle tracks in both directions while maintaining desired roadway widths. Concept plans have been developed to show the existing bike lanes. Further details should be explored during 30 percent design to make a final determination if cycle tracks can be included in this corridor.

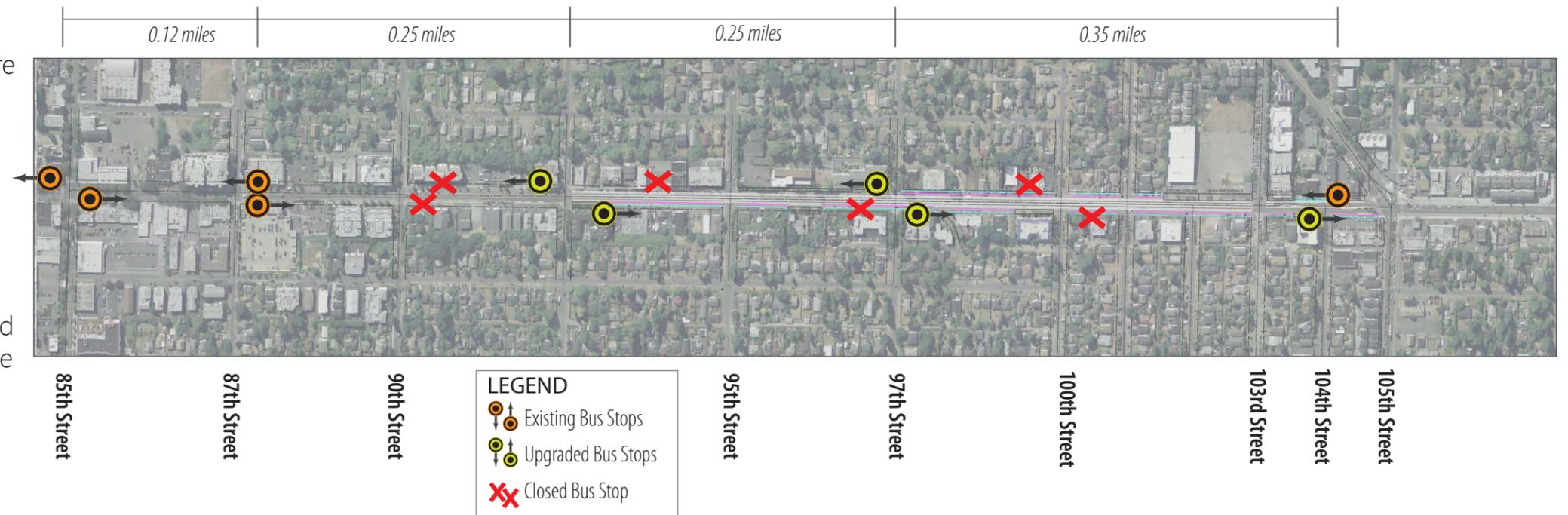
## Bus Stop Design

This project will plan for far side in-lane stops and bus bulbs with the bike lane behind the sidewalk. Specific details for the design of the bus bulbs have not been determined. Two options of incorporating bus bulbs are illustrated on pages 11 and 12. Careful consideration should be given during design of the bulbs to address ADA accessibility, safety of pedestrians and bicyclists, and street maintenance.

## Conceptual Design Plans

The conceptual designs for the Greenwood Avenue Transit Corridor Plan are included as Appendix A. These plans illustrate the future transit and pedestrian improvements recommended in this corridor.

## Bus Stop Placement Summary



*Illustration of in-lane bus stop with curb bulb and bike lane behind bus zone.*

