Corridor Program

Congestion Relief & Bus Rapid Transit Projects

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I-405 South Corridor Bus Rapid Transit Pre-Design

Final Report
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EXECUTIVE SUMMARY

Study Purpose and Scope

The Federal Transit Administration defines Bus Rapid Transit as follows:

> *"A flexible, high performance rapid transit mode that combines a variety of physical, operating and system elements into a permanently integrated system with a quality image and unique identity."*

Bus Rapid Transit combines many of the qualities of light rail service (frequent service, limited stops, direct routing, high reliability, and reduced travel time compared to conventional bus services), with the flexibility of buses that can operate on regular freeway lanes, HOV lanes, dedicated busways, and streets.

The purpose of this pre-design study, conducted as part of the I-405 Corridor Program, was to assess the potential feasibility of a Bus Rapid Transit service along the southern portion of the I-405 corridor (from Bellevue to Sea-Tac International Airport), and identify infrastructure improvements that could support such service.

The first part of the study focused on assessing the overall feasibility of operating Bus Rapid Transit in the southern section of the I-405 corridor, building from BRT planning work completed as part of previous I-405 Corridor studies. The feasibility assessment was based on two planning horizons:

- A 2014 horizon that assumes potential I-405 infrastructure build-out as described in the *I-405 Corridor Implementation Plan*
- A 2030 horizon that assumes potential I-405 infrastructure build-out as described in the *I-405 Corridor Master Plan*

The second part of the study focused on identifying infrastructure elements and improvements along I-405 required to support BRT operations, along with planning-level costs. A potential BRT alignment for the south corridor was identified connecting activity centers in Bellevue, Renton, Tukwila and Sea-Tac International Airport.

Modeling Analysis

In order to assess the potential feasibility of BRT service in the I-405 corridor, a modeling analysis was undertaken that looked at the entire corridor from the Lynnwood Transit Center in the north to Sea-Tac International Airport in the south. The study tested two alternative concepts for how BRT service could be provided including:

1. A single-route concept extending from Lynnwood in the north to Sea-Tac International Airport in the south as illustrated in Exhibit ES-1.
2. A trunk and branch concept that overlays multiple routes in the corridor, extending individual routes into communities surrounding the I-405 corridor as illustrated in Exhibit ES-2.

Analysis of the two modeling concepts suggested that the second one, the trunk and branch concept, offered the greatest potential ridership generation. The single route option, illustrated in Exhibit ES-1, showed that it would have only about 65% of the ridership of the trunk and branch concept (based on projections for 2030).

Exhibit ES-1: Single Route BRT Concept

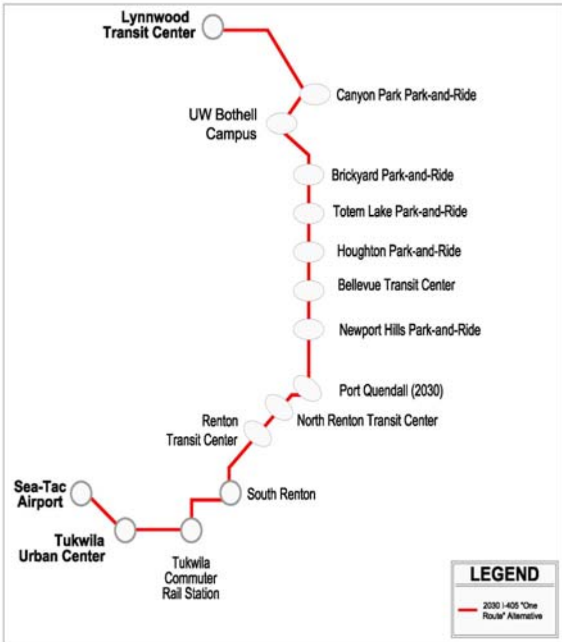
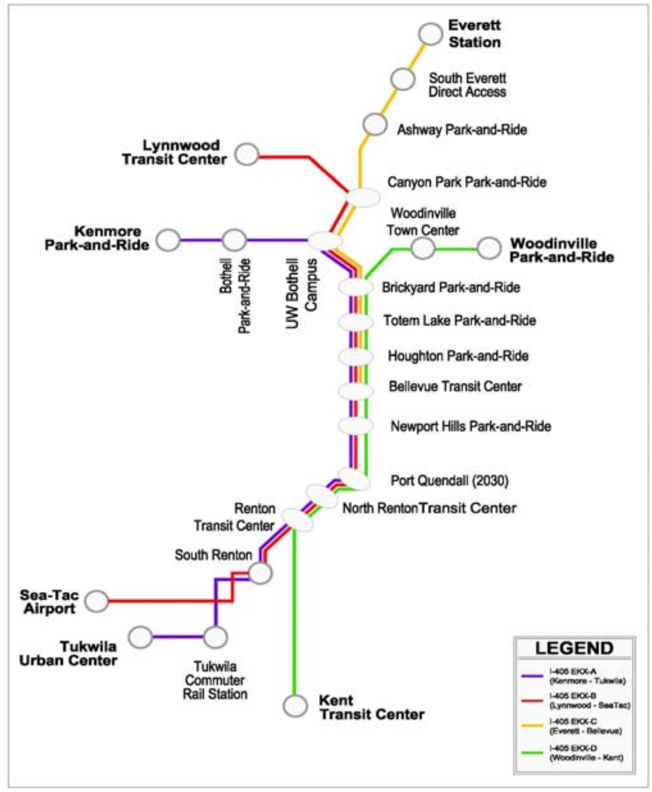


Exhibit ES-2: Trunk and Branch BRT Concept



The trunk and branch service model was based on headways of 20 minutes during peak hours, and 30 minutes during off-peak hours (60 minutes after 8:00 PM.), for each of the four individual routes. The study showed that under the trunk and branch concept, both northbound and southbound BRT buses would carry full-seated loads (assuming 40-foot coaches) during the AM and PM peak hours in 2014. The study also noted that overlaying these routes as indicated in Exhibit ES-2 would provide average headways of 5-7 minutes along the trunk segment of the corridor from Brickyard in the north, to the downtown Renton Transit Center in the south, consistent with service levels typically associated with BRT.

Under either service concept, ridership in the south corridor would be generated in greatest numbers (in decreasing order) by the following activity centers: Bellevue (which accounts for about 25% of all boardings), Sea-Tac International Airport, downtown Renton, and north Renton (based on projected redevelopment in that area). Ridership projections for Tukwila are significantly lower than these activity centers.

Infrastructure Requirements & Cost Estimates

In order to assess potential I-405 infrastructure requirements and costs, an example BRT alignment was identified connecting the activity centers along the corridor. For analysis purposes, the alignment assumed a freeway routing from Bellevue to north Renton, and a combination of arterial and freeway routing to connect Renton with Tukwila and Sea-Tac International Airport.

Key infrastructure-related findings for the southern corridor, from north to south, are as follows:

1. The existing Newport Hills park-and-ride would be best served by BRT through an in-line station and some level of expansion of the park-and-ride to accommodate projected future demands. A conceptual design for a prototypical in-line station and park-and-ride is identified that could be considered for Newport Hills.
2. Provision of BRT service and infrastructure into the Port Quendall area will depend upon how that site is developed. Given current economic conditions, it is not expected that such development will occur significantly in advance of 2030.
3. Planned redevelopment of the north Renton area suggests that this area will become a key activity center and should be served by any BRT service. Supporting infrastructure that would be required includes I-405 direct access ramps at North 8th Street in Renton, and a new transit center and park-and-ride in the north Renton area. A prototypical transit center and park-and-ride is presented that could be considered as a concept for this area.
4. For 2014 (Implementation Plan), it was assumed that any connection between south Renton and Tukwila would be along arterials. The network infrastructure for this is not in place, and would be driven by broader traffic and transportation needs in the area rather than BRT requirements, as ridership projections for Tukwila are low.
5. For 2030 (Master Plan) direct access ramps in south Renton and Tukwila could be used by an I-405 BRT service, but that service alone would not justify their construction. Alternatively, any routing identified for 2014 could continue to be used.
6. If future routing of BRT is on arterials, transit preferential treatments including transit signal priority, queue jump lanes, and business, access and transit (BAT) lanes should be considered. Support of such improvements by the local jurisdiction should be a criterion for deciding if and how to serve an activity center.

Planning-level capital cost estimates were generated for transit signal priority, BRT vehicles and technology, and stop and station infrastructure. Total cost based on these assumptions is approximately $89 million, of which approximately $37 million is estimated for a new transit center and park-and-ride in north Renton, and $28 million for an inline station in Newport Hills. Cost estimates do not include land acquisition for stops, stations and road improvement projects as these are site specific. No specific capital funding has been identified for these elements.

Next Steps

Findings from this study are primarily intended as input to future planning and design work. In this context, potential next steps include:

1. Review major findings from this study with stakeholders including the I-405 Project Team, city of Renton, city of Tukwila, and the public, to help ensure that findings are incorporated into project and local planning.
2. Consider findings of this study by the I-405 Corridor Project as decisions are made with respect to improvements to the Newport Hills park-and-ride, construction of direct access ramps at North 8th in Renton, and construction of direct access ramps in south Renton and Tukwila.
3. Consider findings of this study by Sound Transit and King County Metro in regional transit planning initiatives.
4. Initiate a similar analysis of the northern part of the I-405 corridor to present a complete picture of potential BRT infrastructure requirements for the entire corridor.

1. INTRODUCTION

The I-405 Corridor Program Final Recommendations Report, published in 2002, includes a proposed Bus Rapid Transit (BRT) system along I-405 from Lynnwood to Sea-Tac International Airport. Buses would share HOV lanes along I-405, and use direct access ramps or in-line stops to provide rapid and efficient service. Bus Rapid Transit within the I-405 corridor is included as a proposed improvement in the Corridor Final Environmental Impact Statement (FEIS)[1], and in the selected alternative identified in the Record of Decision[2] issued October, 2002. The selected alternative was adopted by the Federal Transit Administration, Federal Highways Administration, Sound Transit, King County Department of Transportation, and the Washington State Department of Transportation.

The purpose of this report is to further define the south section of the BRT route from the Bellevue Transit Center to Sea-Tac International Airport, focusing primarily on the infrastructure elements that should be considered along I-405 to support BRT service. No decisions have been made with respect to the implementation of such service, which might include a new bus service or enhancement of existing Sound Transit and Metro Transit routes. Such decisions would be the subject of future agency planning and a public input process within the larger context of regional public transportation planning.

While the objective of the pre-design is to identify potential BRT-related infrastructure in the I-405 corridor south of Bellevue, some initial service concepts involving the entire corridor (from Lynnwood to Sea-Tac) were assumed for demand modeling and ridership estimation purposes. In addition, to show connectivity and a potential service concept, some assumptions are made regarding possible routing of the service along arterials in the Cities of Renton and Tukwila. It is recognized however that capital improvements outside of the I-405 corridor are beyond the scope of the I-405 pre-design, and such improvements should be considered assumptions made solely for the purpose of this BRT pre-design study. Actual routing and any associated infrastructure improvements in the Cities of Renton and/or Tukwila will need to be determined in the future based on local and regional needs and priorities. The BRT service is flexible enough to accommodate alternative routings and network configurations as conditions evolve.

1.1 Overview of BRT

BRT provides “higher-quality transit using rubber-tired vehicles” by combining the quality of rail transit and the flexibility of buses. BRT systems operate in a variety of environments such as exclusive busways, HOV lanes, expressways, or ordinary streets, and typically provide a higher quality of service than conventional urban bus services.

The Federal Transit Administrations (FTA) **Bus Rapid Transit (BRT) Implementation Guidelines**, defines BRT as:

> *“A flexible, high performance rapid transit mode that combines a variety of physical, operating and system elements into a permanently integrated system with a quality image and unique identity.”*[3]

Key distinctions between conventional urban bus service and BRT include:

- **Reduced Travel Time:** All BRT projects seek to improve service by reducing travel time. The components of travel time include time getting to and from the transit stop, time waiting for the transit vehicle, and time in the vehicle. Various techniques are used to achieve reduced travel times including use of exclusive rights-of-way such as busways and exclusive lanes on expressways; providing traffic signal priority to transit vehicles; providing limited-stop service or relocating stops to areas where there is less congestion; changing fare collection policies to reduce or eliminate on-vehicle fare purchase; and/or

[1] I-405 Corridor FEIS - http://www.wsdot.wa.gov/projects/I-405/feis.htm
[2] I-405 Corridor Program Record of Decision - http://www.wsdot.wa.gov/projects/i-405/library.htm
[3] Levinson et al., Bus Rapid Transit - Implementation Guidelines*, TCRP Report 90-Volume II*

using vehicle designs that feature fewer steps and more or wider doors. These techniques reduce travel time, improve service reliability and predictability, and reduce passenger waiting and total travel times.

- **Increased Passenger Convenience:** Although faster travel is a key element in improving service and attracting more transit trips, transit will not be attractive to many potential riders unless it is more convenient and user-friendly than other modes. A key distinction between conventional bus service and BRT is the "schedule-less" (high frequency) nature of the latter. With increased frequencies, passengers can arrive at a BRT stop and expect a bus within minutes. In addition to not having to consult a schedule, better passenger information can make transit service easier to use. Providing real-time bus status information, a unified and "branded" system design, and supportive land use, park-and-ride facilities and pedestrian facilities enhance the attractiveness of transit as a mode choice.

1.2 Project Goals and Guidelines

The purpose of this study is to build on existing I-405 BRT concepts to further define the south corridor portion of the I-405 BRT line per FTA's service definition. This corridor extends from downtown Bellevue, through the communities of Renton and Tukwila, to Sea-Tac International Airport. General goals of BRT service in this corridor include:

1. Deliver high quality transit service along the I-405 corridor.
2. Provide a link in the overall Puget Sound regional transit network.
3. Identify ways to provide connections between major activity centers and transportation facilities on the east side of Lake Washington.

Guidelines used in the conduct of this study included:

1. The primary purpose of the study is to identify potential infrastructure improvements along I-405, and assess the potential feasibility of providing BRT service.
2. The BRT should be considered part of a broader regional transit network.
3. BRT service should be reasonably frequent, with headways of under 10 minutes during peak periods, and under 20 minutes during off-peak periods.
4. The BRT should provide all-day operation, with headways adjusted as needed to reflect demand.
5. The BRT should provide rapid service (using HOV lanes where possible) with limited stops.
6. Travel times should be reasonably time competitive with other modes of transportation in the corridor, in order to help promote non-SOV travel.
7. Routing of the BRT should be perceived as being direct, recognizing that deviations may be required to serve stations and activity centers. There will be trade-offs between riders traveling for longer distances and the need to serve some markets.

1.3 Contents of this Report

This report serves as a compilation of the first three technical memorandums produced under this effort. These initial tasks involved documenting current conditions, analyzing ridership forecasts using modeling software, and finally, preparing a proposed alignment and list of stations based upon the model results.

Following this introduction, this report is structured as follows:

- **Existing Conditions:** This section presents the existing conditions along the I-405 corridor, including plans that have been developed, traffic conditions, travel times, transit service, and infrastructure.

- **Potential Stop Locations:** This section reviews and prioritizes the various potential station locations along the corridor.
- **Ridership Forecasts:** This section presents the transit model, including the general approach, assumptions made, and the ridership forecasts that resulted.
- **Alignment:** This section presents the recommended BRT route alignment as a result of the ridership forecasts and other efforts.
- **BRT System Components and Costs:** This section identifies the major components that would comprise a BRT system, and includes potential stop, station and park-and-ride conceptual designs. It also includes planning-level costs for the components identified in this section.

The final section of this report summarizes the overall conclusions of the study, and identifies potential next steps for consideration in future planning and design work.

2. EXISTING CONDITIONS

This section provides a summary of existing conditions along the I-405 Corridor, including plans and reports, stakeholder needs and requirements, infrastructure, and current transit service. This information is intended as background on the baseline conditions used as a starting point for the BRT pre-design.

2.1 Summary of Existing Documentation

The initial start-up activity of the I-405 BRT South Corridor Pre-Design project included a review of pertinent background information, primarily for the purpose of identifying the baseline future (2014 and 2030) conditions.

Information collected from state and local agencies included reports, maps, conceptual designs, planning and forecast information for roads, and area growth. Routing, ridership data, and future capital project information were identified and obtained from transit agencies. Documents gathered and reviewed include the following:

Reports:

- White Paper: Bus Rapid Transit Line Concept, Ten-Year Program Implementing the First Phase of the I-405 Corridor Program Recommendations, August 2003, Washington State Department of Transportation, Urban Corridors Office
- I-405 Corridor Program, Final Recommendation Report, 2002, Washington State Department of Transportation
- I-405 Corridor Final Environmental Impact Statement, 2002, Washington State Department of Transportation
- I-405 Corridor Program Record of Decision, October, 2002, US Department of Transportation
- White Paper: I-405 HOV Support (TDM) Program, Ten-Year Implementation Program of the I-405 Corridor Program Recommendations, July 2003, I-405 TDM Workshop and WSDOT TDM Resource Center
- King County Metro Six-Year Transit Development Plan Update For 2002 to 2007, March 2001, King County Department of Transportation, Metro Transit
- Six-Year Transit Development Plan for 2002 to 2007: Proposed Initiatives, Fall 2001, King County Department of Transportation, Metro Transit Division
- Park-and-ride Utilization Report, 4th Quarter 2003, King County Transportation Department
- BRT Briefing Book, 2001, King County Metro BRT Materials

Maps and other information:

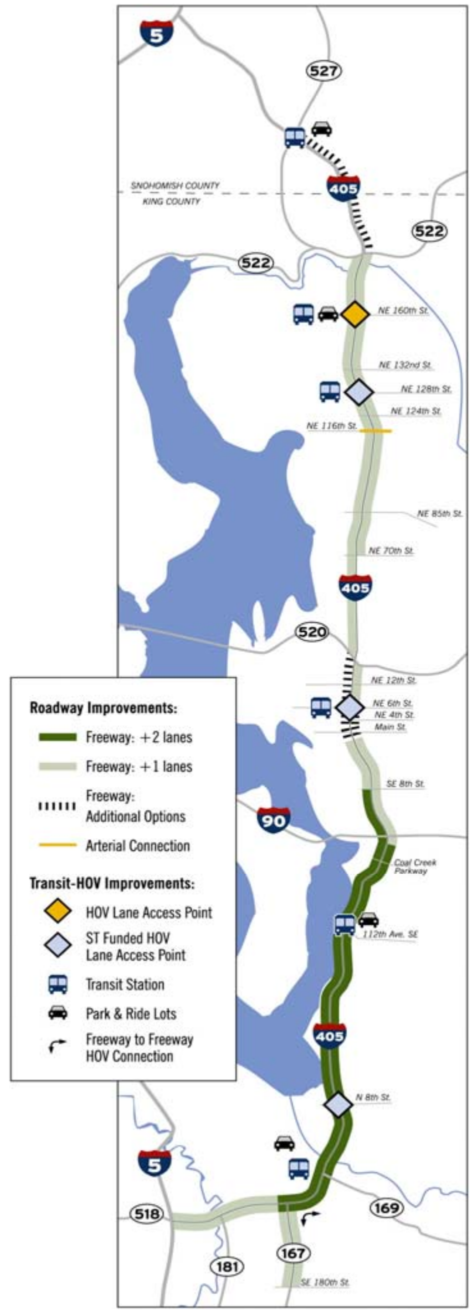
- Phase 1: Nickel Projects Map
- Phase 2: Implementation Plan Map
- Complete Master Plan – 20 Year Vision Map
- Community Transit Route/Ridership Information
- King County Metro Transit Route/Ridership Information
- Sound Transit Route/Ridership Information

These documents provided needed background information on ridership, potential station locations, projected regional growth, and planned infrastructure.

2.2 Context

The BRT pre-design is being carried out within the framework of a larger I-405 program of proposed improvements and ongoing land use and transportation planning by the local city, county and regional agencies.

Exhibit 2-1: I-405 Implementation Plan



2.2.1 I-405 CORRIDOR

I-405 moves nearly 800,000 people a day and carries twice the amount of freight shipped through the Port of Seattle. I-405 connects drivers across Lake Washington and throughout the Puget Sound region, providing access to major employers like Boeing, Microsoft, and PACCAR.

The I-405 Project describes a 20+ year vision of multimodal improvements to the freeway, transit systems, and arterials along the I-405 corridor from Tukwila to Lynnwood[4]. Through improvements such as building additional lanes, park-and-ride facilities, and providing public transit services such as BRT, implementation of the Master Plan will ultimately accommodate an additional 110,000 daily person-trips along the corridor, with a reduction of time spent stuck in traffic of up to 13 million hours per year (or 40 hours per typical user)[5].

For the purpose of the BRT pre-design, two planning horizons have been identified: 2014 and 2030. The 2014 horizon assumes that a certain level of improvements have been made in the corridor based on the I-405 Implementation Plan[6] as illustrated in Exhibit 2-1).

The 2030 horizon assumes additional buildout of the corridor as documented in the I-405 Master Plan[7]. These improvements include direct-access HOV lanes, additional park-and-ride spaces, and bus service enhancements that potentially support BRT service.

Throughout the pre-design process, work on the BRT study was coordinated with the I-405 Design Team to maintain consistency across the different studies currently underway.

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[4] I-405 Corridor Program, Final Recommendation Report, 2002, Washington State Department of Transportation.
[5] I-405 Corridor Program, Final Recommendation Report, 2002, Washington State Department of Transportation.
[6] http://www.wsdot.wa.gov/projects/I-405/resource/i405_map_imp_plan.pdf
[7] http://www.wsdot.wa.gov/projects/I-405/resource/i405_map_master.pdf

2.2.2 CITY INPUT

Meetings were held with the Cities of Tukwila[8] and Renton[9] to discuss BRT service options and solicit input on projected future development in those areas. For the purpose of this document, “north Renton” is defined as the area extending north from downtown Renton (the Renton Transit Center), including the area around south Lake Washington. “South Renton” is defined as the area from downtown Renton south to the Tukwila city boundary. This differs somewhat from other definitions used in the I-405 project, but is required for the BRT pre-design in order to describe the potential BRT concepts.

Within the 2014 time horizon, considerations identified by the Cities of Renton and Tukwila with respect to potential BRT arterial routing included:

- **Logan Avenue N (North Renton)** – The City of Renton provided information on their planned development in the north Renton area, including the creation of a more pedestrian-friendly Park Avenue, and moving bus traffic to Logan Avenue (currently buses are routed on Park Avenue). The City would consider equipping Logan Avenue with transit signal priority (TSP) and business access and transit (BAT) lanes to provide preferential treatment for transit vehicles.
- **N 8th Street Direct Access Ramp (North Renton)** – This access ramp, a Sound Transit project and a component of the I-405 Implementation Plan, represents the preferred access route into north Renton. It is in Sound Transit's 10-year transportation plan for the region, and implementation is dependent on WSDOT funding for road improvements.
- **Strander Boulevard Extension (South Renton)** – Both the City of Renton and City of Tukwila identified local desires to connect/extend Strander Boulevard across Tukwila and Renton within the 2014 horizon. Such an extension was assumed for the BRT pre-design based on City comments and preferences; however, it is understood that such an extension is not funded or formally programmed at this time. Alternate routes for the BRT service into Tukwila are available in the event that Strander Boulevard is not extended. BRT operations would benefit from the inclusion of transit signal priority and transit lanes along Strander Boulevard, however the City of Tukwila has expressed concern over the potential impacts of this on general purpose traffic.

By 2030, other development and infrastructure considerations were identified including:

- Development of the Port Quendall area in north Renton, and construction of a new transportation center as part of that area’s development.
- Completion of reconstruction of the I-405/SR 167 interchange. It is assumed that some improvements to this interchange will be made as part of the I-405 Implementation Plan, with the remainder completed as described in the I-405 Master Plan. A component of the I-405 Master Plan that may be applicable to BRT is the proposed construction of HOV direct access ramps at this interchange from Rainier Avenue South to I-405.
- Redevelopment of industrial lands in the south Lake Washington area. This includes as much as 10 million square feet of office, and 3000+ residential units.
- Development of the Tukwila Urban Center (immediately east of the existing Southcenter Mall) to include both commercial and residential uses, and potential relocation of the existing Sounder commuter rail station south towards Strander Boulevard. For BRT planning purposes, it was assumed this station would be located near an extended Strander Boulevard with BRT buses traveling on general purpose lanes; however, this would need to be determined by Sound Transit based on their requirements and plans.

[8] Meeting Dates: 4/19/2004, 9/20/2004.
[9] Meeting Dates: 4/26/2004, 9/23/2004.

2.2.3 AGENCY INPUT

The primary mechanism for soliciting input from the agencies directly participating in the I-405 BRT Pre-Design was through a Transit Work Group formed for the project. This group included representatives from the Federal Transit Administration, the Washington State DOT, King County Metro and DOT (planning), Sound Transit, and Community Transit.

While the results of the I-405 BRT Pre-Design were reviewed with this group, the findings contained within this document are not intended to represent regional public transportation policy or direction. A key topic discussed with the work group was about the assumptions that should be made regarding the service concept that should be used for modeling BRT service in the corridor. Based upon early analysis, it was determined that a single line BRT would not generate sufficient ridership in the corridor. Further analysis suggested that providing frequent BRT service by overlaying multiple routes would generate the best ridership. For the purpose of this study, it was agreed that a core section of the corridor would be defined from the Brickyard Park-and-ride or UW Bothell campus in the north, to the Renton Transit Center in the south. Beyond these extents, service would be provided to surrounding communities through route branches from the core.

It was also confirmed that the I-405 BRT is one potential element within the public transportation network, and any findings or assumptions contained within this report should be considered input to, rather than recommendations for, broader public transportation planning in the region. The purpose of this pre-design is to identify potential infrastructure needs directly along the I-405 corridor, using reasonable assumptions about the future transit and road networks, travel patterns and land uses. For this reason, the work group was regularly consulted. All of these assumptions, in particular the routing of the BRT on local arterials, are subject to future transportation planning and review with local jurisdictions and the public.

King County and WSDOT have embarked on a program to expand the regional vanpool fleet by as much as 1,700 vanpools in the coming years. This program will be funded through a “revolving no-interest loan fund for private and public purchase of vans” provided by the I-405 plan[10]. In order to support BRT-vanpool connections, it was agreed that vanpool parking near the BRT platform should be provided at stations where feasible to facilitate transit connections between the BRT and vanpools.

2.3 Current Ridership

Many Sound Transit (ST) and King County Metro (KCM) bus routes currently operate on the I-405 freeway. Some of these routes use the I-405 as part of a route across Lake Washington to Seattle and others provide specialized service (such as the Boeing Custom Buses)[11].

As part of the ridership forecasting and modeling process, ST and KCM routes traveling N-S along I-405 and serving the communities identified in this study were reviewed to identify existing transit ridership in the corridor. These included:

- KCM 237 Bellevue to Kingsgate, Woodinville
- KCM 342 Renton to Shoreline P/R
- ST 530 Everett to Bellevue Express via Bothell
- ST 532 Everett to Bellevue Express via Canyon Park
- ST 535 Lynnwood TC to Bellevue Express via Bothell
- ST 560 Bellevue to Sea-Tac International Airport/ West Seattle
- ST 564 Auburn to Bellevue
- ST 565 Federal Way to Bellevue

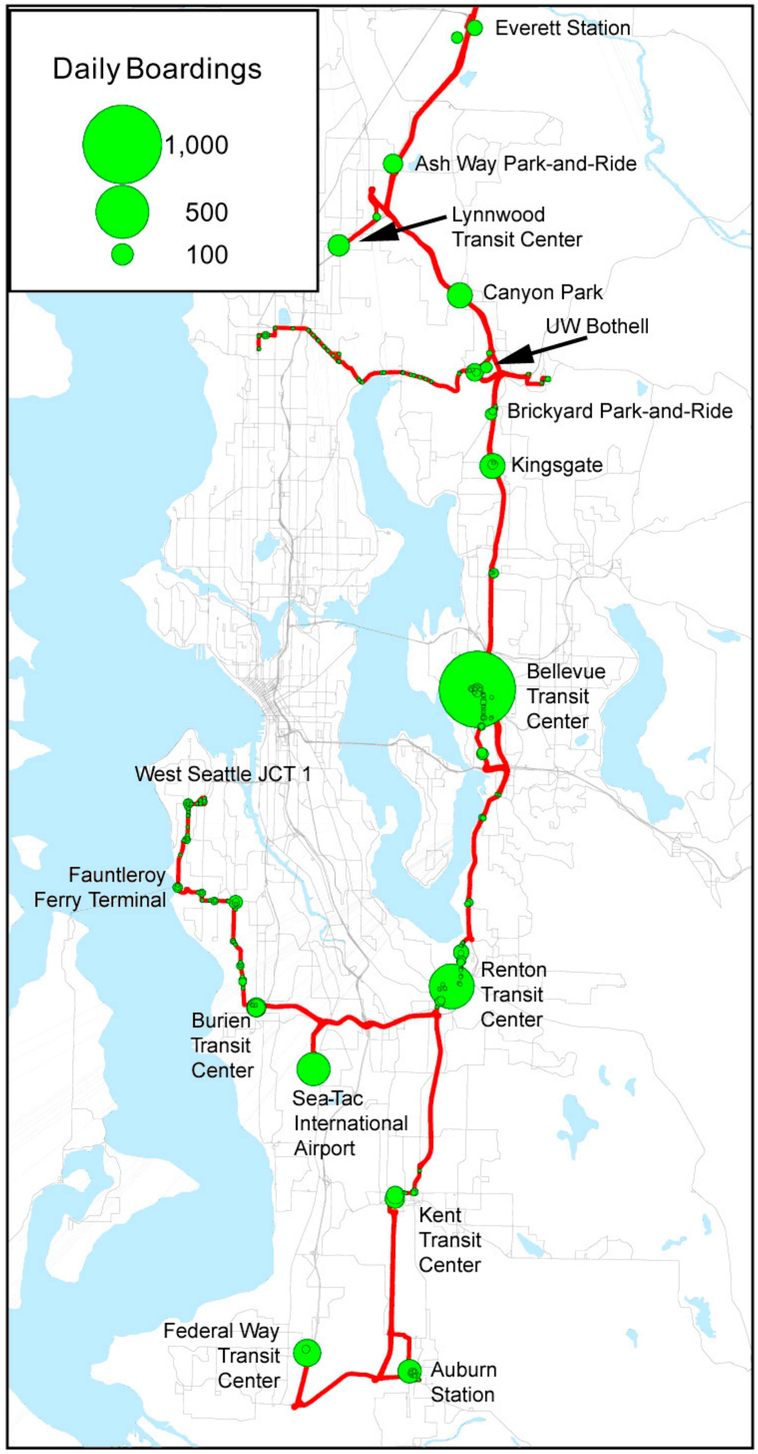
[10] I-405 Corridor Program, Final Recommendation Report, 2002, Washington State Department of Transportation.
[11] Other routes include 111, 114, 247, 252, 257, 260, 265, 424, 167, 942 and 952.

Ridership data from these routes for 2003 indicates the current level of transit demand in the corridor and location of key activity centers. Weekday boardings aggregated from these routes are presented in Exhibit 2-2 as an illustration of where those activity centers are, and which predominate in terms of existing transit ridership.

None of the existing I-405 bus routes directly serve Tukwila (it is served by other parallel routes). Consequently this representation of boardings in the corridor does not include trips originating within Tukwila.

Along the southern portion of the corridor (Bellevue to Sea-Tac), the highest demands are observed at (in decreasing order), the Bellevue Transit Center, Renton Transit Center, and Sea-Tac International Airport. Non-I-405 bus routes such as MT 140 (Burien-Sea-Tac-Tukwila-Renton) serve Tukwila-based travel, which has somewhat lower demand than Renton or Sea-Tac International Airport. Other bus routes serve many of the I-405 locations shown on the exhibit, but for sake of clarity only the boardings for the primarily north-south routes on the freeway were considered.

Exhibit 2-2: 2003 I-405 Transit Boardings (for routes operating on I-405)



2.4 Current Travel Times

As input to the identification of a potential BRT alignment and service modeling, a travel time survey was conducted in early 2004 along the HOV and general purpose lanes of the I-405 portions of the corridor from north Renton to Bellevue, and along arterial portions of the corridor through Renton and Tukwila. The survey included several drives of the corridor to develop travel time profiles between the Bellevue Transit Center and Sea-Tac International Airport.

Three time sampling runs were performed during the AM peak period (6:00-9:00 a.m.), and five runs were completed during mid-day off-peak times. The vehicles collecting the travel time data used the HOV lanes to approximate the path BRT would simulate typical traffic conditions. The route followed (from north to South) was:

112th Ave NE
NE 8th Street
I-405
North Park Drive
Garden Ave North
N 8th Street
North Park Drive
I-405
SR 518
International Boulevard S

Analysis was performed on the data to generate average travel times and to identify travel time delay locations.

2.4.1 OBSERVED TRAVEL TIMES

The time-space diagrams illustrated in Exhibits 2-3 through 2-6 summarize the results of the travel time runs. Distance is indicated along the X-axis, and time along the Y-axis. Flatter, more gradual slopes along the graph indicate faster travel times, while a steeply sloped line indicates slower speeds.

2.4.1.1 Northbound

Northbound travel times from Sea-Tac International Airport to Bellevue Transit Center are shown in Exhibits 2-3 and 2-4. Exhibit 2-3 presents individual northbound travel times for three AM peak (6:00 – 9:00 a.m.) and five off-peak (9:00 a.m. – 3:00 p.m.) runs, while Exhibit 2-4 presents the average of all eight runs.

As illustrated by the graph, critical congestion points occur at: Exit 4 (Sunset Blvd.), Exit 7 (NE 44th St.), Exit 9 (112th Ave SE), and near the Bellevue Transit Center. Five runs had very consistent travel times of 28-29 minutes. The remaining three runs experienced 5 to 10 minutes of added travel time due to congestion.

The average travel time for all eight runs was 31.3 minutes, which represents the time taken for an automobile to travel the approximate route of a BRT service in the I-405 corridor. The BRT line would require additional time for bus deceleration and acceleration and stop/station dwell times for the boarding and alighting of transit passengers. On average, this additional time for stops and stations would be approximately 15 seconds per location.

Exhibit 2-3: Northbound I-405 Travel Times (Individual Runs)

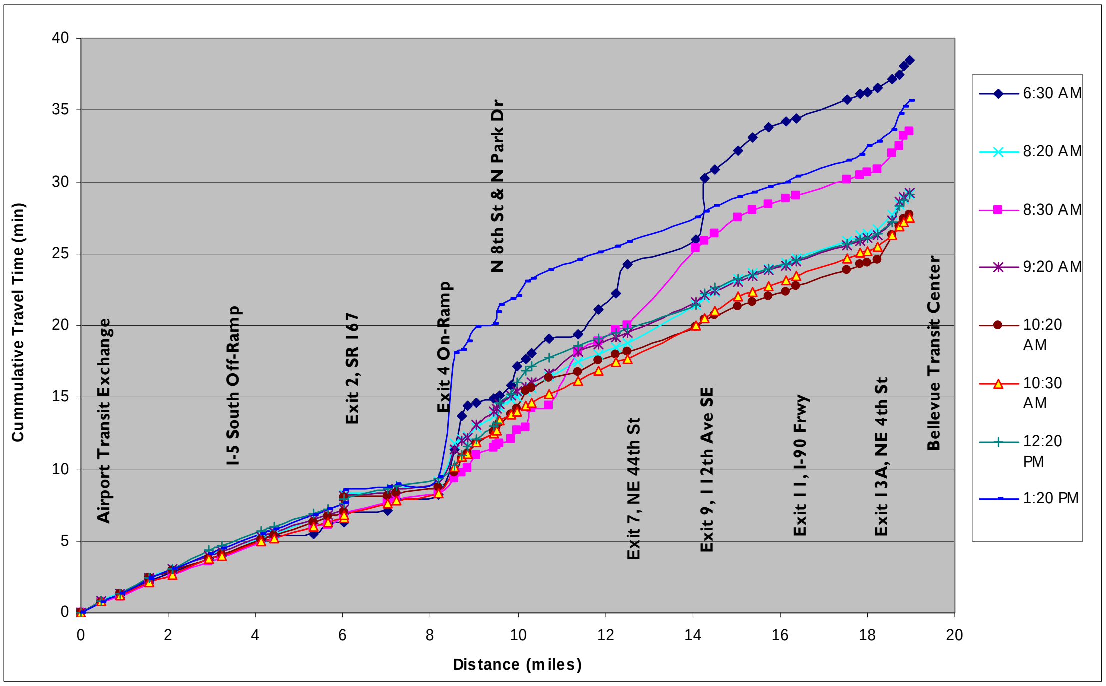
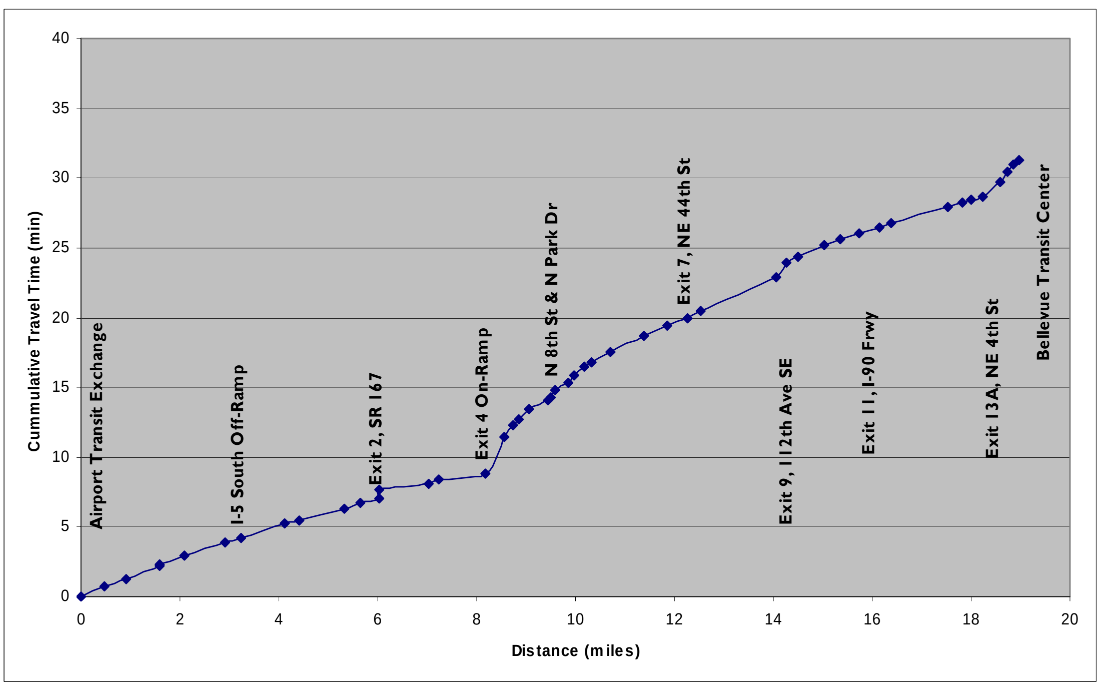


Exhibit 2-4: Northbound I-405 Average Travel Time



2.4.1.2 Southbound

Southbound travel times from Bellevue Transit Center to Sea-Tac International Airport are shown in Exhibits 2-5 and 2-6. Exhibit 2-5 includes three AM peak (6:00 – 9:00 a.m.) and five off-peak (9:00 a.m. – 3:00 p.m.) runs, while Exhibit 2-6 presents the average of the eight runs.

Exhibit 2-5: Southbound I-405 Travel Times (Individual Runs)

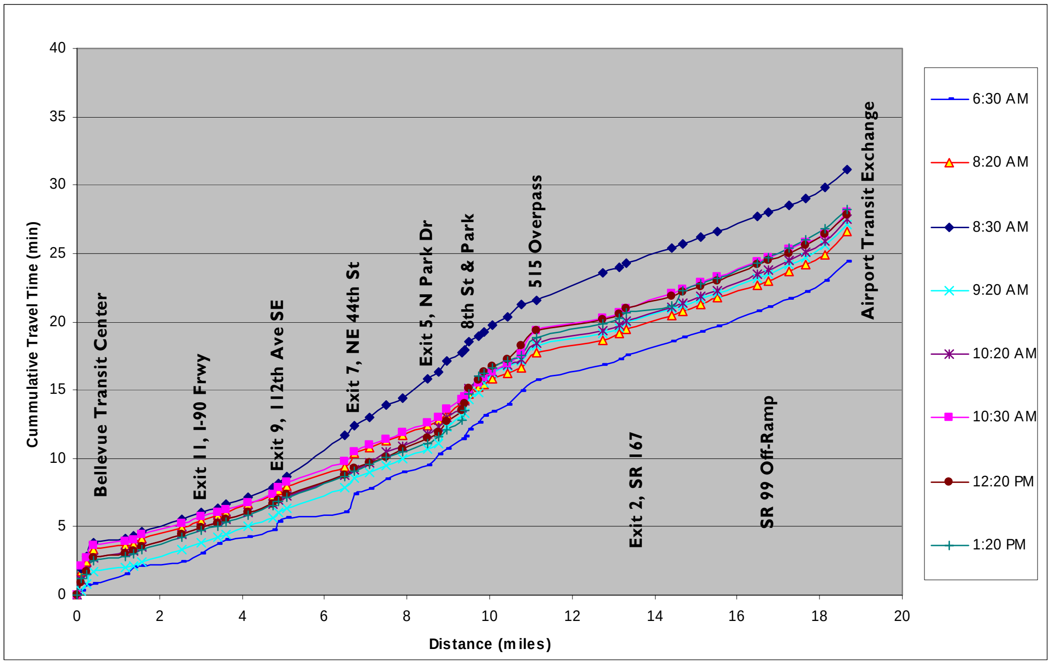
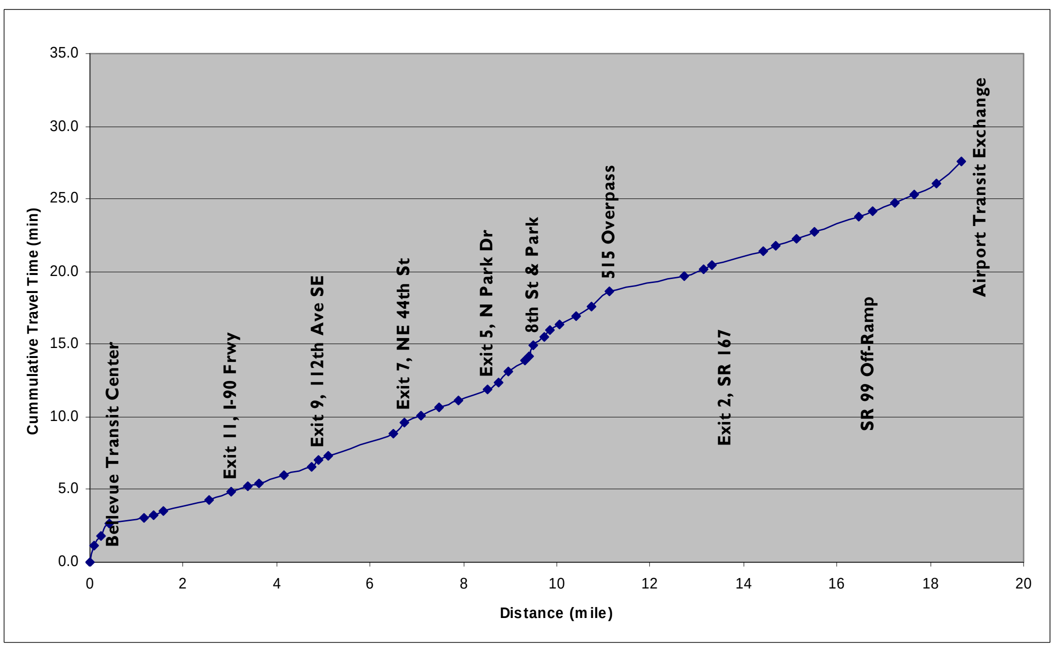


Exhibit 2-6: Southbound I-405 Average Travel Time



Except for two runs, the travel times were very consistent. The exceptions were the first run southbound at 6:30 am, which was 2 minutes faster than typical, and the run at 8:30 am that incurred additional delay between Exit 9 (112th Ave SE) and Exit 7 (NE 44th St). The section over arterial roads in Renton had lower travel speeds.

The average travel time for all eight runs was 27.6 minutes; as noted, this is the typical travel time for an automobile on a potential route for the I-405 BRT, and does not include additional time for bus deceleration and acceleration and stop/station dwell times.

2.4.2 OBSERVED DELAY POINTS

Exhibit 2-7 illustrates location-specific delays observed during the travel time runs, averaged across the AM peak and mid-day off-peak runs. The delays fall into six categories: signal/stop sign, left turn, right turn, congestion, parking and driveway. The signal/stop sign category includes delay associated with stopping for red signal time and stop signs. The left turn category tracks the delay associated with making left-hand turns against opposing traffic. Left hand turns typically have to wait for adequate vehicle passing to make movement. Right hand turn delay involves making an unprotected right hand turn from one street onto another.

The congestion category includes slowed traffic conditions due to accidents, excessive traffic, and/or weather conditions. Parking delay tracks the reduced travel time due to on-street parking movements. Driveway delay includes vehicles entering/exiting a driveway. This category is differentiated from right hand turns as drivers entering a driveway are preparing to stop and park, while right hand turning movements only require a deceleration to make the turn from one street to the next.

In the northbound direction, reduced freeway speeds were observed between Exits 4 (Sunset Blvd.) and 10 (Coal Creek Pkwy.). This correlates to the congestion delay from Renton Boeing to just after the Newport Hills exit as illustrated on the right side of Exhibit 2-7. Difficulty was noted during the drive in moving from the HOV lane to the exit lane during periods of congestion over this stretch of highway. It was also noted that the traffic at exit ramps backed up onto the freeway, stopping traffic on I-405 approaching the exit ramp.

In the southbound direction, reduced speeds were observed between Exits 7 (NE 44th St.) and 5 (N Park Dr.). This correlates to the congestion shown on the left side of Exhibit 2-7, between Port Quendall and the Renton Boeing exit. Difficulty was noted during the drive in moving from HOV to exit lane during congestion in this stretch of highway. It was also noted the traffic at exit ramps backed up onto the freeway, stopping traffic on I-405 preceding the exit ramp.

Because the travel time runs include the AM peak, higher delays were observed in the northbound direction than southbound (due to the directional nature of traffic flow along the I-405 corridor). It is expected that the situation would be reversed in the afternoon, as traffic flow is primarily southbound. While unprotected right hand turns can be a major source of delay, the travel time survey through north Renton identified signal delay as the most significant source of delay through arterials. It should be noted that the travel time survey vehicles were not equipped with Transit Signal Priority (TSP) and typically experienced red time at signalized intersections.

Exhibit 2-7(a):

Southbound Delay (averaged over all runs)

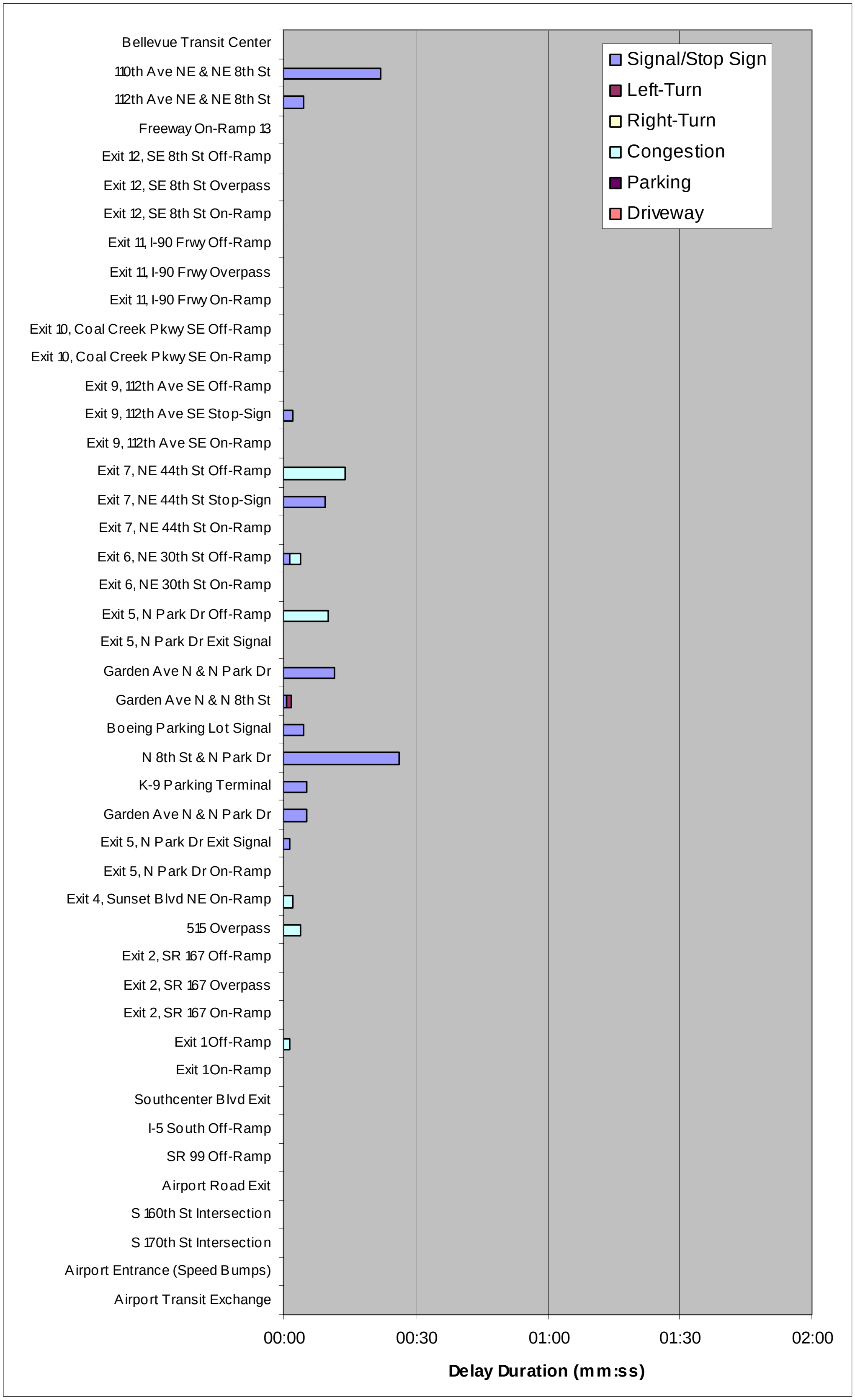
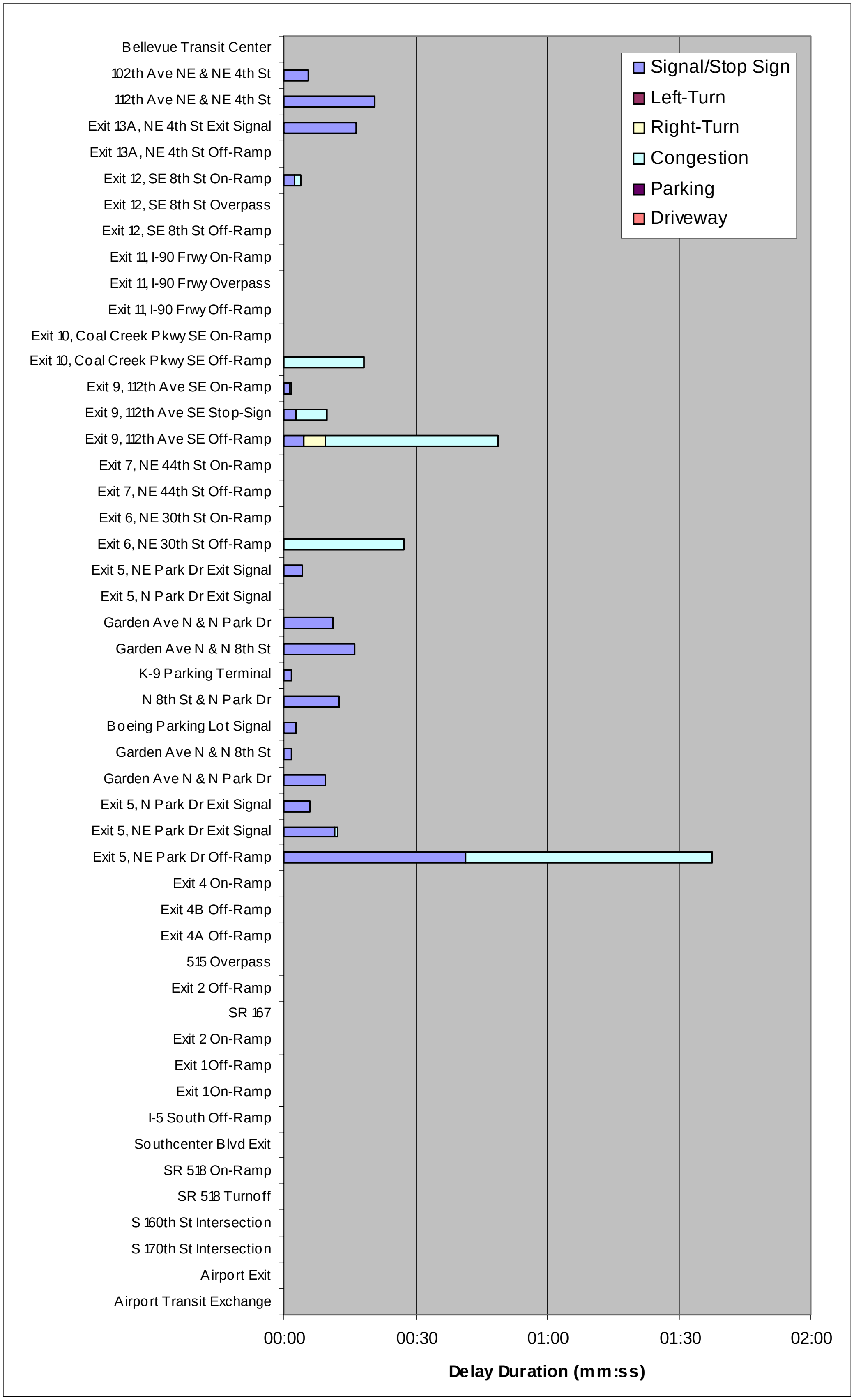


Exhibit 2-7(b):

Northbound Delay (averaged over all runs)



2.5 Key Findings – Existing Conditions

From the existing conditions review, the following key findings were noted for consideration in the I-405 BRT pre-design:

- The pre-design should build off previous I-405 studies and must be compatible with the overall I-405 Implementation and Master plans.
- A key focus should be on serving the activity centers in the I-405 corridor. Downtown Bellevue, downtown Renton, and Sea-Tac International Airport have the highest relative transit boardings in the south portion of the I-405 corridor and are recommended to be served[12].
- Both Renton and Tukwila anticipate significant growth and development by 2030. The BRT pre-design should include appropriate assumptions regarding that growth, building upon land use assumptions in Vision 2020 and Directions 2030.
- The primary potential sources of travel delay for a BRT service include signal delays, congestion, and difficulty in making the weave between HOV lanes and on- and off-ramps. Service and alignment options will need to consider these factors.
- The primary focus for the pre-design study should be on identifying station locations that provide access to the primary demand and facilities so that buses can bypass the primary potential sources of delay along the I-405 corridor.
- While certain assumptions can be made regarding arterial routing of a BRT service, actual routing will ultimately depend upon what infrastructure improvements are made in those areas based on broader transportation needs. The I-405 BRT service should be flexible enough to support whatever changes emerge in the future.

[12] These three centers are currently served by ST 560, which could potentially be the future BRT (or part of it) at such time that the improvements being identified by this study are implemented.

3. POTENTIAL STOP LOCATIONS

This chapter provides an initial identification of potential BRT stops in the southern part of the I-405 corridor, highlighting the basic attributes and rational for their identification. These were identified to serve activity centers along the I-405 corridor from Bellevue to Sea-Tac International Airport, and were used to establish baseline assumptions in subsequent pre-design work activities. Potential stops north of Bellevue and branch segments were included for modeling purposes.

Although the primary focus of this project is to define potential stops and other requirements in the southern part of the corridor (south of Bellevue), it is recognized that some assumptions regarding the northern part of the corridor have to be made as well in order to conduct required ridership modeling. Therefore, this chapter also presents a preliminary list of possible stops in the northern part of the corridor, recognizing that these have not been reviewed in detail and would likely evolve should work be conducted on a north corridor BRT pre-design.

3.1 Initial South Corridor Stops

For the purpose of this pre-design, a BRT "stop" is defined as a curbside bus stop with basic amenities such as a shelter and passenger information materials. A BRT "station" is defined as a stop co-located or integrated into a park-and-ride and/or larger transit center.

Based on previous I-405 studies, current corridor transit ridership, and the travel time drive-throughs, primary activity centers and potential stop and station locations were identified, as illustrated in Exhibit 3-1. Potential locations in Renton and Tukwila were reviewed and confirmed with City staff at meetings held in April 2004.

For consideration in the BRT pre-design, the comparative table in Exhibit 3-2 was developed, listing each potential station location and its associated characteristics including:

- **Priority** – "*Recommended to be served*" indicates a preferred stop that fits all of the BRT service objectives. "*Opportunity to serve*" indicates a location that could be added to the BRT route if the travel time penalty is not great. *"Low"* indicates a location that does not substantially meet the BRT service objectives.
- **Implementation Year** – This indicates the planning year the station could potentially be added, as part of either the I-405 Implementation Phase (2014) or Master Plan (2030). This is a function of the overall plan for the corridor, potential development timeframes for the surrounding areas, funding, and consensus amongst participating parties.
- **Access** – This indicates the type of access to the station from I-405, such as an inline station, direct access, or arterial access.
- **Issues and Considerations** – This column lists issues or considerations that could impact the desirability or feasibility of incorporating the potential location in the BRT service.

Exhibit 3-1: Initial South Corridor BRT Stops

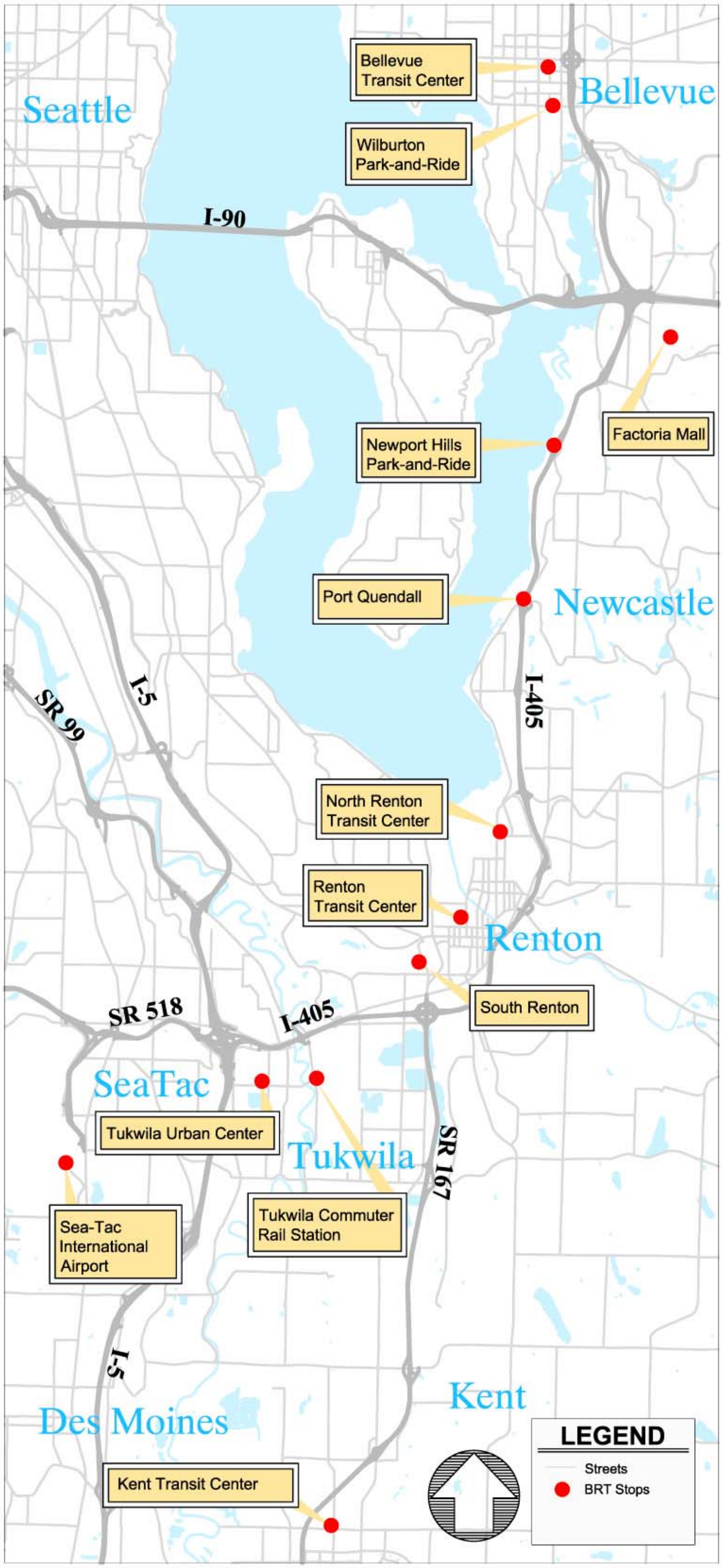


Exhibit 3-2: South I-405 BRT – Potential Station Matrix

Name	Priority	Implementation Year	Access	Issues and Considerations
Bellevue Transit Center	Recommended to be served	2014	Station with direct access	• Major transfer point • Link in regional transit network • No additional work needed
Wilburton Park-and-ride (SE 8th)	Low	2014	To be determined	• Short term opportunity dependent on travel time impacts. • Primarily a local stop; limited regional potential
Factoria Mall	Low	2014	To be determined	• Activity center • Opportunity dependent on routing and travel time impacts (there is no direct routing)
Newport Hills Park-and-Ride	Recommended to be served	2014	In-line station	• 292 space Park-and-Ride, currently at 61% capacity
Port Quendall	Serve once developed	2030	Station with direct access	• No firm development of the area committed to. • Current Northbound geometry not suitable for BRT. • Not a major transfer point, source of ridership, or activity center.
North Renton Park-and-Ride	Recommended to be served	2014	Station with direct access	• 100 space park-and-ride, currently 43% capacity. • Serves major activity center and future area redevelopment
Renton Transit Center	Recommended to be served	2014	Station with arterial access	• No new work needed • Major activity center • Major transfer point
South Renton	Opportunity to serve	2014	Station with arterial access	• Several park-and-ride facilities within south Renton/downtown area. • Park-and-ride facilities primarily utilized by Seattle bound commuters (not I-405 users)
Tukwila Commuter Rail Station	Opportunity to serve	2014	Station with arterial access or stop	• Link to Sounder, but relatively few other transit connections • May be relocated south towards Strander in the future
Tukwila Urban Center	Recommended to be served	2014	Station with arterial access	• Currently work-trip oriented • Serves major employment area and proposed urban redevelopment to a more mixed use activity center; number of potential riders would increase as a result.
154th Street LRT Station	Low	2014	To be determined	• Park-and-ride serves primarily Seattle commuters. • Would provide a BRT connection between Renton and future Sound Transit Link light rail

Name	Priority	Implementation Year	Access	Issues and Considerations
Sea-Tac International Airport	Recommended to be served	2014	To be determined	• Source of ridership. • Link in regional transit network • Link to LRT

A review of road geometrics confirmed that it would not be feasible to serve the Wilburton P&R or the Factoria Mall stops from I-405. By servicing Wilburton Park-and-Ride, the main trunk of the BRT line would have to detour via arterials from Bellevue Transit Center bypassing the newly constructed direct access ramps built by Sound Transit. Access to the Factoria Mall would also require a significant reroute off I-405 and back again to service. The ridership gains did not justify the travel time penalties created from servicing these two sites, and the stops were therefore dropped from further consideration.

3.2 Potential North Section Stops

To provide a complete service concept for the south section of the I-405 BRT, it was necessary to also identify potential station locations along the northern section. These were identified through discussions and review of ridership numbers provided by Sound Transit, King County Metro, and Community Transit. Further detailed analysis of these stations is beyond the scope of this project.

- **Lynnwood Transit Center** – This transit center was recently completed and includes direct access HOV lanes to I-5. Direct access from I-405 will not be available until the Master Plan timeframe, so for 2014, an arterial route connecting to I-405 was assumed.
- **Everett Station** – This transit center is currently complete.
- **South Everett Direct Access** – This stop, at I-5 and 112th, will serve a new park-and-ride.
- **Ash Way Park-and-Ride** – This stop will serve the park-and-ride.
- **Kenmore Park-and-Ride** – This stop will serve the park-and-ride. (King County Metro notes some reconfiguration might be required to facilitate buses departing eastbound on SR-522.)
- **Bothell Park-and-ride** – This stop will serve the park-and-ride.
- **UW Bothell Campus** – It is anticipated that there will be improved access to the campus by 2014, Beardslee Blvd.
- **Woodinville Park-and-Ride** – This stop will serve the park-and-ride.
- **Woodinville Town Center** – This stop will serve the town center.
- **Canyon Park Park-and-Ride** – This station will include flyer stops along with a new Sound Transit pedestrian bridge to link riders with the park-and-ride facility. The flyer stops are on planned on the interchange ramps, and buses must merge to and from HOV lane to serve them.
- **Brickyard Park-and-Ride** – This stop will include direct access HOV lanes leading to a BRT station and park-and-ride.
- **Kingsgate Park-and-Ride (Totem Lake)** – This stop will be located on the freeway as flyer-like stops on the freeway ramps at NE 128th Street interchange. A Sound Transit project will build direct access with stops on the ramps. Buses will wait for a signal to cross NE 128th street at grade (from off-ramp across to on-ramp), with TSP to minimize waits.
- **Houghton Park-and-Ride** – This park-and-ride at 70th St, is currently being served via outside freeway stations. A station at 85th is proposed in the I-405 Implementation and Master Plans, but is not included in the modeled network.

4. RIDERSHIP FORECASTS

An initial model for I-405 BRT ridership was first developed in 2003 as part of a previous I-405 study. That analysis showed that even in the 2030 time frame, a single line BRT route likely would not generate sufficient ridership to make it a feasible service[13]. One reason for this is that development along the corridor is largely commercial and light industrial, with relatively little residential, thus offering limited potential to provide direct origin-destination service without a transfer.

For this study, an alternative concept was developed for modeling purposes that could potentially improve ridership potential. This concept extends service off the I-405 corridor into adjacent communities using a "trunk and branch" route concept, with I-405 between Brickyard or UW Bothell and downtown Renton acting as the "trunk". These branches serve urban centers and activity areas close to the I-405 corridor, thus providing service directly into residential and activity areas.

Using the PSRC's transportation demand model, coupled with updated city land use projections, the ridership forecasting model was revised to include these communities. The model provided the ridership forecast numbers that were used to both update demand and service levels in the corridor, and also refine which of the preliminary stops identified for the south corridor as recommended be served. PSRC is the Metropolitan Planning Organization (MPO) for the greater Seattle-Tacoma-Bellevue region, and maintains the regional model information. The current regional model does not contain the most recent city land use projections along the corridor.

4.1 Results of Previous Model Analysis

A preliminary BRT service concept for the I-405 corridor was a model developed for the "I-405 Corridor Program White Paper: Bus Rapid Transit Line Concept" (August 2003), connecting transit centers and stations as illustrated in Exhibit 4-1. This document presents a preliminary analysis of a BRT service along the I-405 corridor between Lynnwood and Sea-Tac International Airport.

The southbound and northbound ridership estimates summarized in the BRT Concept White Paper are presented in Exhibits 4-2 and 4-3 respectively. These show the estimated number of passenger boardings and alightings in each direction, and the average "leave load" (the cumulative number of passengers on all the buses traveling in the specified direction, as they depart the stop).

The initial model estimates were based on an assumption of an 11-hour operating day with 10-minute headways on a dedicated BRT service along the I-405 corridor. Even with this high level of service (66 daily buses per direction), average daily leave loads were estimated to be below 18 passengers/bus along the entire corridor. It should be noted that the actual leave loads would vary considerably by time of day, with higher values during the peak periods in the peak direction; however, there would be correspondingly lower values during off-peak times.

The initial model results suggest that ridership will not be sufficient in the near to mid-term to support this frequency of service. The model estimates do indicate that by 2030 weekday ridership could increase to 9,700 passengers from 4,640 in 2014.

[13] White Paper: Bus Rapid Transit Line Concept, Ten-Year Program Implementing the First Phase of the I-405 Corridor Program Recommendations, August 2003

Exhibit 4-1: White Paper BRT Route Schematic (for modeling purposes only)

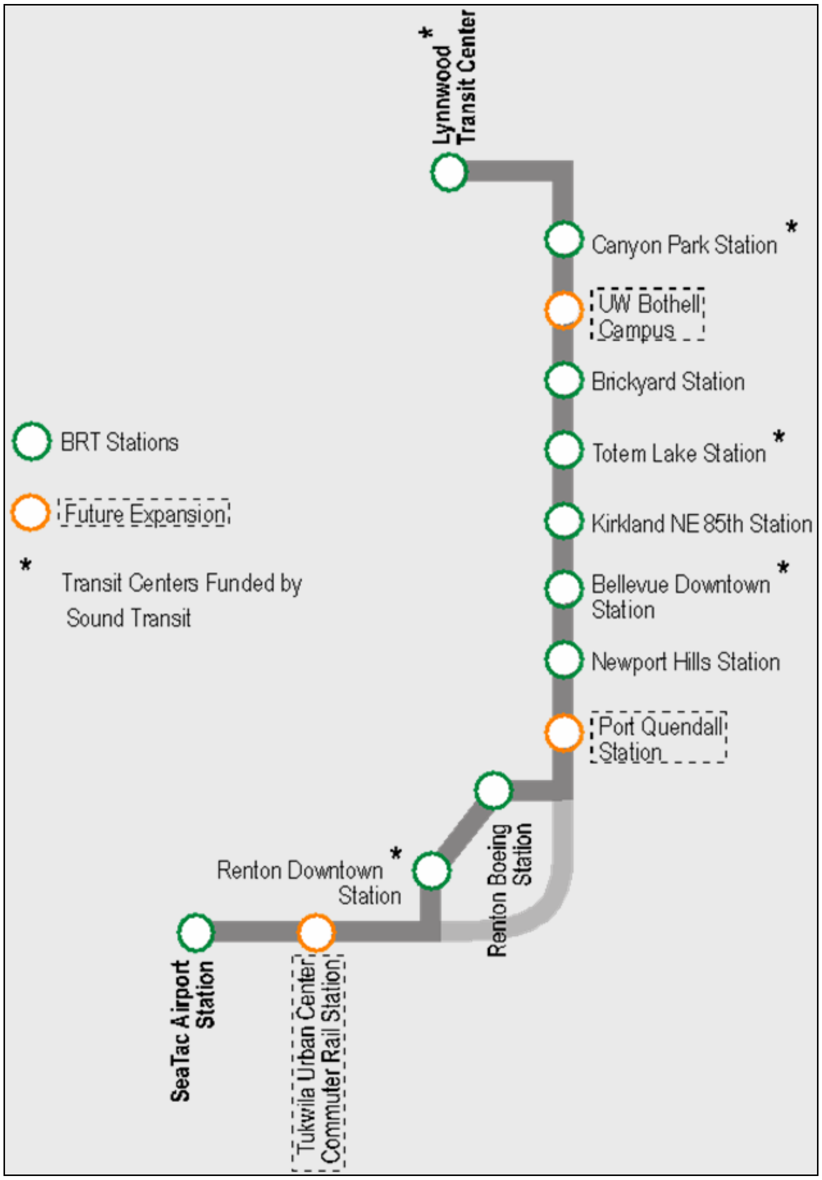


Exhibit 4-2: Initial Southbound Ridership Estimates (2014)

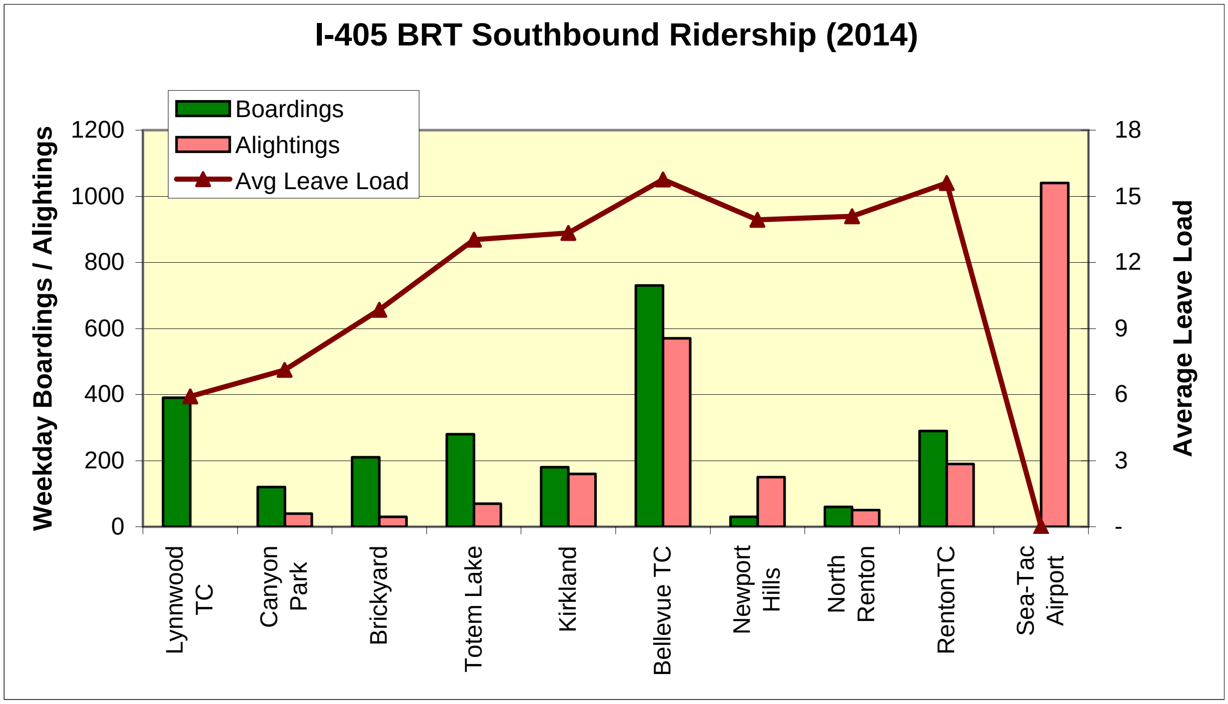
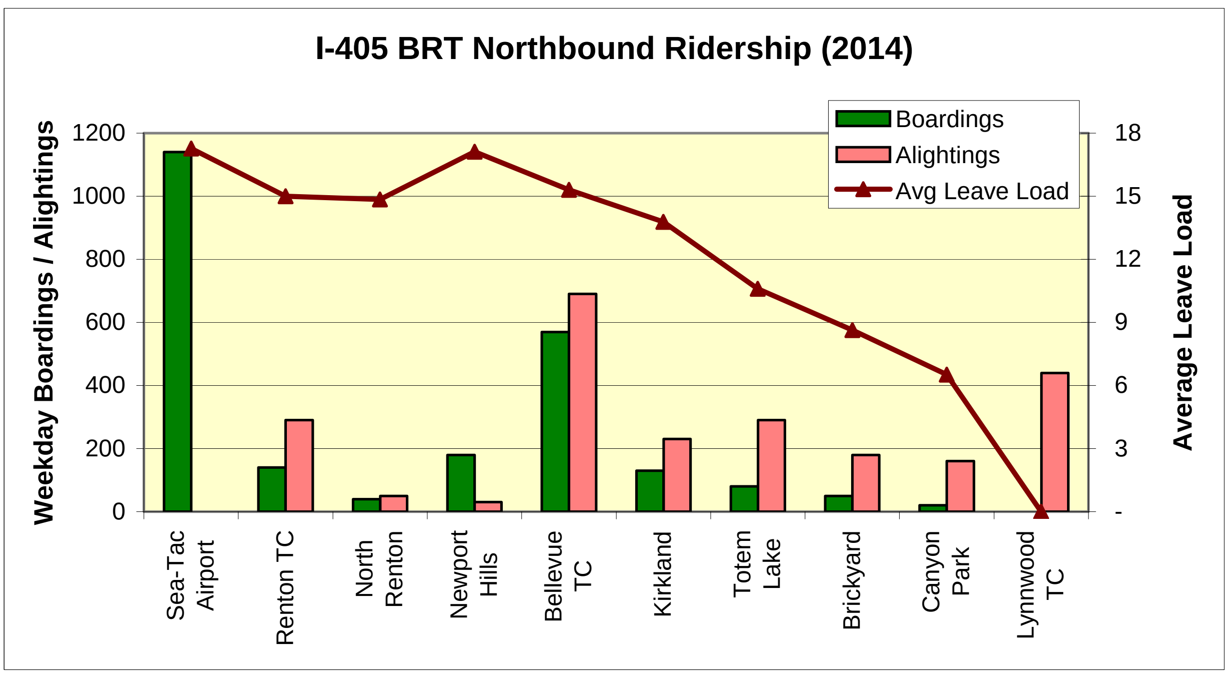


Exhibit 4-3: Initial Northbound Ridership Estimates (2014)



4.2 Updated Model Approach

The Puget Sound Regional Council's transportation demand model was used to develop estimates of transportation demand (both transit and auto) for two horizon years: 2014 and 2030. This model uses the traditional four-step process for estimating travel patterns in an urban area:

- Trip generation (based on land use characteristics)
- Trip distribution (based on the ease of travel between zones)
- Mode choice (based on the attributes of competing modes)
- Trip assignment (based on travel speeds via competing routes)

The transportation demand modeling performed for the I-405 BRT pre-design involved the integration of refined regional methodologies, along with an enhanced regional network resolution and attributes that combined corridor specific improvements developed specifically for the I-405 corridor with data from local modeling inputs.

In order to apply the model and develop estimates of ridership for the BRT service in the I-405 corridor, assumptions were required for the future land use and transportation infrastructure within the corridor including:

- Land use characteristics such as the number of households and employment in each traffic analysis zone (TAZ)
- Network infrastructure and transit service (in particular, the extent of light rail and commuter rail services)

The Puget Sound Regional Council (PSRC) released the housing and employment projections used in this study in February 2004. The PSRC provides official projections for the years 2000, 2010, 2020 and 2030. Since the horizon years for this study are 2014 and 2030, the year 2014 estimates were interpolated from the PSRC figures for 2010 and 2020.

4.2.1 REGIONAL AND LOCAL LAND USE

The initial 2014 and 2030 land use forecasts were developed using the regional land use estimates provided by Puget Sound Regional Council (PSRC), and are consistent with the land use data used in the I-405 Corridor Program (data were released by PSRC in December 2003). Year 2014 land use forecasts were interpolated from the 2010 and 2020 regional databases. The 2030 land use forecasts were initially the same as those provided by PSRC.

Upon consultation with local governments within the I-405 corridor, modifications were made to the 2014 and 2030 forecasts to reflect revised land use assumptions being used by local jurisdictions. These are assumptions only, and have been used solely for the purpose of better estimating future BRT ridership demands. Current traffic models do not assume the same land use as many of the future development conditions have a high degree of uncertainty, and have not been adopted into the accepted regional model. Forecasts for the I-405 BRT pre-design will therefore differ from other modeling efforts conducted in the corridor, and should be considered in the context of this specific study alone.

Exhibit 4-4 summarizes the proposed modification to 2014 land use as identified in the current PSRC model, and Exhibit 4-5 summarizes the 2030 modifications. In 2014, the most significant differences relate to greater than expected development in Lynnwood and Totem Lake, some changes in Bothell due to expansion of the University of Washington campus, and initial development in north Renton and the Tukwila Urban Center (based on information provided by those Cities).

Exhibit 4-4: Modifications to 2014 Land Use Assumptions

PSRC TAZ	Area	PSRC		Revision		Difference	
		Households	Employment	Households	Employment	Households	Employment
548,551	Lynnwood	1433	3376	2355	5222	922	1846
235	UW-Bothell	1509	913	1509	1213	0	300
283,284	Bellevue CBD	4992	51656	4992	51656	0	0

PSRC TAZ	Area	PSRC		Revision		Difference	
		Households	Employment	Households	Employment	Households	Employment
240	Totem Lake	1571	8854	2004	8854	433	0
297	Port Quendall	2756	800	2756	800	0	0
309,310	North Renton	1891	13107	1921	13661	30	554
325	Tukwila	0	26371	1000	26371	1000	0

In 2030, additional changes have been shown in Bellevue, Port Quendall, north Renton and Tukwila representing additional development. The 2030 Bellevue land use was obtained from the latest information provided by Bellevue staff (June, 2004). The Renton data are reflective of the south Lake Washington re-development plan and the proposed Port Quendall development.

Exhibit 4-5: Modifications to 2030 Land Use Assumptions

PSRC TAZ	Area	PSRC		Revision		Difference	
		Households	Employment	Households	Employment	Households	Employment
548,551	Lynnwood	1717	4632	2973	7856	1256	3224
235	UW-Bothell	1824	1040	1824	1340	0	300
283,284	Bellevue CBD	11431	72581	14543	80538	3112	7957
240	Totem Lake	2185	11332	2230	10621	45	-711
297	Port Quendall	2761	2413	4532	5639	1771	3226
309,310	North Renton	2453	13631	2948	25437	495	11806
325	Tukwila	0	34766	1500	34766	1500	0

4.3 Model Assumptions

4.3.1 BASELINE NETWORK

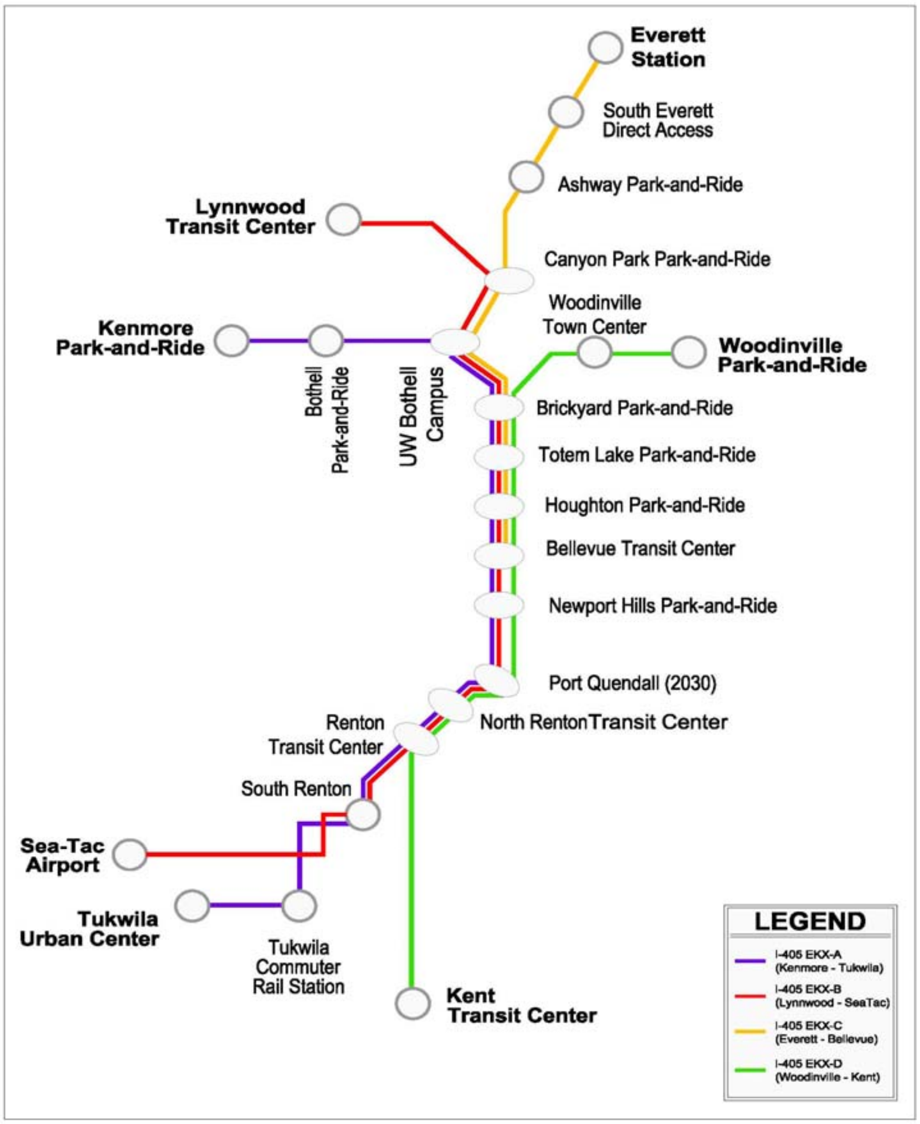
In order to generate the ridership forecasts, it was necessary to assume a candidate network for the BRT service. As noted previously, demand would be insufficient to support a single I-405 BRT line in 2014 beyond the core segment (Bothell or Brickyard to Sea-Tac International Airport). For the purpose of this pre-design project, an alternative approach was adopted that would involve "overlaying" multiple routes into a trunk and branch network for modeling purposes. Attributes of this network are as follows:

- The "trunk" portion of the network follows I-405 and a portion of the arterial network from Brickyard or the UW Bothell campus to downtown Renton in the south. The north and south ends of the trunk act as interception points for service into the surrounding communities.
- For the purpose of the I-405 BRT South Corridor Pre-Design, it was not necessary to determine whether or not UW Bothell or Brickyard should be defined as the northern intercept point. UW Bothell is a major activity center, but has geometric and roadway constraints. Brickyard provides a potential intercept point for transit services into Bothell/Kenmore to the west and Woodinville to the east, but is not in itself a major activity center. If work were to proceed on a north corridor pre-design, the attributes and constraints of both of these locations will need to be reviewed further.
- The "branches" are continuations, extensions or connections of routes using the I-405 trunk into the surrounding communities, operating at lower frequencies. Actual definition of the routes would need to be done as part of future transit service planning, as would integration as part of the overall transit network. The branches shown here are only as required to support the modeling work.

- From previous modeling work and some initial runs of a revised network, the relative distribution of ridership between the northern corridor (north of Bellevue) and southern corridor (south of Bellevue) was known. In order to provide balanced BRT service, it was estimated that the network should include four routes serving north of Bellevue, and three serving south.

The resultant modeling network that was created is illustrated in Exhibit 4-6. It includes a series of assumed overlapping routes that provide a high frequency of service along the trunk part of the corridor, with distribution to the surrounding communities.

Exhibit 4-6: Candidate Trunk and Branch Route Concept (for Modeling Purposes Only)



The model assumes that direct transit and HOV access will be provided to the Brickyard park-and-ride area. Other key network related transit improvements assumed included: southbound ramp access in Canyon Park (a flyer stop on the southbound general purpose ramp with a pedestrian bridge over to the park-and-ride area); completion of the Totem Lake Freeway Station at NE 128th St.; construction of a new inline station at Newport Hills, implementation of a stop at Port Quendall in 2030; construction of the N 8th direct access ramps in north Renton; and construction of a new transit center in the north Renton area.

The model also assumed that BRT service into Renton and Tukwila would be via the arterial street network in both 2014 and 2030. While in 2030 there is the potential to connect south Renton to Tukwila via I-405 direct access ramps into Tukwila, the difference in travel time between the arterial street network and this option would not have a significant impact on the modeling results.

A review of road geometrics also confirmed that it would not be feasible to serve the Wilburton or Factoria Mall area stops from I-405. These stops, discussed briefly in Section 3, were dropped from further consideration.

4.3.2 OPERATIONAL ASSUMPTIONS

The baseline analysis assumes that the HOV lanes will be operating at 3+ occupancy, per current WSDOT projections. It was also assumed that the Sound Transit Central Link Project is operational by 2014 from Northgate to Sea-Tac with peak period and mid-day headways of 5 minutes and 7.5 minutes respectively. The Sounder Commuter rail was assumed to operate between Everett and Tacoma during peak periods in 2014 and throughout the day by 2030.

The transit system assumed in the corridor, for each of the analysis years, is based on earlier analysis performed in the development of the I-405 EIS. The year 2014 transit service is based on the year 2001 six-year plan (~2007). Due to changes in the economic/financial realities, this slightly aggressive plan was considered appropriate for year 2014 analysis. For the completion of the I-405 EIS a year 2020 transit service concept was developed based on the initial 2007 plan. This 2020 service concept was then used as the transit service concept for the year 2030.

The service assumptions for the I-405 BRT routes are presented in Exhibit 4-7. Although the headway on any given route is 20 minutes during the peak periods, the combined headway on the core portion of the route is in the range of 5 to 7 minutes.

Exhibit 4-7: Transit Service Assumptions (for Modeling Purposes Only)

Route	Peak Headway	Off-Peak Headway
I-405 EKX - A (Kenmore Park-and-ride - Tukwila UC)	20 min.	30 min. (60 min. after 8 PM)
I-405 EKX – B (Lynnwood Transit Center - Sea-Tac International Airport)	20 min.	30 min. (60 min. after 8 PM)
I-405 EKX – C (Everett Station – Bellevue Transit Center)	20 min.	30 min. (60 min. after 8 PM)
I-405 EKX - D (Woodinville Park-and-ride – Kent Station)	20 min.	30 min. (60 min. after 8 PM)

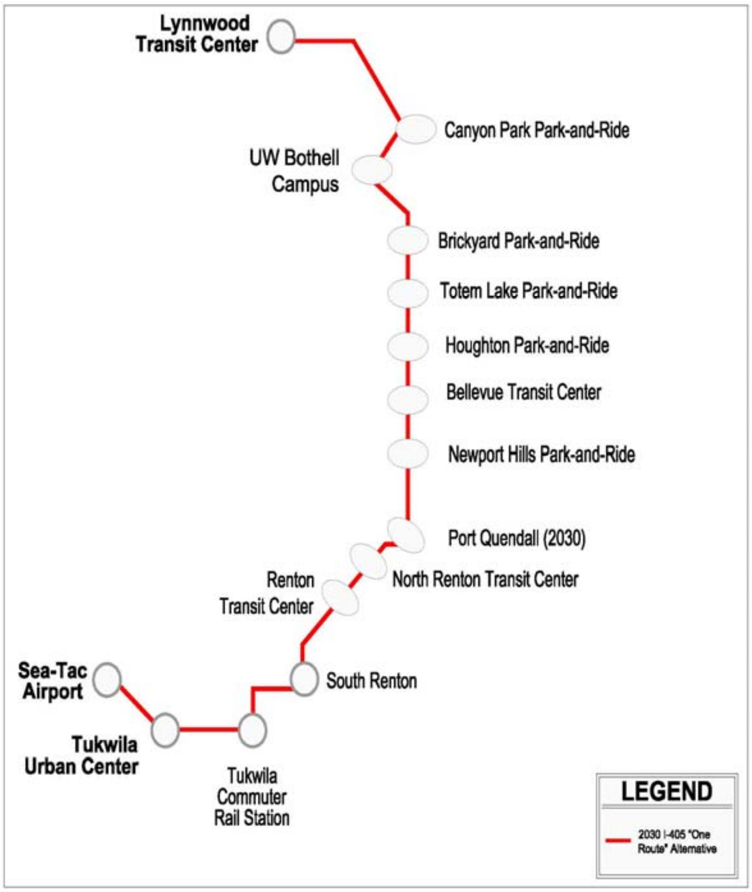
- Average headway 5-7 min. in peak periods along the trunk segment from Brickyard to the Renton Transit Center
- Average headway 8-10 min. in off-peak periods (before 8 PM) along the trunk segment from Brickyard to the Renton Transit Center

4.3.3 VARIATIONS AND SENSITIVITY ANALYSES

The same infrastructure and alignment concept was used for both 2014 and 2030 baseline forecasts, with the exception that a stop at Port Quendall was assumed only in the 2030 scenario. As described in Section 5 of this report, there are alternative options available for connecting south Renton to Tukwila, including arterial connections in 2014 (Implementation Plan horizon) and connection in 2030 using I-405 and HOV direct access ramps at Rainier Avenue S/I-405 (Renton) and just west of the rail lines in Tukwila. Travel time differences between these alternatives (expected to be nominal) would not have a substantial effect on the modeling results.

A sensitivity analysis was run against a “single route” concept extending from Lynnwood to Sea-Tac using the 2014 alignment as illustrated in Exhibit 4-8. This route assumed that there was an improved connection via Klickitat between Tukwila and Sea-Tac to support direct transit service.

Exhibit 4-8: Single Route Variation/Sensitivity Analysis (for Modeling Purposes Only)



A sensitivity run was also conducted to test the impacts of a 2+ occupancy policy for the I-405 HOV lanes versus the 3+ policy assumed as the baseline for this study. A 3+ HOV policy has the potential of increasing total person throughput in the corridor given the same amount of available roadway capacity.

4.4 Model Results

Ridership forecasts for the 2014 and 2030 horizons were modeled using the network illustrated in Exhibit 4-6. Sensitivity runs were also performed as described in section 4.3.3. Summary results are presented below, with detailed results included in the companion I-405 BRT Pre-Design Technical Appendices.

4.4.1 2014 AND 2030 MODEL RESULTS

2014 and 2030 model runs were performed for both the AM peak period (6:00 – 9:00 a.m.) and for the mid-day period (9:00 a.m. – 3:00 p.m.). Results from the AM peak period can be used to determine if the proposed BRT service provides sufficient capacity to meet forecasted demands, while results from the mid-day period help (in conjunction with the peak demand) to determine the overall effectiveness of the service.

Exhibit 4-9 (a) and (b) illustrates the demand pattern on the I-405 BRT routes during the AM peak period for 2014 and 2030 respectively. Some of the key characteristics of the forecasted demand pattern are as follows:

- Bellevue is the primary destination in the corridor during the AM peak period;
- Both the north and south parts of the corridor primarily serve Bellevue-destined commuters (only 8-9% are through passengers during the peak periods).
- Network connections (in particular to Sea-Tac International Airport and its planned LRT station) appear to be important on the south leg. While the ridership appears to be modest when compared to other stops, the sample service concept locates potential Sea-Tac and Tukwila stops each on individual branches with less frequent service than the trunk.
- During the AM peak hour, both SB and NB services will carry full seated loads on average (assuming low floor standard 40’ buses) at maximum load point (Bellevue) in 2014. For some peak period runs, 40’ coach capacity is exceeded.

Projected demand for the I-405 BRT routes for the years 2014 and 2030 is shown in Exhibit 4-10, based on the trunk and branch network that was assumed for modeling purposes. The projected daily boardings and alightings by stop are summarized in Exhibit 4-11. The 2030 demand is estimated to be 20,890. Compared to the year 2014 estimate of 12,230 this represents an annual growth in ridership of approximately 3.3 percent a year.

Note that the projected number of passengers carried on the BRT system in the peak period (up to 2590 per direction) represents (in 2014) nearly one-half the number of trips carried in a general-purpose lane, but with far fewer vehicles than if these were auto-based trips.

Exhibit 4-9(a): 2014 AM Peak Period Patterns

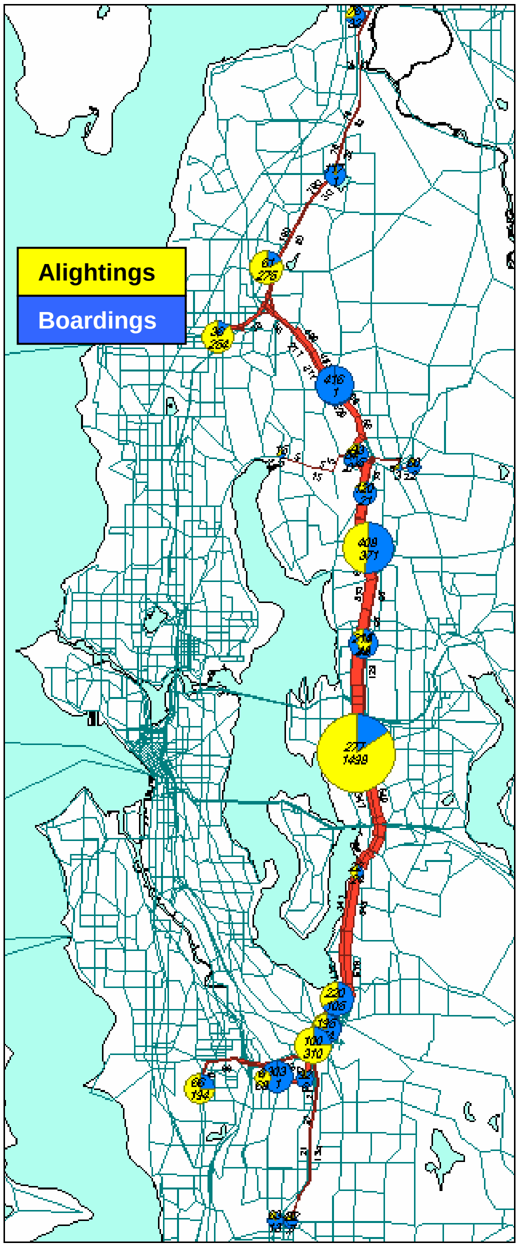


Exhibit 4-9(b): 2030 AM Peak Period Patterns

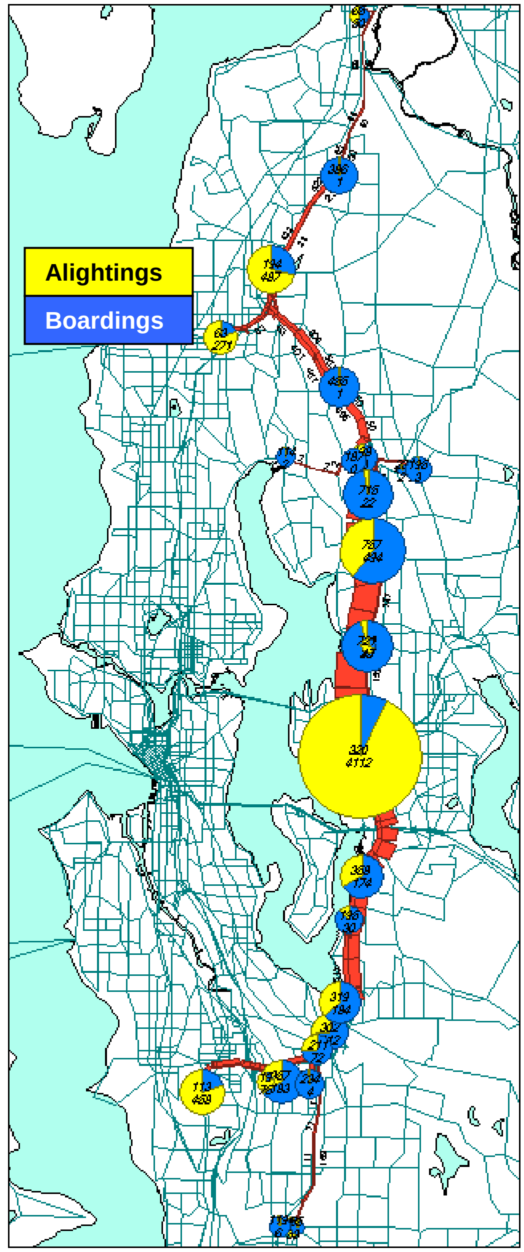


Exhibit 4-10: 2014 & 2030 Forecasted Demand (Total Daily) for 4-Route Trunk and Branch Modeling Concept

	2014 Total Demand			2030 Total Demand		
	Southbound	Northbound	Total	Southbound	Northbound	Total
AM Peak Period	2,300	1,460	3,760	4,300	1,970	6,270
PM Peak period	2,590	2,120	4,710	1,970	4,300	6,270
Off-Peak	1,460	2,300	3,760	4,660	3,690	8,350
Daily (Weekday)	6,350	5,880	12,230	10,930	9,960	20,890

Exhibit 4-11: Summary of Forecasted Daily Boardings and Alightings (Potential Stops in South I-405 Corridor* - In order of decreasing boardings)

Station/Stop Name	2014 Boardings	2014 Alightings	2030 Boardings	2030 Alightings
Bellevue Transit Center	3,740	3,680	6,600	6,400
Sea-Tac International Airport	860	530	2,230	1,375
Renton Transit Center	840	870	1400	1,500
North Renton Park-and-Ride	650	680	950	1,075
South Renton	330	380	500	770
Newport Hills Park-and-Ride	200	170	290	260
Port Quendall	N/A	N/A	230	250
Tukwila Urban Center	140	160	210	240
Tukwila Commuter Rail Station	170	185	210	220

* Figures include trips starting and ending outside the South I-405 corridor, e.g. in Lynnwood, Kent, etc.)

4.4.2 SCREENLINE ANALYSIS

The 2014 forecasted volumes crossing three different screenlines in the corridor during the AM peak period, as well as during the mid-day and over the whole day are tabulated in Exhibit 4-12. As shown in the exhibit, the maximum directional transit volume across any screenline is forecast to be 1390 passengers southbound during the AM peak period.

About 40% of this volume, or about 560 passengers, would cross the screenline during the peak hour. The corresponding volumes in the northbound direction are 840 passengers during the peak period and about 340 during the peak hour.

Exhibit 4-12: 2014 BRT Screenline Demands

Screenline	AM Peak Period		Off-Peak Period		Daily	
	SB	NB	SB	NB	SB	NB
North of Brickyard	720	110	490	370	1,310	1,200
North of Bellevue TC	1,390*	130	1,160	930	2,680	2,450
South of Bellevue TC	290	840**	920	750	2,040	1,970

* - Southbound Average Passenger per bus: 1,390/36 = 39

** - Northbound Average Passenger per bus: 840/27 = 31

The 2030 forecasted volumes crossing three different screenlines in the corridor during the AM peak period, as well as during the mid-day and over the whole day are tabulated in Exhibit 4-13. As shown in the exhibit, the maximum directional transit volume across any screenline is forecast to be 2,780 passengers southbound during the AM peak period. About 40% of this volume, or about 1,110 passengers, would cross the screenline during the peak hour. The corresponding volumes in the northbound direction are 1,110 passengers during the peak period and about 440 during the peak hour.

Exhibit 4-13: 2030 BRT Screenline Demands

Screenline	AM Peak Period		Off-Peak Period		Daily	
	SB	NB	SB	NB	SB	NB
North of Brickyard	1,160	120	940	860	2,220	2,140
North of Bellevue TC	2,780*	150	2,180	1,710	5,110	4,640
South of Bellevue TC	610	1,110**	1,830	1,590	3,550	3,310

* - Southbound Average Passenger per bus: 2,780/36 = 77
** - Northbound Average Passenger per bus: 1,110/27 = 41

4.4.3 SENSITIVITY ANALYSIS: 2+ VS 3+ HOV OPERATION

Exhibit 4-14 provides a comparison of year 2014 demand based on a 2+ and a 3+ HOV definition model run. Transit ridership in the peak period is twenty percent higher in the peak period and fifteen percent for the whole day (12,230 versus 10,690) when the baseline 3+ HOV definition is used. The increase over the 2+ HOV operation (the typical year 2005 operation) is due to the combination of an increase in HOV speeds (with 3+ HOV) and degradation of general-purpose speeds.

Some two-person carpools that would have used 2+ HOV lanes otherwise become transit riders, some become 3+ person carpools, and the remainder must travel in the general-purpose lanes. Some trips that would have been single occupant vehicle trips also become transit riders under HOV 3+ due to the effects on travel times.

Exhibit 4-14: Impact of HOV Occupancy on Transit Volumes (2014)

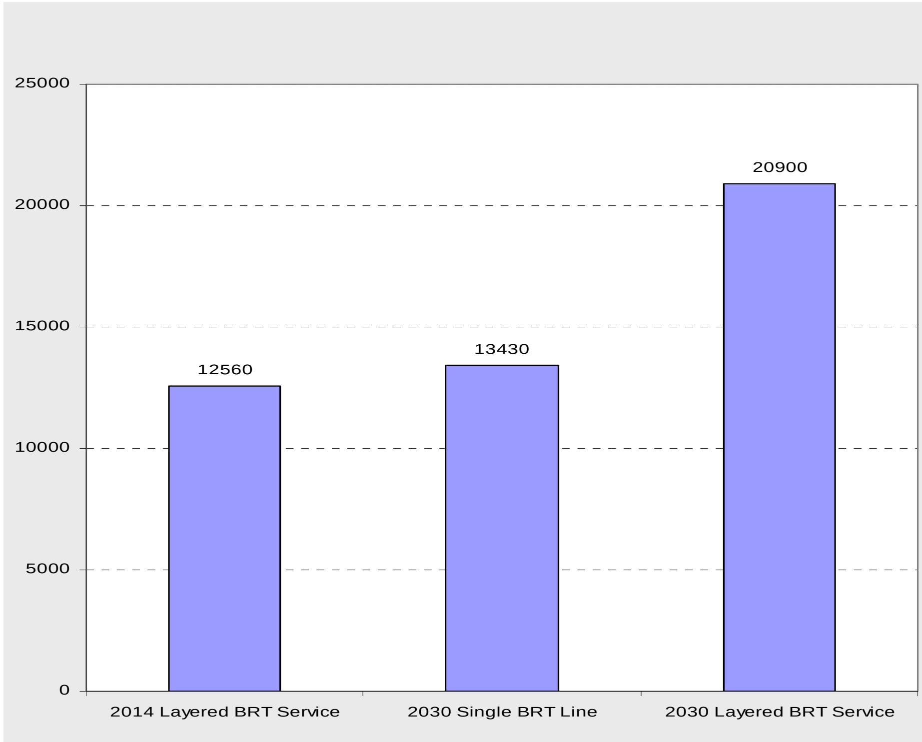
	Southbound		Northbound		Total	
	2+	3+	2+	3+	2+	3+
AM Peak Period	1,900	2,300	1,240	1,460	3,140	3,760
PM Peak period	1,240	1,460	1,900	2,300	3,140	3,760
Off-Peak	2,420	2,590	1,990	2,120	4,410	4,710
Daily (Weekday)	5,560	6,350	5,130	5,880	10,690	12,230

4.4.4 SENSITIVITY ANALYSIS: SINGLE ROUTE BRT

A single route 2030 BRT concept as illustrated in Exhibit 4-8 was modeled to compare with the baseline layered concept to see if sufficient ridership could be generated without a trunk and branch network. The single line BRT concept is similar to the initial modeling runs developed for the BRT white paper, and assumes a major arterial reconfiguration of the Klickitat overpass at I-5 to support a direct connection between Tukwila and Sea-Tac International Airport (outside of the scope of the I-405 project), and also assumes a 10-minute all-day service frequency.

Exhibit 4-15 present a summary of the impacts on ridership of implementing a single route BRT per Exhibit 4.7. Projected 2030 ridership of a single line BRT service is only about 65% of the layered service, and only marginally better than the 2014 layered service. The graph does not include the 4,900 trips for the single BRT line provided by other transit services, which correspond to the branches dropped from the layered BRT service. This supports earlier observations that a single route BRT service may not be able to generate an adequate level of ridership.

Exhibit 4-15: Single Route Sensitivity Analysis Results



4.5 Key Forecast Findings

Key findings from the modeling and forecasts are as follows for the assumed scenario (layered route structure, 3+ HOV lane policy):

- Bellevue accounts for over 25% of total daily boardings; other key generators are Sea-Tac International Airport, Renton, and Totem Lake.
- Both the south and north corridor serve primarily Bellevue-destined or transferring passengers (only 8-9% are through passengers during peak).
- Network connections (to Sea-Tac International Airport, LRT, and Commuter Rail) appear to be important in the southern corridor based on the ridership achieved by the branch routes to those locations.
- During the AM peak hour, both southbound and northbound services are projected to carry full seated loads on average (assuming low floor standard 40' buses) at maximum load point (Bellevue) in 2014. For some peak period runs, 40' coach capacity exceeded. Off-peak ridership however remains relatively low.
- A 3+ HOV lane policy provides projected BRT ridership that is about 15% greater than with a 2+ HOV lane policy.
- A single line BRT route from Lynnwood to Sea-Tac International Airport would have less ridership than the layered concept by about 35%. By including ridership provided by other transit agencies which correspond to service areas dropped from the layered service, the single line BRT route would have 12% less ridership than that of the layered service.

5. EXAMPLE I-405 SOUTH CORRIDOR BRT ALIGNMENT

In order to identify the potential impacts on infrastructure along the I-405 South Corridor, an example pre-design alignment for BRT service was developed. Parameters that governed the development of this alignment are as follows:

- The alignment should be focused on the I-405 corridor, deviating onto arterial streets only to the extent needed to serve activity centers.
- The alignment should support direct routing between stops with minimal circulation and resultant travel time impacts.
- The alignment should support a layered “trunk and branch” BRT service concept similar to that described in the previous chapter.
- The alignment should serve key transit “intercept points” in order to provide regional transit connections. For the south corridor this includes Bellevue, downtown Renton, and connections to existing and future Sound Transit services.
- The alignment may make reasonable assumptions regarding the future infrastructure environment, but should be flexible enough to accommodate changes to that infrastructure. In particular, it should be recognized that any major improvements to the arterial network are beyond the scope of the I-405 project and will be determined by broader local and regional needs and priorities.
- The alignment should consider and be compatible with other high-capacity transit initiatives in the area.

5.1 Example Alignment

Exhibit 5-1 presents example alignment for the south corridor BRT trunk service and branches. The south corridor trunk section begins at the Bellevue Transit Center, and continues to downtown Renton, with branches from there extending to the Tukwila Urban Center, Sea-Tac International Airport, and the Kent Transit Center.

Starting at the Bellevue Transit Center the BRT alignment uses the I-405 freeway HOV lanes, taking advantage of the new direct access ramps in Bellevue. Moving south on I-405 the alignment serves the Newport Hills (inline station) and Port Quendall (2030 direct access) stops. The alignment would depart from the freeway at the N 8th Street direct access HOV ramp into the north Renton area, serving a potential new transit center there.

From north Renton, the alignment travels along Logan Avenue to the existing Renton Transit Center, and continue to a stop in south Renton. From the south Renton stop, the alignment branches into the communities of Tukwila, Sea-Tac, and Kent. The Tukwila branch would serve both a relocated Sounder station, as well as the Tukwila Urban Center including the Southcenter Mall and area businesses. The Sea-Tac alignment would merge back onto I-405, connecting to SR 518 and the airport. The Kent alignment would leave the south Renton stop and merge onto SR 167 heading southbound to the Kent Transit Center.

With respect to the Sea-Tac branch, consideration was given to terminating at the Sound Transit Link light rail South 154th Street station instead of Sea-Tac. Based on the results of the modeling analysis, however, it was determined that Sea-Tac would be a better terminus than South 154th Street because of its ridership generation potential and direct routing. It is also understood that other high-capacity transit options are being considered by Sound Transit to connect to the South 154th Street Link station.

Exhibit 5-1: Example I-405 BRT South Corridor Alignment

5.2 Bellevue to North Renton

Between the Bellevue Transit Center and north Renton, the BRT alignment would primarily be on I-405. Improvements along I-405 have been identified within the implementation plan, and include additional high occupancy vehicle (HOV) lanes, new interchanges, and direct access ramps benefiting the BRT as it travels the I-405 freeway.

Bellevue Transit Center - The initial stop on the I-405 BRT South Corridor alignment would be the Bellevue Transit Center. From the Bellevue Transit Center, the BRT would access I-405 via the direct access ramp at NE 6th Street to the high occupancy vehicle (HOV) lanes on the freeway. This direct access ramp was funded by Sound Transit and opened in December 2004. By co-locating the BRT stop at the Bellevue Transit Center, a BRT service would be able to leverage off the capital improvements implemented by Sound Transit.

Newport Hills - Traveling south along the I-405 HOV lane, the next stop would be located at Newport Hills. This facility, identified as part of the Implementation Plan, includes an inline station and access to an expanded park-and-ride facility. From there the BRT continues on I-405 using the HOV lane.

Port Quendall (2030 stop) – Port Quendall has the potential of being substantially developed into a mixed use site. Current economics are such that this development will likely not occur for some time (i.e. post-2014), so for the purpose of the BRT study it was assumed that this would be a 2030 stop only. The I-405 Master Plan includes provisions for direct HOV access into this site that would support a BRT stop at this location, should it be developed,

5.3 North Renton to the Renton Transit Center

Exhibit 5.2 illustrates a potential alignment from I-405 to downtown Renton.

North Renton Transit Center - From the I-405 HOV lane, the BRT exits the freeway at N 8th Street via a new direct access ramp that would touch down near Garden Avenue. From there the BRT continues to a new arterial stop on N 8th, integrated with a new transit center and park-and-ride serving development in the north Renton area. No funding for a transit center and park-and-ride at this location has been identified at this time.

A review of existing and planned land use in the area suggests that N 8th between Park Avenue and Logan would be a preferred location for this stop. Input from the City of Renton suggests that this area will be developed before the area east of Park Avenue, and would be preferred over the area to the east of Park Avenue.

Renton Transit Center - From north Renton, two options were identified for connecting to the downtown Renton Transit Center:

- Option 1 - Travel via arterials, or
- Option 2 - Return to the I-405 BRT freeway and exit freeway at Exit 2/SR 167.

Exhibit 5-3 compares estimated travel times of these options based on field travel time studies conducted in early 2004. Under Option 1, there is a relatively direct connection to downtown Renton via Logan Avenue with an estimated travel time of under 4 minutes. Under Option 2, additional time is required to return to I-405 from north Renton, travel along the freeway, and then exit and travel along arterials to downtown Renton.

Exhibit 5-2: Potential North Renton Alignment

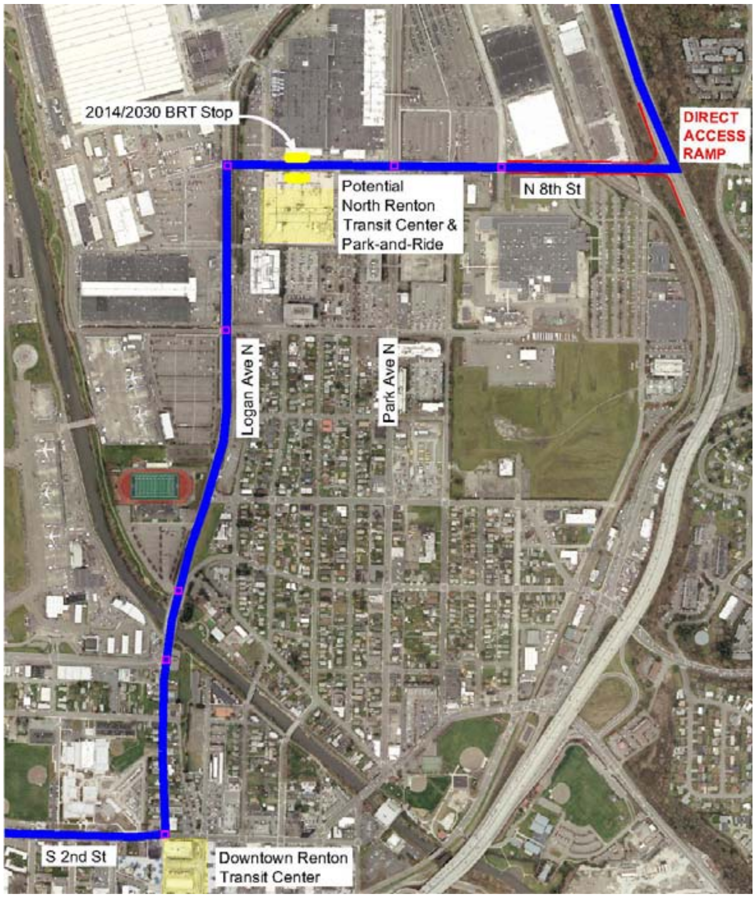


Exhibit 5-3: Comparison of I-405 and Arterial Travel Times

	Road Type	Distance (mile)	Speed (mph)	Travel Time (min)	Total Distance (mile)	Travel Time Total (min)
Option 1	Arterials	1.2	20	3.6	**1.2**	**3.6**
Option 2	Arterials	1.5	20	4.5		
	Freeway	2.3	45	3.1	**3.8**	**7.6**

To avoid circulation delays associated with Option 2, the arterial alignment (Option 1) has been identified as a more advantageous option.

Under Option 1, two arterial sub-options are available for routing to downtown Renton:

- Logan Avenue N
- Park Avenue N

Currently Park Avenue N is used for bus traffic. However discussions with the City of Renton suggest that Logan Avenue N may be improved in the future to become the major north/south arterial through Renton. Park Avenue may also be redeveloped in the future to become a more pedestrian-oriented arterial, moving its traffic to Logan Avenue N. The City of Renton was open to considering transit signal priority and business access and transit (BAT) lanes along Logan to improve the efficiency of transit operations.

Assuming that Logan Avenue N could be used, the BRT would bear left at the intersection of Airport Way and Logan Avenue N, continue on to S 2nd Street, and then turn into the Renton Transit Center. Operations of the traffic signal at Airport Way and Logan may need to be reviewed to determine if improvements can be made to support BRT movements.

5.4 Renton Transit Center to South Renton

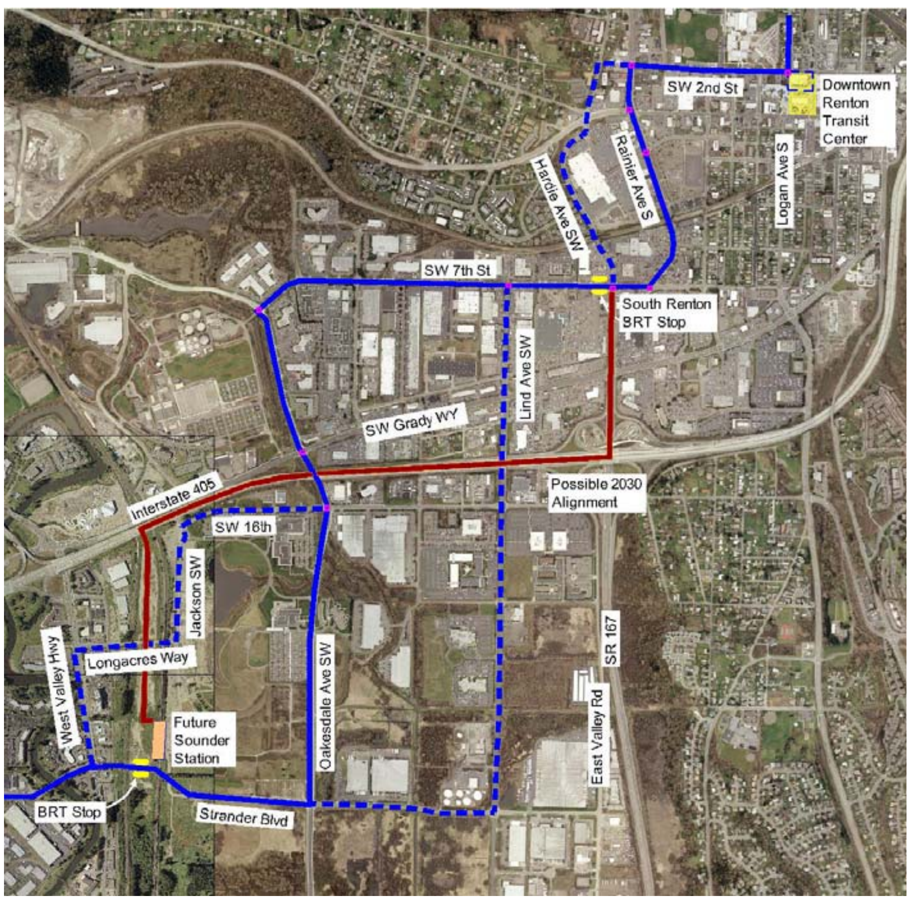
Two alignment options were investigated between the Renton Transit Center and a potential new stop in south Renton including:

- Option 1: Rainier Avenue S
- Option 2: Hardie Avenue SW

Transit services are currently routed along Rainier Avenue S. This street experiences significant congestion and has limited opportunity for expansion (although a study is underway by the City of Renton analyzing potential improvements).

Preliminary indications are that the City of Renton would prefer a BRT alignment along Hardie Avenue SW (Option 2). While this option would allow the BRT to travel off the congested main thoroughfare, the road infrastructure would require significant improvements and has some geometric challenges. For the purpose of this study, the Rainier Avenue S alignment has been identified as the preferred option, with Hardie Avenue SW as an alternative should the City proceed with potential improvements. This is illustrated in Exhibit 5-4.

Exhibit 5.4: Potential Renton to Tukwila Alignment
(Dashed lines indicate possible alternative alignments)



5.5 South Renton to Tukwila

Exhibit 5.5 illustrates potential options to connect south Renton to Tukwila.

South Renton – From the Renton Transit Center, the BRT travels west on SW 2nd Street, connecting to SW 7th Street using either the Rainier Avenue S or Hardie Avenue SW options. In order to serve the south Renton area, it is proposed that a stop be located on SW 7th Street. The location is flexible, but needs to be compatible with either a Rainier Avenue S or Hardie Avenue SW alignment.

From there, several options are available to connect the south Renton stop to the potential relocation of a Sounder/Multimodal Rail Station (at SW 27th Street and Strander Boulevard).

2014 Alignment: The I-405 Implementation Plan does not include HOV direct access ramps into south Renton and Tukwila. The 2014 BRT alignment therefore assumes that connections between south Renton and Tukwila could be made using one of two potential arterial routes:

- Option 1: Continue on SW 7th Street, turn left onto Lind Avenue SW, and connect to Strander Boulevard.
- Option 2: Continue on SW 7th Street, turn left onto Oaksdale Avenue SW, and connect to Strander Boulevard.

The primary issue with either of these options is that Strander Boulevard does not currently connect between Tukwila and Renton, and no projects have been funded to complete this connection. As well, the Option 1 routing would likely have BRT travel time impacts due to signal delays and traffic congestion on Lind due to conflicts with general purpose traffic accessing I-405 at a future Lind/I-405 ramp (this ramp is a component of the I-405 Implementation Plan).

From an operational perspective, Option 2 is preferred over Option 1 as Oaksdale has less potential for delays from traffic congestion and signals than Lind, thus providing better opportunities to maintain BRT speed and reliability. There may also be opportunities to implement preferential treatments for transit on Oaksdale (transit signal priority, geometric improvements) with less potential impact on general purpose traffic than implementing similar treatments on Lind. For the purpose of this study, potential Option 2 (Oaksdale) has been identified as a preferred arterial alignment over Option 1.

These options were discussed with the Cities of Renton and Tukwila, and both indicated a preference for the use of Oaksdale versus Lind in an arterial connection scenario. Connecting Strander Boulevard is however beyond the scope of the I-405 freeway improvements, and represents an initiative that would likely be driven by broader traffic and transportation needs in the area.

2030 Alignment: The I-405 Master Plan includes HOV direct access ramps at the Rainier Avenue S/I-405 interchange in south Renton, as well as just west of the existing railroad line in Tukwila. The potential exists therefore to utilize a portion of I-405 to provide the connection between south Renton and Tukwila.

From Rainier Avenue S or Hardie Avenue SW, the alignment continues down Rainier Avenue South to the HOV direct access ramps at the I-405 interchange. From there, the alignment continues west along I-405, accessing a relocated Sounder station from the Tukwila HOV direct access ramps just west of the railroad lines, as illustrated by the red line on Exhibits 5-4 and 5-5.

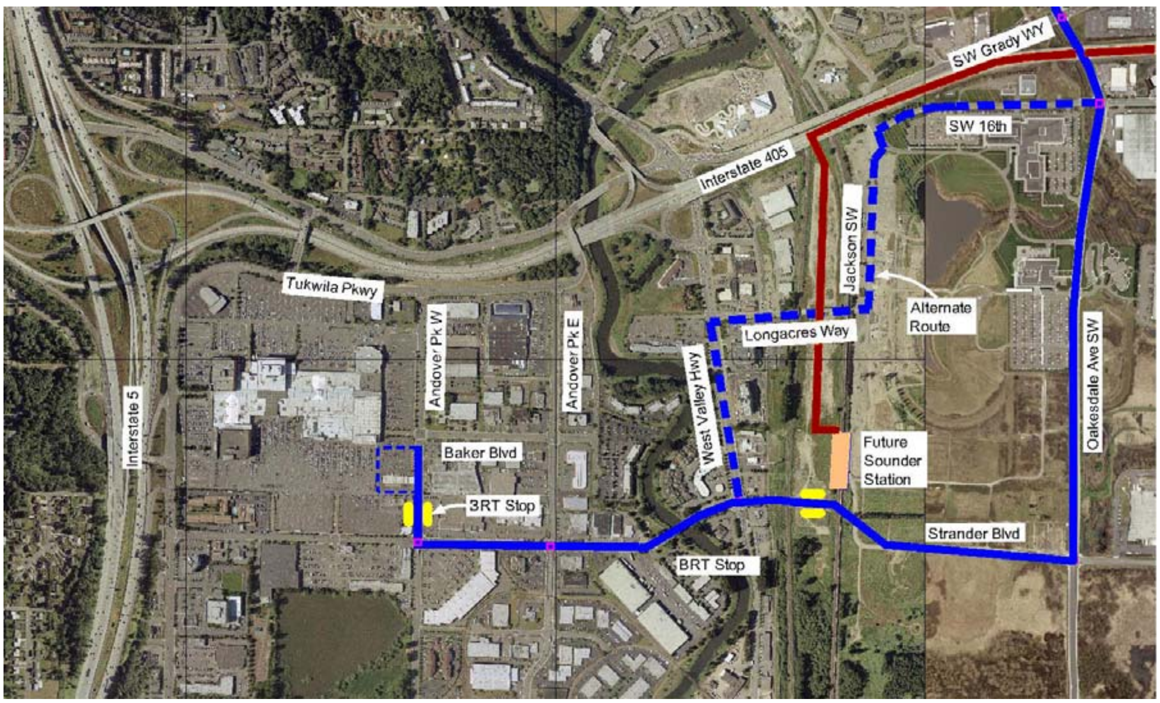
This option would no longer require BRT travel on either Oaksdale or Strander, and may provide a more direct connection to the Sounder Station. The disadvantage is that BRT vehicles would be required to share right-of-way with general purpose vehicles on a congested portion of Rainier Avenue S between SW 7th and SW Grady Way, potentially introducing congestion and signal delay. As well, the distance that would be traveled along I-405 is relatively short (just over a mile), suggesting that any travel time benefit over the Oaksdale arterial routing would be nominal.

For the purpose of the BRT study, it has been assumed that in 2030 the alignment would shift to I-405 if both the south Renton and Tukwila HOV direct access ramps are constructed. It is also assumed that any decision to construct these ramps would be made based on broader transit network and connectivity requirements, as the benefits from a BRT perspective are expected to be nominal and would not justify construction of these ramps.

Sounder/Tukwila Commuter Rail – Through one of the options noted above, the BRT alignment would connect to a relocated Tukwila Sounder (commuter rail) station. If this station is not relocated, it is possible that the BRT could access the existing Sounder station on S Longacres Way just east of the railroad tracks. This would result in an indirect BRT routing (dashed lines) which is not recommended due to travel time and routing impacts.

Tukwila Urban Center – From the Tukwila Commuter Rail Station the alignment continues west on Strander Boulevard then turns north onto Andover Park W. It is proposed that the BRT have a curbside stop on Andover Park W, integrated as appropriate with redevelopment of the area.

Exhibit 5-5: Potential Tukwila Alignment
(Dashed lines indicate possible alternative alignments)



Two potential alignment options were identified to provide the BRT system the ability to position the vehicle for return service and provide a location for layovers. These two options included:

- Option 1: Layover and circulate on Baker Boulevard /Tukwila Parkway
- Option 2: Layover and circulate through the Southcenter Mall parking area

Current local transit uses Tukwila Parkway for bus layovers. By traveling east on Baker Boulevard and Andover Park E, the BRT could not only reposition the buses for return service, but could co-locate with local buses for layovers. The City of Tukwila intends to develop Baker Boulevard as a pedestrian-oriented street. This suggests that Option 2 would be preferred, provided that suitable accommodations can be made in the mall parking lot to layover and turn vehicles. A less preferred alternative would be to layover on Tukwila Parkway and circulate using Andover Park E. This would also have an impact on stop design.

5.6 South Renton to Sea-Tac International Airport

Sea-Tac International Airport – From south Renton, the alignment has a BRT branch traveling west on SW 7th Street, turning south on Lind Avenue SW, and accessing I-405 from the Lind ramp (via a proposed HOV queue jump), during the timeframe of the Implementation Plan. With the Master Plan, more direct transit access could be realized using the proposed I-405 Rainier Avenue HOV direct access. The BRT then travels west on I-405, continuing as the freeway becomes SR 518. If the Tukwila HOV direct access ramps were constructed as well, buses could potentially exit at this location, stop at the Sounder station, and re-enter I-405, continuing to the airport.

The final connection to the airport is along SR 518 and the airport access road. As there are currently no HOV lanes along SR 518 and no long range plans for them, the BRT would make this last connection using the general purpose lanes.

No specific stop has been identified at the Airport. In the interim, the existing bus stop at the terminal could be used. Should Sound Transit and the Port of Seattle develop the Link light rail station at the airport, the BRT service could be moved and co-located with that facility. This south Renton-Sea-Tac branch is currently served on a similar routing by ST 560, and it is possible it might be upgraded to operate more frequently.

5.7 South Renton to Kent

Kent Transit Center – From the Renton Transit Center, the 2014 (Implementation Plan) alignment has a BRT branch traveling west on S 2nd Street, turning south on Rainier Avenue S, and accessing the SR 167 freeway at the I-405/SR 167 interchange. Under the Master Plan (2030), the connection to SR 167 will be from East Valley Road to a new HOV half-interchange in the vicinity of SW 27th Street. From SR 167, the BRT will continue along designated arterials to the Kent Transit Center.

6. BRT COMPONENTS AND SYSTEMS

This section provides an overview of components and systems that, along with limited stops and a high frequency of service, help define a bus rapid transit system. Information is presented as needed for the purpose of this pre-design study, however it is recognized that final decisions on what components to include, and the actual design of those components would not be determined until if and/or when a decision is made to move forward with BRT implementation.

For the purpose of this pre-design, BRT components have been classified into three categories of potential improvement projects: Road infrastructure, vehicles, and stops and stations. Prototypical stop and station layouts have been identified as input to future design work, along with conceptual renderings of potential shelters, an inline station, and transit center.

6.1 Roadway Components

The roadway components of the BRT system are key elements that support speed and reliability of service, and help make BRT competitive in travel time to other modes. They include technology improvements along the route, as well as road improvement projects to support preferential treatment of transit.

6.1.1 TRANSIT SIGNAL PRIORITY

Traditional approaches to traffic signal design and operation have been based on the demand and performance characteristics of general purpose (GP) vehicles. For example, traffic signal coordination offsets are typically set for continuous travel between signals based on automobile operating speeds and green time is typically allocated based on volume of vehicles, not persons. This approach is generally accepted because a large proportion of the traffic demand is typically GP vehicles. However, this basic approach does not accommodate some of the unique characteristics of transit vehicle operations, such as slower speeds and passenger pick-up and drop-off, resulting in delays to transit buses.

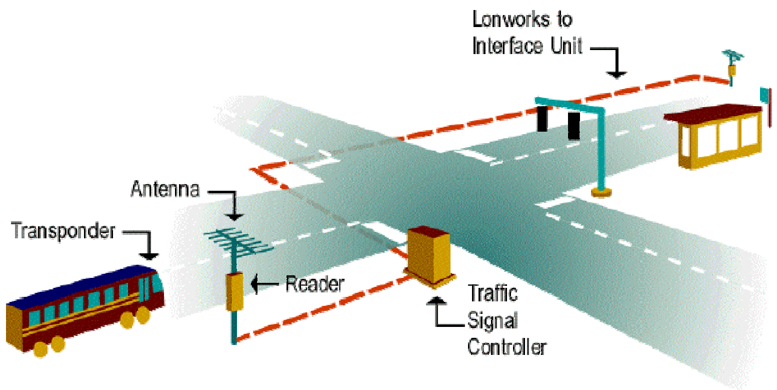
Transit Signal Priority (TSP) is similar to emergency vehicle signal pre-emption, but instead of imposing complete control over the signal, the influence of TSP is only to request that the signal extend the green time or reduce the red time in order to help an approaching transit vehicle clear the intersection more quickly. TSP is particularly valuable if intersection delay is an issue which, as noted in Section 2 (see Exhibit 2-7), occurs along the example route in areas such as north Renton and Bellevue. To support efficient TSP operation, transit stops should be placed at the far side of an intersection. Queue jump lanes are an important complement to TSP, particularly at congested intersections where queue spillback may result in significant signal delay.

TSP applications are being implemented by many jurisdictions around the world as a means to enhance the attractiveness of transit by offering more reliable and faster service. Given the person carrying efficiency of transit vehicles, a small reduction in transit delay at traffic signals equates to significant savings in person delay. Reductions in total route travel time may also allow service frequency to be maintained or improved without additional resources. Consequently, the rise in TSP applications is leading to more efficient transportation and overall environmental benefits.

King County Metro currently collaborates with local cities to implement TSP on key corridors within the County using a system as illustrated in Exhibit 6-1.

Exhibit 6-1: TSP System Diagram

Source: King County Metro



Completed and planned corridors in King County include:

- Aurora Avenue, 15th Ave W, and 1st Avenue in Seattle
- Aurora Avenue in Shoreline
- SR99/Pacific Highway S. in Federal Way, Kent, Des Moines, Sea-Tac, and Tukwila
- NE 124th Street in Kirkland
- 148th and 156th Avenue NE in Redmond
- Downtown Renton (along Grady Way, and Rainier Ave)

As illustrated in the table below, there are several strategies and methods by which TSP can be implemented. Should implementation of an I-405 BRT proceed in the future, a key element of design would be to work with King County Metro, Sound Transit, and any communities that an arterial routing of the BRT passes through to identify appropriate and beneficial transit signal priority strategies.

Option	Method
Passive Priority	Pre-determined signal timing plans developed using analysis of transit route and demands. Complimented by queue jumpers, bus lanes, bus stop relocation, taper length modifications, parking/stoppage restrictions, and minor geometric improvements.
Active Signal Priority	Traffic signal change can be implemented locally by the signal controller or centrally by a signal monitoring and control system. Vehicle detection can be interfaced to the signal controller or can be managed by a separate transit vehicle monitoring system and passed on to the traffic signal system and subsequently the traffic signal controllers. Granting of signal priority can be unconditional (granted every time a transit vehicle approaches a signalized intersection) or conditional (granted only when the approaching transit vehicle meets certain specified conditions).

Option	Method
Active Signal Priority Strategies	**Green Extension**: green is maintained beyond its regular maximum split to allow sufficient time for the transit vehicle to clear the intersection. **Early Green**: the controller advances to the desired green phase using minimums and optional phase skipping. **Phase Insert**: a short green phase is inserted into a long red phase to allow a transit vehicle at the intersection stop bar to proceed. Required Technologies for active signal priority include bus detection and a controller interface. Bus detection can operate on a point detection system, an area detection system, or an integrated priority system. For the controller interface, request for signal priority can be communicated from a centralized "transit center" to a traffic control center, or from a transit vehicle to the roadside signal controller.

King County Metro's current TSP Program utilizes signal-timing strategies that extend green time, or provide an early green time to eligible transit vehicles. When initiated, the TSP strategies must maintain any minimum clearance intervals, not skip any phases, and not break any existing signal coordination along a corridor.

6.1.1.1 Potential TSP Locations

Using the travel time and delay information from Section 2, along with current traffic volume information for the City of Renton, the intersections along the example route were reviewed to identify locations where a potential BRT service could benefit from TSP implementation. These locations are preliminary only, and should be reviewed with the City of Renton and King County Metro, and considered in terms of prioritization within any regional TSP implementation before any decisions are made to move forward. Per information received from the City of Tukwila, TSP is not being considered in that city at this time.

For the example route, there are a number of intersections where TSP could be considered to support BRT and other transit operations:

- Logan Ave. N. at Airport Way (Left Turn Signal)
- Rainier Ave. N. at S. 3rd St.
- Rainier Ave. N. at S. 3rd Pl.
- Rainier Ave. N. at S. 4th Pl.
- Rainier Ave. N. at S. 7th St.
- S. 7th St. at Oakesdale Ave. SW
- Oakesdale Ave. SW at SW Grady Way
- Oakesdale Ave. SW at SW 16th St.
- Oakesdale Ave. SW at SW 27th St.
- Strander Blvd. At West Valley Highway

Although TSP at the following intersections potentially offers some benefit, traffic volumes and signal delay are not expected to be significant:

- Logan Ave. at N. 6^{th} St.
- Logan Ave. at N. 3^{rd} St.
- Logan Ave. at S. 2^{nd} St.
- Oakesdale Ave. SW at Longacres Access Rd.

6.1.2 PHYSICAL IMPROVEMENTS

There are three major approaches to providing physical road improvements to support BRT operations. These include improvements along arterial and freeway segments of the route, at arterial/freeway interfaces, and at signalized intersections (in addition to TSP).

6.1.2.1 Preferential Lanes

Preferential lanes enable BRT buses to bypass congestion experienced on general-use roads, and are most applicable along roads that experience severe recurring (volume related) congestion and a poor level of service. There is substantial variation in what constitutes a preferential lane; at its simplest, a preferential lane is a shared transit and HOV lane in the far left or far right lane of an existing road. At the other extreme, a preferential lane is an exclusive bus-only lane operating in its own right-of-way. BRT systems typically include preferential lanes for at least part of the length of their routes. Small sections of preferential lane can be provided to bypass spot congestion in corridors with localized but predictable problem locations.

Preferential lanes tend to be costly, especially if new right-of-way must be acquired. Lane widths and designs vary depending on whether, and what type of, lane assist technology is used. With “lane assist” (see description below), buses can operate in narrower lanes than possible with driver control alone. Savings can be realized in right-of-way acquisition. However, lane infrastructure for lane assist systems is more costly.

In general, preferential lane treatments can be summarized in terms of the following infrastructure improvement categories:

Category	Method
Freeway HOV Lane	Freeway HOV Lanes are lanes regulated for the exclusive use of high occupancy vehicles (HOV). In addition to transit, other permitted users often include carpools of two or more persons, or three or more persons, and motorcycles. Signs and road markings are used to distinguish HOV lanes from general-purpose lanes. Most often, HOV lanes are positioned on the far left or far right side of the road.
Direct Access Freeway Ramp	A direct access freeway ramp provides a direct route for transit vehicles, and potentially other HOV vehicles, from an arterial to a freeway median HOV lane without the need to merge across traffic.
Business Access and Transit (BAT) Lane	Business access and transit (BAT) lanes are a form of preferential lane used on arterials in the King and Snohomish County areas. BAT lanes are intended primarily for use by transit, and may be used for through travel. Use by general purpose vehicles is restricted to brief occupation of the lane while turning in to a business driveway. Carpools may or may not be permitted to use BAT lanes for through travel, depending on local regulations.

Under the example BRT routing, vehicles would access I-405 at Bellevue through the recently completed direct access ramps. Service would continue southbound along the freeway HOV lanes to a new direct access ramp at North 8^{th} in Renton, where it would exit to the arterial network. As noted in Section 5.5, routing into Tukwila would continue either on the arterial network or potentially along I-405 using HOV direct access ramps in south Renton and Tukwila (this is an option under the I-405 Master Plan only).

A review of travel times along the example route suggests that BRT speed and reliability could be improved through the implementation of BAT lanes in Renton, specifically in the section of the arterial network along Logan Avenue North from North 6th Street to Airport Way. The City of Renton may wish to consider this in any proposed improvements to Logan Avenue North and Hardie Avenue Southwest.

6.1.2.2 Queue Jump Lanes

Queue jump lanes are special lanes that provide a space for transit vehicles to by-pass queues of general-purpose vehicles at intersections as illustrated in the graphic in Exhibit 6-2. They provide benefits similar to preferential lanes, but do so specifically at signalized intersections. If delay at intersections represent a significant portion of total delay, and general congestion delay is minimal, it may be most cost effective to provide queue jump lanes and no other preferential lanes. By creating a congestion bypass at each intersection, queue jump lanes with transit signal priority can accomplish a significant portion of the time savings of exclusive bus-only lanes at considerably less infrastructure costs.

Exhibit 6-2 : Transit Queue Jump Lane

Source: www.ltd.com

Queue jump lanes may be constructed by widening the road, or by re-purposing an existing lane. At intersections with an existing separate free right turn lane, this lane can be signed for use by buses, allowing them to bypass a queue stopped on red. If this approach is used, it becomes necessary to reduce the size of the triangular island typically located at the end of a right turn lane, and relocate any signal pole(s), to permit the buses to pass straight through the intersection.

Along the example BRT route, implementation of queue jump lanes offers the highest potential to improve operations along Rainier Avenue (both northbound and southbound) Road geometrics likely preclude the ability to provide full BAT lanes, however queue jumps at key intersections could provide a substantial portion of the benefits associated with providing transit preferential lane treatment.

6.2 BRT Vehicles and Technology

6.2.1 VEHICLES

Vehicles are the most visible feature of the BRT system, and make key contributions to the improved performance that characterizes BRT. A unique appearance—from distinctive paint schemes to sleek, rail-like vehicle shapes—distinguishes BRT from standard transit services, makes the system easier for travelers to understand, and contributes to service appeal. Low floors and wider doors help speed boarding and alighting, particularly if used in conjunction with precision docking and off-board fare collection (see discussion in the following section).

A BRT vehicle fleet is traditionally comprised of standard transit buses with some styling enhancements and component upgrades. However, some agencies are exploring procurement of new high-end vehicles that have a resemblance to light rail vehicles and include such advanced systems as automatic docking and advanced guidance (see example in Exhibit 6-3). Service along I-405 requires that buses be able to travel at freeway speeds. The use of lower emissions and quieter vehicles improve rider experience, system performance, and community perception, and reduces overall environmental impacts.

Exhibit 6-3: BRT Articulated Bus

In general, a BRT vehicle has many or all of the following characteristics:

- **Low floor design:** allows for easier and quicker ingress and egress from the vehicle, and supports automatic docking requirements.
- **Branding:** providing a distinctive look to the vehicles to promote the service as BRT. This can include choosing vehicles that have a rail-like image.
- **Performance:** Capable of freeway speeds; low-emissions; smooth, quiet ride
- **Passenger amenities:** Clean, comfortable interiors and on-board passenger information
- **Configuration:** More and wider doors (3 doors at 32 inches each ideal)
- **Capacity:** Seating to standing ratio of 2:1 to 1:1
- **Operational enhancements:** Capability for automatic docking and/or guidance.

BRT vehicles can be procured as either 40' standard vehicles or 60' articulated vehicles. Typical capacities for these sized vehicles are shown below:

Vehicle Type	Length (ft)	Seated Capacity	Additional Standing Capacity
Standard	40	40	15
Articulated	60	64	48

For the I-405 BRT project, the decision on what size vehicle to be used would be made by the entity funding and/or operating the service. Based on the ridership projections for the corridor, 60' vehicles would be required during some periods of the day to provide all passengers with a seat.

In terms of propulsion system, fuel types to be considered include:

Clean Diesel: This is conventional diesel technology that uses reformulated fuels to reduce particulate and Nitrous Oxide emissions (NOx). The advantage of this option is that it requires no special fueling facilities, and utilizes mature propulsion technology.

Hybrid Technology: Smaller shuttle buses using battery power and traction motors at or on the wheel hubs, can provide an emission free vehicle. However, this is practical only using shorter buses in low mileage applications. For conventional bus service, the hybrid concept combines a battery with a small diesel engine. A key issue is the comparison of the added capital cost of the hybrid vehicle versus the savings in fuel consumption and emissions. While a dual-powered vehicle uses either one of two separate power sources, a hybrid vehicle typically uses two internal power sources at the same time. The key design feature is the extended life that the battery can provide under these operating conditions.

Engine Fuels: A modified diesel engine can also use other fuels to reduce emissions. This includes compressed natural gas (CNG), liquefied natural gas, liquefied petroleum gas, ethanol, and methanol. CNG has been widely used because it is cost competitive. Key considerations for evaluating this alternative are cost, safety, engine maintenance, and operating range. In particular, special fueling equipment is typically required.

For the I-405 BRT project, the decision on the propulsion system to be used would be made by the entity funding and/or operating the service, and may be substantially different in 2014 and 2030 than now. At this time, either clean diesel or hybrid technology would likely offer a balance between low emissions and cost for I-405 service.

6.2.2 TECHNOLOGY IMPROVEMENTS

In addition to physical changes to the transit operating environment and transit vehicles, there are many solutions involving communications and computing technologies that can contribute to increased service efficiency and improved passenger experience. Advanced Public Transit Systems (APTS) is a set of integrated on-board technologies with on-board vehicle location processing at its core. The bus "knows" not only where it is but also where it is supposed to be, and it can share this information with data collection and customer information systems. The following technologies descriptions highlight those elements of APTS that may be applicable to BRT service along I-405. Both Sound Transit and King County Metro are looking at similar enhancements for their current bus services[14].

6.2.2.1 Automatic Vehicle Location

Automatic Vehicle Location (AVL) is at the foundation of most other APTS technologies. Vehicle location is tracked in real-time and supplied to dispatch and various on-board and wayside systems. Automatic tracking of vehicle location enables on-board automatic stop annunciation, wayside and internet based next bus information, and rapid response to emergency situations. AVL can be achieved through several different methods, including signpost/odometer systems, dead-reckoning systems, and ground-based radio positioning and paging systems, but the current system of choice is the global positioning system (GPS). King County Metro is in the process of procuring a new GPS-based AVL system to replace their existing signpost system.

6.2.2.2 Automatic Stop Annunciation

Automatic Stop Annunciation (ASA) provides both audio and visual announcements of the next stop, both for customer convenience and also for hearing or visually impaired customers. Pre-recorded or computer generated voice announcements and digital displays notify passengers on-board of the next stop. Additionally, buses compliment their standard destination sign with an audible announcement of their route and destination when they arrive at a stop. All of these functions are triggered by the bus's location as identified by the AVL system.

[14] Sound Transit Corridor Transit Technology Initiative and King County Metro's Onboard Systems Project

6.2.2.3 Automatic Passenger Counters

Automatic Passenger Counters (APC) count passengers as they board and alight at each stop, thus negating the need for periodic surveys to determine ridership and provide Federal National Transit Database reporting. In addition to providing vital information for service planning, real-time APC can assist in dynamically improving service efficiency. Passenger counts can be used as an input to TSP, where priority is only granted if a transit vehicle is sufficiently full. Dispatchers and field supervisors can use loading information to decrease bunching and reduce missed headways.

6.2.2.4 Guidance—Precision Docking and Lane Assist

The purpose of transit guidance technologies is to monitor and guide the lateral position of transit vehicles. In the case of lane assist, control over the lateral position of the vehicle enables the operation of transit vehicles in narrow, transit only busways or transit lanes. Reducing the required lane width for a busway or transit lane can reduce right-of-way acquisition costs and, in some cases, can make an exclusive transit travel way feasible where it otherwise would not have been possible due to space constraints.

Precision docking is guidance used at transit stations and stops. Precision docking enables transit vehicles to consistently stop alongside their platforms with a gap as small as a few centimeters. By combining precision docking, low floor vehicles, and appropriate platform height, level boarding can be achieved on bus transit as illustrated in Exhibit 6-4.

Exhibit 6-4: Precision Docking

Source www.rtcsouthernnevada.com/max

Precision docking and lane assist are two applications of the same concept. In general, lane assist technologies can operate equally well as precision docking technologies. Available technology options are as follows:

Option	Method
Mechanical Guidance	Curb guided buses have a guide wheel mounted on each front wheel, which runs along the vertical part of the curb of a specially designed busway, enabling the bus to safely navigate narrow lanes.
Optical Guidance	The current optical guidance technology consists of a camera mounted on the front of the bus that tracks paired dashed lines painted on the road. An on-board computer automatically steers the bus so that it is centered over the lines.
Magnetic Guidance	In magnetic guidance systems, magnets are embedded in the road and on-board sensors guide the bus along the appropriate path between the magnets.
DGPS Guidance	Differential Global Positioning System (DGPS) guidance combines an on-board database of high quality geospatial data and real-time DGPS to identify a bus's position within its lane with centimeter accuracy.

Of the above technologies, only curb-guided, optical, and magnetic guidance are currently in commercial production.

6.3 Stop and Station General Provisions

For the purpose of the I-405 BRT pre-design, facilities along the corridor have been classified under two general categories:

1. **Stops** refers to simple curbside stops that may be utilized only by the BRT buses, or shared between the BRT buses and local bus services. In general these are not major transfer points, and include only basic BRT amenities.

2. **Stations** refers to transit centers and park-and-rides where the BRT stop is combined with other major facilities.

The stations and stops on the BRT Corridor will generally need to be located where the following exist:

- Designated transit focal points;
- Intersections with major arterials, especially commercial arterials and those with connecting transit service or potential for connecting transit services.
- Other relatively high-demand destinations or activity areas.

BRT stops and stations would typically be located so that intersecting arterial bus routes would be able to join the BRT corridor and access the same stations as the BRT services at the intersecting location. This would be the case at most stations, at least during peak periods.

6.3.1 STOP AND STATION GENERAL LOCATIONS

From the modeling work described in Section 4 of this document, a preliminary list of potential stop and station locations was identified for the example BRT route as follows:

- Bellevue Transit Center (existing transit center)
- Newport Hills Park-and-Ride (new station)
- Port Quendall (possible new stop in 2030)
- North Renton Transit Center at N.8th St. vicinity (new station)
- Renton Transit Center (existing transit center)
- South Renton at SW 7th St. vicinity (new stop)
- Sounder/Tukwila Commuter Rail Station (new stop)
- Tukwila Urban Center at Strander/Andover Park W. (new stop)

6.3.2 PARK-AND-RIDES

As is the case with current bus services, park-and-ride facilities will be a major element in generating ridership for a BRT line. Park-and-ride facilities at select BRT stations (or BRT stations at select park-and-ride locations) will be a key strategy to take advantage of, and justify, the high frequency proposed for the BRT services. These may be in addition to existing facilities in the corridor, or existing facilities that are enhanced and expanded to accommodate additional demands.

For the example BRT route, the potential of implementing a new park-and-ride in north Renton in the vicinity of North 8th was identified, along with an expansion of the existing Newport Hills park-and-ride. Park-and-rides may also be considered at other arterial locations along the route depending upon demands for such service.

Based on the modeling results, estimates were made of potential changes to park-and-ride facility capacity in order to accommodate projected future demands for BRT and other transit routes serving the park-and-ride. These estimates are summarized in Exhibit 6-5.

Exhibit 6-5: Estimated Park-and-Ride Capacity

Location	Current Capacity	Projected Additional Spaces	Projected Total Capacity
Newport Hills	275	100	375
North Renton	N/A (new facility)	400	400
Tukwila Commuter Rail	N/A (new facility)	350 (1)	350

(1) It is estimated that approximately 250 of these spaces would be required for Sounder, with the remaining 100 for BRT and bus connections.

6.3.3 TECHNOLOGY IMPROVEMENTS

Technology improvements at BRT Stops and Stations can promote speed and reliability of service, provide traveler information to passengers, and provide a safer environment. The primary improvements to be considered at any stop or station are described below.

6.3.3.1 Fare Collection

A key feature of BRT is providing streamlined fare collection, either on-board or off-board, in order to ensure the rapid throughput needed to achieve BRT's goal of minimizing travel times. All transit agencies in the Central Puget Sound region are in the process of introducing a new smart card-based fare collection system that will allow passengers to pay their fare by presenting a card to an electronic reader on the bus or at a stop. The transaction time is under a quarter of a second.

For cash paying customers, boarding times can be decreased by selling tickets at a vending machine at a stop as illustrated in Exhibit 6-6, and allowing passengers to board at any door (not just the front door). Inspectors on the vehicle verify that a customer has paid a fare in a similar manner to Sound Transit's current Sounder Commuter Rail system.

Exhibit 6-6: Off-Board Ticket Vending Machine

Source www.rtcsouthernnevada.com/max

For the purpose of the I-405 pre-design, off-board fare collection via a smart card reader or ticket vending machine has been assumed as it has the greatest impact on the design of the stops and stations. This would need to be reviewed in the future should implementation proceed as it introduces requirements for onboard inspection of fare media, as well as for regular servicing of fare collection equipment at each BRT stop.

6.3.3.2 Passenger Information Systems

Advanced Traveler Information Systems (ATIS) are key technology applications within the transit industry, designed to keep transit riders better informed, reduce service anxiety, and thus encourage improvements in ridership and customer services. Similar to rail rapid transit systems, a BRT system could display several forms of traveler information, based on current bus location and expected arrival times. Components include:

- Static information such as the stop name, route maps, and schedules.
- Next bus arrival information presented on reader boards as illustrated in Exhibit 6-7.
- Personal information services such as handheld computer or cellphone access to next bus arrival information.

Exhibit 6-7: Bus Arrival Information Sign

Source: TriMet MAX

For the purpose of the I-405 BRT pre-design, it has been assumed that electronic reader boards would be provided at each stop and station. Stop-based reader boards would likely only have 1 or 2 message lines. Station-based reader boards may require additional message lines to provide information on multiple routes.

6.3.3.3 Stop and Station Safety

Stop and Station Safety measures improve the passenger experience and contribute to rider confidence. Crime Prevention through Environmental Design (CPTED) and Situational Crime Prevention (SCP) can diminish the conditions for crime. Closed Circuit Television (CCTV) and emergency call stations can speed incident response or the apprehension of offenders. Safe zones combine the positive influence of CPTED and SCP with the quick response of call stations and the record creating function of CCTV.

Emergency call stations provide travelers with a way to contact transit personnel or law enforcement in the event of an emergency. Types of emergency call stations include:

- "Blue Light" Emergency Phones – directly calls police or transit security.
- Emergency Notification Buttons – alerts transit agency that a crime is in progress, most useful if integrated with CCTV.
- Public Pay Phones – can be used for emergency calls.

For the purpose of the BRT pre-design, it has been assumed that "Blue Light" emergency phones, CCTV cameras and public pay phones would be provided at stations only. CPTED and SCP techniques would be applied at both stations and stops. Emergency notification buttons, with or without CCTV, could also be considered for stops.

6.4 Stop and Station Prototype Concepts

6.4.1 GENERAL ATTRIBUTES

Three conceptual stop configurations have been identified including: curbside stop, transit center and park-and-ride, and inline freeway station and park-and-ride. General requirements to be addressed in any stop or station design include:

- Rider comfort
- Rider information
- Efficient stop/start
- Meets ridership forecasts/ sized appropriately
- Safety
- Multi-modal support
- Transit operator support

Curbside Stops – Curbside stops are typically located at the far side of a signalized intersection. Placement of transit stops along arterials on the downstream side of an intersection is important to support various other technology improvements such as transit signal priority, queue jumps, and transit-only signals. Typical treatments for curbside stops support rider comfort, passenger information and safety. Components include:

- Shelter area
- Lighting
- Bench
- Trash receptacle
- Static system/route map
- Technology items
- Emergency notification buttons
- Illuminated advertisements (optional)

Transit Centers and Park-and-Rides – Transit Centers need to support all of the elements listed above, as well as additional components to support transfers, connections and passenger waiting. Key additional components that would typically be required include:

- Pedestrian walkways
- Bike racks
- Maps, signage
- Benches
- Shelters
- Lights
- “Blue light” emergency stations
- Trash receptacles
- Noise screens (depending on location. Required at inline stations)

Other components that could be considered include:

- Enclosed bike lockers
- Restrooms (consistent with transit agency policies)
- Closed circuit TV monitoring
- Pay phones
- Water fountain
- Transit room, authorized personnel only
- Newspaper machines

Exhibit 6-8 illustrates typical transit center components including seating and shelter.

Exhibit 6-8: Existing Transit Center Example (Downtown Renton)

Park-and-ride lots at transit centers have several key attributes that make them a functional component of the BRT system. Through usage forecasts, lot size and capacity must be identified to be able to accommodate the necessary amount of users. The actual lot should also include areas for vanpool parking, kiss & ride loading and unloading, as well as space for taxis.

In Line Stations and Park-and-Rides

An in-line transit station is located in the freeway median, and connected via a pedestrian bridge to a park-and-ride or other facility (at this time, only Newport Hills has been identified as an inline station for the south segment of the corridor). In-line stations are simply a pull through station, and do not have the size or capacity for any vehicle wait-time. Access is from the freeway HOV lanes.

The same attributes of a transit center park-and-ride apply to those found at the inline station park-and-ride. In addition to those, the inline station park-and-ride facility must provide a safe and comfortable pedestrian environment to access and wait at the platform.

6.4.2 DESIGN CONSIDERATIONS

There will be a variety of site and neighborhood conditions along the BRT corridor. The design of the stations and shelters should be readily identifiable as well as accommodate both current and future transit passenger volumes. Both BRT and local transit services are expected to be accommodated at most of the stations and stops. The design of the stations and stops should be simple, clear, accessible and promote ease of circulation and transfer between services where required.

Design considerations include:

- Provide a safe, efficient, and convenient configuration to promote ease of transfer between services where applicable.
- Provide a safe, comfortable platform and waiting area. Include environmental protections as required such as noise barriers.
- Provide clear, consistent and easily understandable transit and way finding information that can be referenced quickly.
- Provide adequate waiting and boarding areas for ease of circulation, and timely loading and off-loading of passengers.
- Emphasize pedestrian links to adjacent uses including park-and-ride facilities and local development.
- Integrate stations and stops into surrounding communities.
- Integrate user amenities into stations and stops such as retail where applicable.
- Promote accessibility and meet applicable ADA (Americans with Disabilities Act) standards.
- Promote a sense of security through use of Crime Prevention Through Environmental Design (CPTED) principles including natural surveillance, territorial reinforcement, natural access control, target hardening, hierarchy of space, clear and open sightlines, clear circulation and pathways, support of activities, and lighting design.
- Incorporate I-405 Urban Design Guidelines (UDG) to those elements covered in the UDG. All other items should be reviewed with the I-405 Design Team.

6.4.3 PROTOTYPE STOP

Exhibits 6-9 and 6-10 present a typical BRT stop and shelter that would be located along the arterial portions of the BRT corridor. Per discussions with local transit agencies and cities, stops are curbside and do not include pullouts to maximize operational efficiency.

Stop design principles include:

- Provide patrons with comfort and protection from weather conditions.
- Provide identity within the BRT System.
- Provide a feeling of security and openness, clarity of orientation, spatial comfort and security. CPTED principals should be applied to shelter design.
- Provide adequate lighting - provide for both natural day lighting and adequate illumination levels to maintain level of security during non' daylight hours
- Promote accessibility and meet applicable ADA (Americans with Disabilities Act) standards.
- Integrate technology and fare control systems into shelter design.
- Standard materials and construction practices should be implemented for a common look.
- Use interchangeable shelter components such as glass sizes, lighting, seating, trash containers, windscreens and signage.
- Components and structural elements should be easily transportable to and from shelter sites.
- All materials should be durable to minimize maintenance and life cycle costs.
- Promote local themes and public art as well as provide for advertising and graphics.

The stop area includes the following features:

- Curb length for bus loading/unloading should be at least 70 feet to accommodate a 60 ft. articulated bus.
- Platform widths are at least 12 feet to accommodate a 6 - 8 ft. wide shelter.
- Bollards are located at the nose of the stop for safety and for pedestrian guidance.
- Landscaping and ornamental street lighting are included to enhance the pedestrian look of the stops where appropriate.
- Pedestrian signals are included as required for crossing.
- Tactile warning strips are included along the edges of the platform for the visually impaired.

Passenger boarding volumes will dictate shelter sizes. For simplicity of design, construction and maintainability it is proposed that the shelters be designed in a modular fashion which can easily combine to create the required shelter size and accommodate structural elements.

6.4.4 PROTOTYPE TRANSIT CENTER AND PARK-AND-RIDE

Exhibits 6-11 and 6-12 present a prototypical BRT station and park-and-ride that incorporates a transit center and parking structure. In addition to the stop components, it includes the following features:

- Vanpool and carpool parking areas (part of the park-and-ride)
- Kiss-and-ride drop off area with easy entry and exit (part of the park-and-ride)
- A pedestrian crossing with pedestrian activated signals
- Local bus stops and BRT stops with distinct shelters for easy way finding
- Potentially retail spaces near the pedestrian traffic areas (would depend on site)

6.4.5 PROTOTYPE INLINE STATION AND PARK-AND-RIDE

Exhibits 6-13 through 6-16 present a prototypical inline BRT station and surface park-and-ride facility based on a site concept developed for Newport Hills. In addition to the general stop components, the station includes the following features:

- Common center loading platform
- Features to minimize traffic noise at the platform from the highway
- Landscaped areas for visual buffer zone between platform and highway
- Vanpool and carpool parking areas (part of the park-and-ride)
- Kiss-and-ride drop off area with easy entry and exit (part of the park-and-ride)
- A pedestrian bridge to access the in line station platform with elevators and stairs

Exhibit 6.9: Conceptual BRT Stop

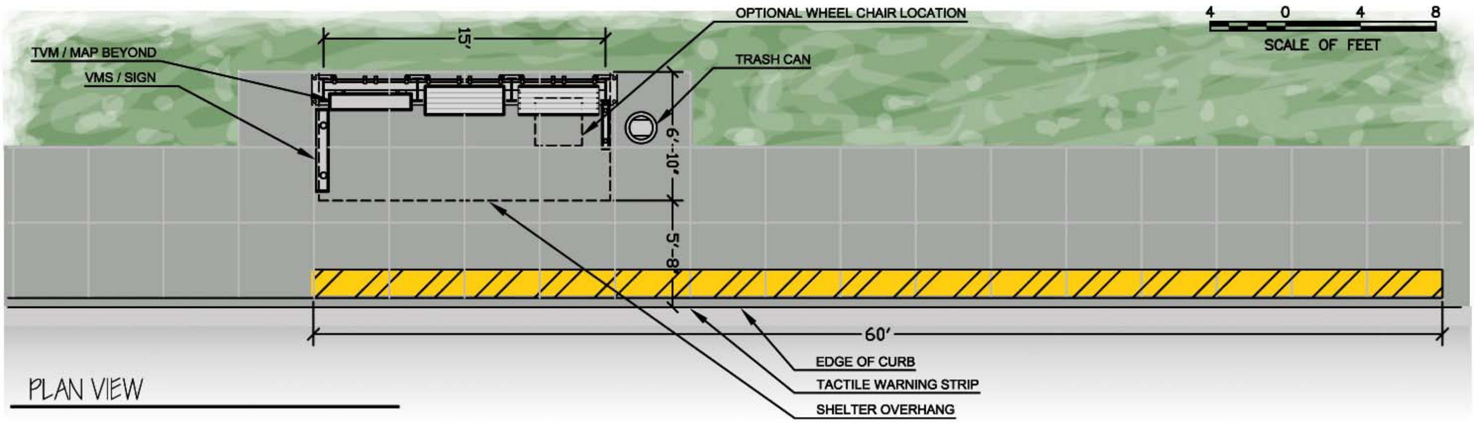


Exhibit 6.10: Conceptual BRT Shelter

Exhibit 6.11: Conceptual Transit Center and Park-and-Ride – Plan View

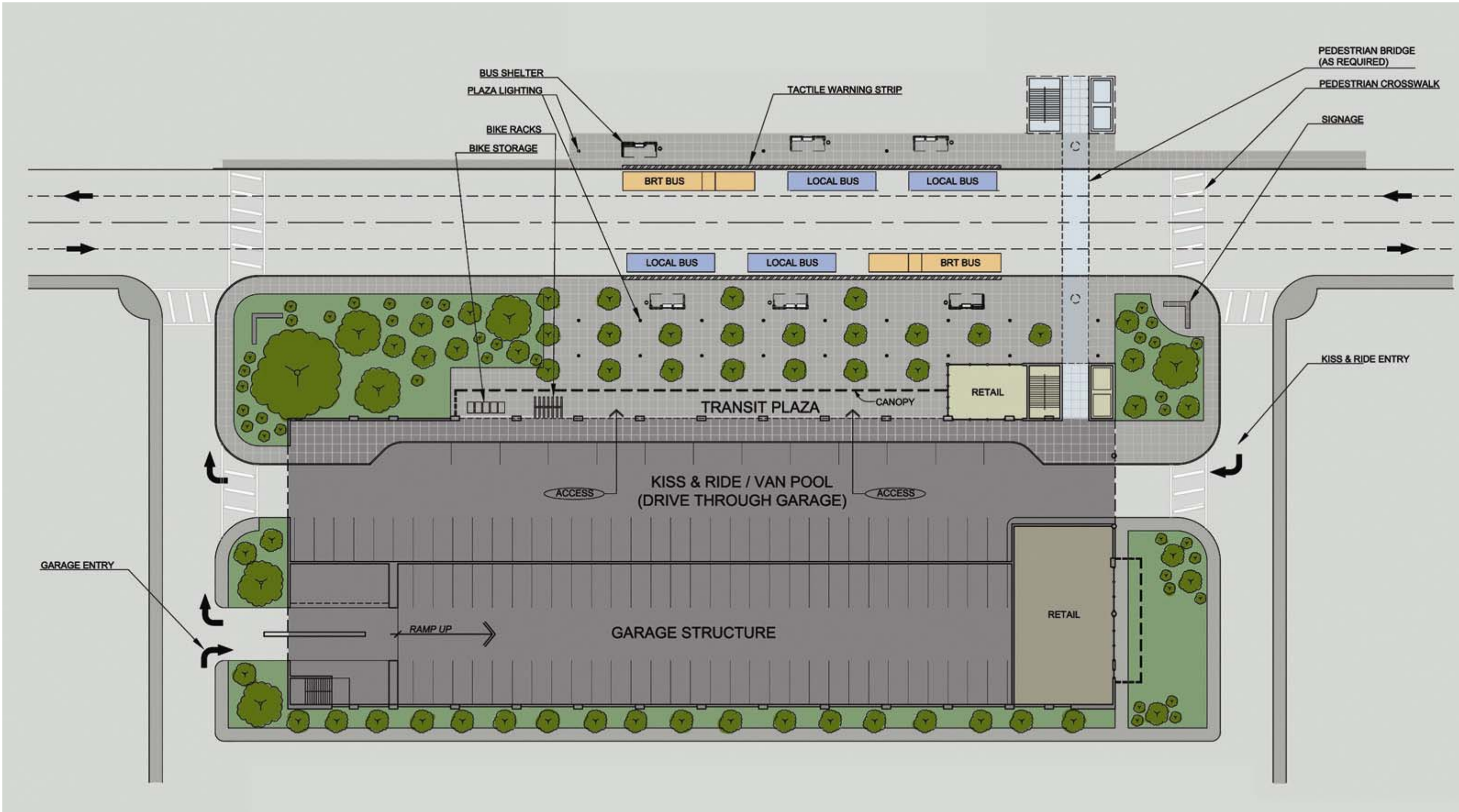


Exhibit 6.12: Conceptual Transit Center and Park-and-Ride – Perspective

Exhibit 6.13: Conceptual Inline Station and Park-and-Ride – Plan View

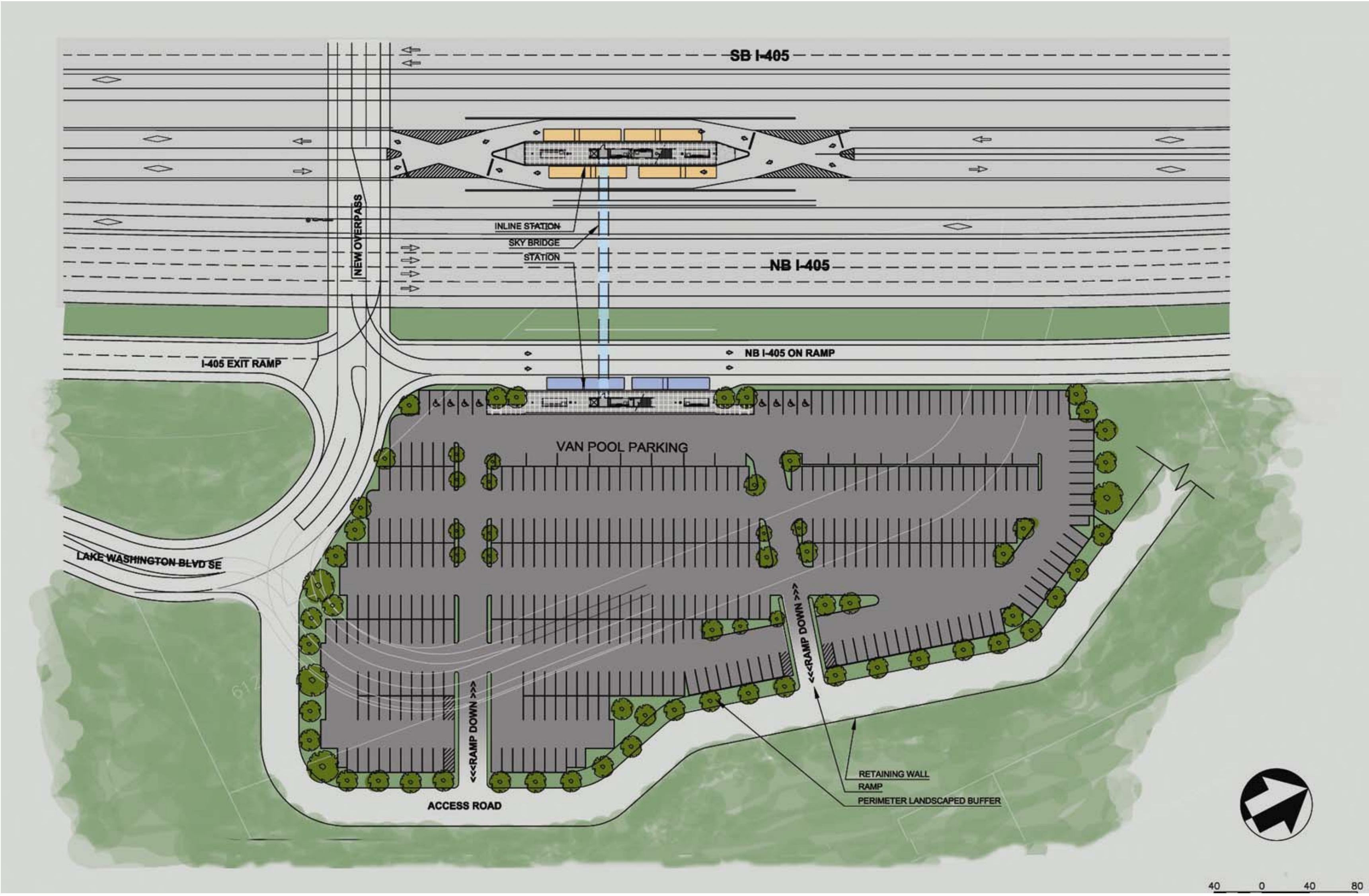


Exhibit 6.14: Conceptual Inline Station and Park-and-Ride – Platform Details

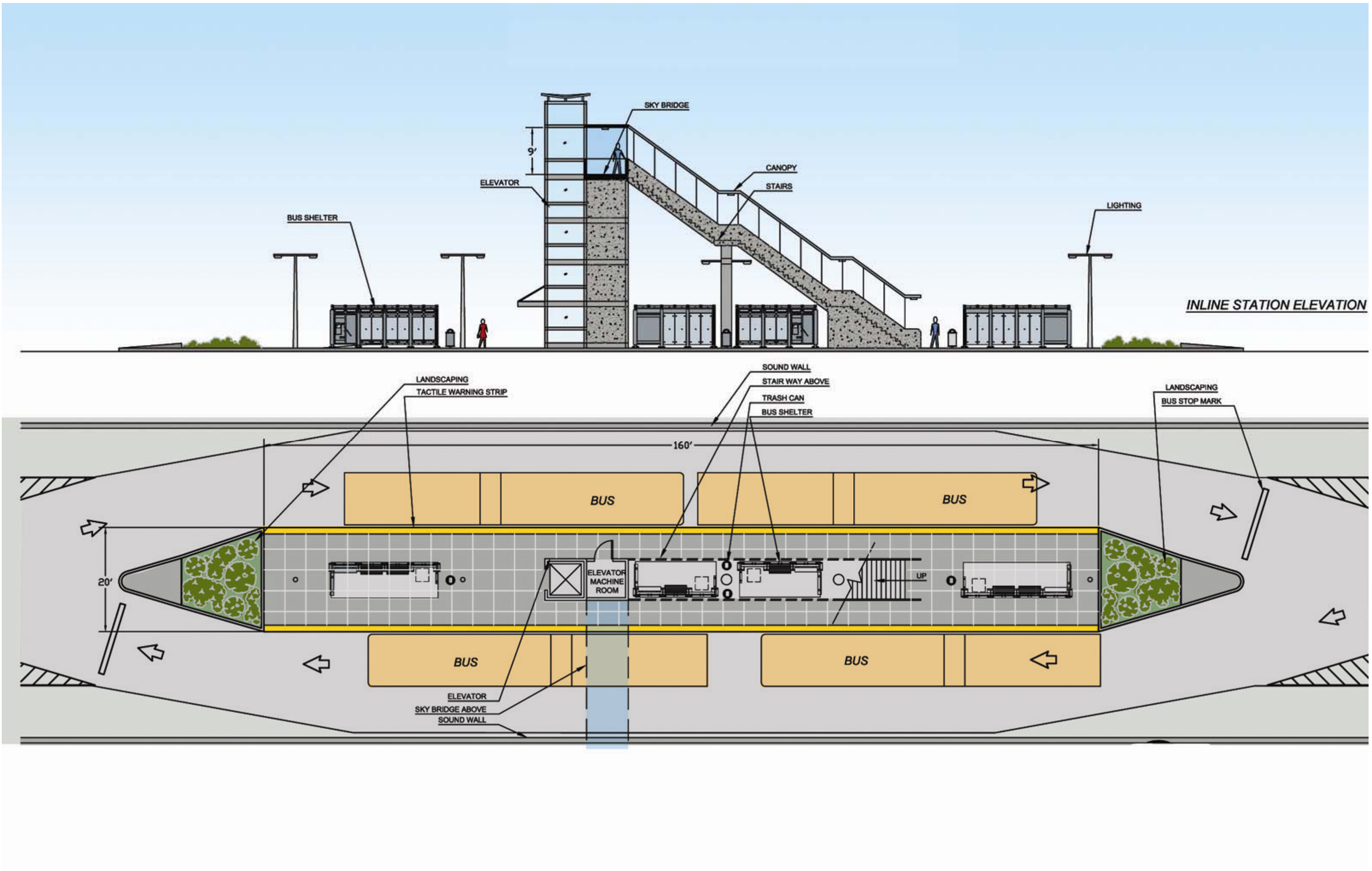


Exhibit 6.15: Conceptual Inline Station and Park-and-Ride – Perspective

Exhibit 6.16: Conceptual Inline Station and Park-and-Ride – Platform Perspective

7. PLANNING LEVEL CAPITAL COST ESTIMATES

This section provides a summary of planning-level rough order of magnitude (ROM) unit costs, and a summary ROM estimate for the I-405 South Corridor BRT system components. BRT components and potential improvement projects identified in the previous section have been classified into three categories including:

- **Roadway Components** – This category includes roadway and technology improvement projects along the route to support preferential treatment of transit.
- **BRT Vehicles and Technology** – This category includes transit vehicles and technologies that can contribute to increased service efficiency and improved passenger experience.
- **Stop and Stations** – This category includes three conceptual stop configurations including: curbside stop, transit center and park-and-ride garage, and inline freeway station and surface park-and-ride lot.

7.1 ROM Unit Costs

The ROM's calculated in this section provide a high level analysis based on potential improvements identified in this document. ROM estimates for the three categories of potential improvement projects listed above are presented in Exhibit 7-1. These figures have been calculated in 2005 dollars.

Exhibit 7-1: ROM Unit Costs

	Unit	Est. Cost
Roadway Components		
Transit Signal Priority	per intersection	$90,000
Direct Access Ramps, Freeway HOV, BAT and Queue Jump Lanes	per site	*Not Costed (1)*
BRT Vehicles and Technology		
60' Articulated Bus	per bus	$500,000 *(2)*
Automatic Vehicle Location, Automatic Stop Annunciation, Automatic Passenger Counters, and Precision Docking	per bus	$30,000
Stop and Stations		
Curbside Stop	per stop	$160,000
Transit Center & Park-and-Ride Garage	per center	$36,950,000 *(3)*
Inline Station & Surface Park-and-Ride Lot	per station	$27,600,000 *(4)*

(1) Lane improvements have not been costed as estimates vary significantly depending on the road geometry at each location.

(2) The coaches depend upon the operating agency. For costing purposes, 60' coaches have been assumed at a unit price of $500,000/ bus. 40' buses could potentially meet service needs (assuming standing passengers during the peak hour) at a cost of approximately $400,000 per bus.

(3) This figure includes $24,100,000 for the cost of the Transit Center and a unit price of $25,000/space for the parking garage, exclusive of land costs.

(4) The inline station accounts for $21,000,000 with an additional $17,500/space cost for the surface park-and-ride lot, exclusive of land costs.

Cost data and information was gathered from previous BRT studies such as Community Transits' SR-99 BRT Corridor Study. In addition to previous studies, Sound Transit (ST) provided several engineer's estimates and bid results for future and current capital projects.

7.2 Summary ROM Estimate

Based on the unit cost ROM's developed in the previous section, a total project ROM has been developed. This ROM, shown in Exhibit 7-2, is generated from the alignment and service requirements modeling results.

Exhibit 7.2: Summary I-405 BRT South Corridor ROM Estimate

	Number	Cost
Roadway Components		
Transit Signal Priority	14	$1,260,000 *(1)*
Direct Access Ramps, Freeway HOV, BAT and Queue Jump Lanes	-	*Not Costed (2)*
BRT Vehicles and Technology		
60' Articulated Bus	42	$21,000,000
Automatic Vehicle Location, Automatic Stop Annunciation, Automatic Passenger Counters, and Precision Docking	42	$1,260,000
Stop and Stations		
Curbside Stop	6	$960,000
Transit Center & Park-and-Ride Garage	1	$36,950,000
Inline Station & Park-and-Ride Surface Lot	1	$27,600,000
I-405 BRT South Corridor System Total		**$89,030,000**

(1) Transit Signal Priority locations will need to be confirmed as the alignment is determined in the future. These are estimates only.

(2) Lane improvements have not been costed as estimates vary significantly depending on the road geometry at each location. The N 8th St. direct access project is included in current Sound Transit projects and budgeting.

These ROM's include design fees but do not include any costs for: operations and maintenance, central system components, or land/property acquisition. Also, it is understood that no specific funding has been identified at this time for these improvements.

8. FINDINGS AND NEXT STEPS

The purpose of this report was to assess the potential feasibility of a Bus Rapid Transit service along the southern portion of the I-405 corridor (from Bellevue to Sea-Tac International Airport), and identify potential infrastructure improvements to support such service.

The study included two primary components:

- A modeling analysis that projected ridership based on a potential service concept.
- Identification of potential infrastructure improvement projects in the corridor based on an illustrative, but not necessarily recommended, alignment.

8.1 Key Findings

The modeling analysis showed that with an overlay service concept, reasonable peak-hour demands could be generated (i.e. coaches filled to seated capacity) assuming an average 5-7 minute headway in the core section of the corridor between Brickyard and downtown Renton. Off-peak demand however is projected to be relatively low. The analysis also showed that a single line BRT route serving the same activity centers would have only about 65% of the ridership of the overlay concept.

The modeling analysis assumed a 3+ HOV lane policy along I-405. If the current 2+ policy were maintained, it is estimated that BRT ridership would be reduced by about 15% because of increased congestion and longer travel times.

The primary ridership generators in the southern portion of the corridor (in order of decreasing contribution) are Bellevue (which accounts for about 25% of all boardings), Sea-Tac International Airport, downtown Renton, and north Renton (based on projected redevelopment in that area). Ridership projections for Tukwila are significantly lower than these other activity centers.

Key infrastructure-related findings for the southern corridor, from north to south, are as follows:

1. BRT, supported by an in-line station and some level of expanded park and ride to accommodate projected future demands, would best serve the Newport Hills park-and-ride lot. The conceptual design for a prototypical in-line station and park-and-ride could be considered for Newport Hills.
2. Whether or not BRT service and infrastructure should serve the Port Quendall area depends upon how that site is developed in the future. Given current economic conditions, it is expected such development will occur closer to 2030.
3. Planned redevelopment of the north Renton area suggests that this area will become a key activity center and should be served by any BRT service. Supporting infrastructure that required includes I-405 direct access ramps at North 8th Street in Renton, and a new transit center and park-and-ride in the north Renton area. A prototypical transit center and park-and-ride is presented that could be considered as a concept for this area.
4. For 2014 (Implementation Plan), it was assumed that any connection between south Renton and Tukwila would be along arterials. The network infrastructure for this is not in place and would be driven by broader traffic and transportation needs in the area rather than BRT requirements as ridership projections for Tukwila are low.
5. For 2030 (Master Plan) direct access ramps in south Renton and Tukwila could be used by an I-405 BRT service, but that service alone would not justify their construction. Alternatively, any routing identified for 2014 could continue to be used.

6. If BRT is routed along arterials, consideration should be given to implementing transit preferential treatments including transit signal priority, queue jump lanes, and business, access and transit (BAT) lanes on those streets. Support of such improvements by the local jurisdiction should be a criterion for deciding if and how to serve an activity center.

Planning-level capital cost estimates were generated for transit signal priority, BRT vehicles and technology, and stop and station infrastructure. Total cost based on these assumptions is approximately $89 million, of which approximately $37 million is estimated for a new transit center and park-and-ride in north Renton, and $28 million for an inline station in Newport Hills. Cost estimates do not include land acquisition for stops, stations and road improvement projects as these are site specific. No specific capital funding has been identified for these elements.

8.2 Next Steps

Findings from this study are primarily intended as input to future planning and design work. In this context, potential next steps include:

1. Review major findings from this study with stakeholders including the I-405 Project Team, City of Renton, City of Tukwila, and the public to help ensure that findings are considered in project and local planning.

2. Consider findings of this study by the I-405 Corridor Project as decisions are made with respect to improvements to the Newport Hills park-and-ride, construction of direct access ramps at North 8th in Renton, and construction of direct access ramps in south Renton and Tukwila.

3. Consider findings of this study by Sound Transit and King County Metro in regional transit planning initiatives.

4. Initiate a similar analysis of the northern part of the I-405 corridor to present a complete picture of potential BRT infrastructure requirements for the entire corridor.