SOUND TRANSIT

HCT Planning

Sound Transit Long-Range Plan Update

Issue Paper N.2.S.2: I-5 Northgate to Everett Mode Analysis

Supplement to Issue Paper N.2: I-5 Corridor Northgate to Everett HCT Assessment

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Foreword

This issue paper is part of a series of reports designed to inform the Sound Transit Board in its decision-making on the Regional Transit Long-Range Plan update for the Sound Transit service area. Each issue paper provides information about a specific element or area of the Long-Range Plan and potential options. These reports focus on issues such as costs, ridership, engineering feasibility and operations.

The environmental impacts of the updated Long-Range Plan and Options, as well as potential mitigation measures, are examined in the Draft Supplemental EIS for the Regional Transit Long-Range Plan (December 2004). The Draft SEIS supplements the 1993 EIS prepared on the Regional Transit System Plan, and it generally updates that information and analysis through the year 2030. Public and agency comments on the 2004 Draft Supplemental EIS have been received and will be responded to in a final SEIS to be issued in June 2005.

The Sound Transit Board anticipates identifying a draft updated Long-Range Plan in the spring of 2005. There will be an opportunity for public review and comment on the draft Plan. The Board will adopt a final updated Long-Range Plan after public comments are received on the draft plan and the final SEIS is issued.

References in these reports to Sound Transit's existing Long-Range Plan are to the 1996 Regional Transit Long-Range Vision, which functions as the agency's Long-Range Plan. Discussion of the updated Long-Range Plan refers to the Plan being developed by Sound Transit over the coming months.

The following issue papers are being prepared:

East Corridor

E.1 – I-90 Corridor / East King County High Capacity Transit Analysis

North Corridor

N.1 – BRT in SR 99 Corridor

N.2 – I-5 Corridor Northgate to Everett HCT Assessment

N.2.S – I-5 Corridor Northgate to Everett HCT Assessment Supplement—Light Rail on SR 99

N.2.S.2 – I-5 Corridor Northgate to Everett HCT Assessment Supplement—Mode Analysis

N.3 – Seattle Streetcar Options

N.4 – SR 522 Corridor HCT Assessment

N.5 – Convertibility of BRT to Light Rail

South Corridor

S.1 – Tacoma Link Integration with Central Link

S.2 – Potential Rail Extensions to Frederickson and Orting

S.3 – HCT System Development Issues in the South Corridor

S.4 – Potential Tacoma Link Extension – West

S.5 – Rail between Burien and Renton

S.6 – Potential Tacoma Link Extension – East

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1. Introduction and Summary

1.1. Purposes of this Paper

In 1996, area voters approved light rail as the high capacity transit (HCT) mode between Sea Tac and Northgate, and the Long-Range Plan adopted by the Sound Transit board of directors at that time designated the corridor between Northgate and Everett for a future light rail extension. However, some questions have been raised about other HCT modes for this segment. This study compares the tradeoffs of choosing among two possible long-term HCT choices between Northgate and Everett, designed to serve the same markets and provide similar accessibility:

- Extending light rail operating primarily in exclusive rights-of-way; and
- HOV lane-based bus rapid transit (HOV/BRT) operating in shared traffic, with a transfer to light rail for trips continuing south of Northgate.

Because the performance of HOV/BRT can be influenced by other traffic, it is examined under two different future operating conditions: as fast as today ("Faster" BRT) and 25 percent slower than today ("Slower" BRT). Comparisons are drawn between these scenarios based on forecast 2030 travel times and ridership potential, capital and operating costs, and system integration and reliability factors.

1.2. Key Findings

Table 1 summarizes the key findings of this analysis. Interpretation of the results follows the table. In short, HOV/BRT would likely be cheaper to construct and operate and could be implemented more incrementally, but light rail would carry more riders and provide faster travel times and better reliability in the face of growing travel demand and freeway congestion. HOV/BRT performance over time would rely on actions to maintain the speed and reliability of the HOV system, while light rail operating performance would be relatively constant over time because of its separation from other traffic.

Table 1. Summary Findings

	Northgate – Everett HCT Scenarios		
	Light Rail	*Faster HOV/BRT**	*Slower HOV/BRT***
2030 Travel Times (mins)			
Everett – Northgate	38	37 - 55	48 - 66
Everett – U District	45	49 - 67	60 - 78
Everett – Seattle	53	57 - 75	68 - 86
Lynnwood - Northgate	13	17 - 24	21 - 29
Lynnwood – U District	20	29 - 36	33 - 41
Lynnwood – Seattle	28	36 - 44	41 - 48
2030 Daily Rider Volume			
South of Lynnwood	50,000	43,000	36,000
South of 175th	66,000	57,000	48,000
Capital Costs (2005 $)			
Total	$3.3 - $4.2 B	$1.4 - $1.9 B	
Operating Costs (2005 $)			
Optimized Capacity***	$90 M / yr.	$61 M / yr.	$65 M / yr.
Equalized Capacity****	$90 M / yr.	$94 M / yr.	$105 M / yr.

* HOV lanes assumed to operate as fast as today on average; range reflects non-stop v. all-stop bus service
** HOV lanes assumed to operate 25percent slower than today on average; range reflects non-stop v. all-stop bus service
*** Light Rail and HOV/BRT capacity sized separately to meet estimated directional ridership demand for each
**** HOV/BRT capacity sized to match Light Rail

1.2.1. Travel Times

Transit travel times would generally be longer under the HOV/BRT Scenario because of the transfer to light rail at Northgate. This is true if the HOV lanes operate as well as today and is further intensified if they don't, and is true of both all-stop and non-stop bus services along the corridor. Transfer times between bus/BRT and light rail at Northgate would be reduced by adding direct HOV lane access between Northgate and I-5 and significant bus circulation and passenger facility improvements at the transit center, but overall travel times would still be greater for HOV/BRT because of the necessary transfer. Travel times would also be longer under the HOV/BRT Scenario because the freeway HOV lanes north of Northgate, even operating in the future as well as today, would not provide as fast a trip as light rail.

Because the HOV lanes in which HOV/BRT service would operate are shared with other vehicles and are affected by traffic conditions in adjacent general purpose lanes, maintaining HOV lane travel times is dependent on operational management actions by the Washington State Department of Transportation (WSDOT), the owner of the freeway facility. In contrast, travel times in fully-exclusive light rail rights-of-way would be essentially the same over time and would not be dependent on management actions of other parties.

1.2.2. Ridership

Ridership for the Light Rail Scenario would be higher than for the HOV/BRT Scenario, again because the latter requires transfers between bus/BRT and light rail at Northgate, lengthening travel times. At Lynnwood, light rail would attract 16 percent more riders, and 19 percent more at 175th Street in Shoreline. If the HOV lanes were to operate 25 percent slower in the future ("slower" BRT), the differentials become even greater – over 38 percent more on rail than HOV/BRT at both Lynnwood and Shoreline.

1.2.3. Capital Costs

Capital costs for the HOV/BRT Scenario would be significantly lower than for the Light Rail Scenario, largely because the majority of the HOV/BRT running ways already exist in the form of the I-5 HOV lanes, while new running ways would have to be constructed for light rail. The combined costs of constructing the remaining HOV lane direct access and in-line station improvements, building bus stations and a larger Northgate bus-rail transfer facility, buying buses, and building adequate bus maintenance capacity would still be cheaper than building additional light rail tracks, stations, power systems and maintenance facilities, and buying trains. Keeping the HOV lanes operating as well as today adds costs to the HOV/BRT Scenario. This analysis assumes widening the lanes and shoulders to current highway standards for the most problematic section along I-5 between Northgate and NE 175th Street. This could be achieved at a relatively modest cost. Other operational treatments available might be more effective, but may come at a higher cost.

1.2.4. Operating Costs

If the goal is to optimize service levels to match forecast demand, total annual operating costs for the HOV/BRT Scenario -- including both bus/BRT service and increased light rail service south of Northgate to accommodate transfer demand -- would be substantially less than for the Light Rail Scenario. This is because bus service can be more easily tailored than rail service to directional demand levels, and demand forecasts indicate substantially less service would be needed in the off-peak direction. However, this service design would result in less off-peak direction service and accessibility than in the Light Rail scenario.

In contrast, the Light Rail Scenario presumes equal service levels in both directions at all times, a requirement of making sure trains are available in the right places at the right times to meet peak direction demand. Though this light rail service design is more expensive to operate because of added vehicle mileage, it may better support land use densification and economic development activities along outlying portions of the line and attract additional riders to the system by providing a frequent, reliable option for travelers in the off-peak direction.

If the goal were instead to provide the same level of land use and economic development support in both scenarios by providing equal service capacity and accessibility in both directions, HOV/BRT operating costs would be higher than light rail. This is due to a substantial increase in the bus vehicle hours and miles necessary to provide comparable service levels to light rail. Capital costs for bus fleet and maintenance capacity would also rise if this were the goal.

1.3. Other Considerations

In addition to the quantifiable considerations of travel time, ridership and cost, there are other factors that should be taken into account when comparing and weighing the merits of alternative long term transit modes in this corridor.

1.3.1. Service Reliability

Though not quantifiable through the travel model or reflected in the ridership forecasts, the Light Rail Scenario would provide substantially more reliable HCT service than the HOV/BRT Scenario. This is because light rail would operate entirely in rights-of-way protected from other traffic. HOV/BRT would operate in shared HOV lanes that are subject to interruptions due to traffic congestion in the HOV lanes or adjacent general purpose lanes, and traffic accidents. At some locations, HOV/BRT services would need to leave the HOV system to access local streets and transit facilities off of the HOV running way, subjecting them to further traffic congestion and delay. The day-to-day variations in the level of impact of these factors make HOV/BRT less reliable, less predictable and ultimately less attractive to riders. The same operations management issues described under the section entitled “Travel Times” also apply to maintaining service reliability.

1.3.2. System Integration

Providing continuous service along the corridor with one mode reduces the number of transfers in the system, and may consequently reduce the size and complexity of facilities required to accommodate those transfers. In the HOV/BRT Scenario, construction of a larger bus terminal/layover facility to accommodate peak period bus transfers to/from light rail could require a substantial amount of space at the Northgate station. The facility design concept developed for this analysis would not require significant changes to the proposed light rail station, but might require significant changes to the current design concepts for local bus transfer, park and ride expansion, and transit-oriented development at or near the station.

1.3.3. Implementation

The HOV/BRT Scenario would provide more implementation flexibility because facilities could be constructed and service added incrementally along the entire corridor. In contrast, light rail would be implemented in a series of phases, each of which require relatively full completion of all capital infrastructure as each extension of the system is added. Incremental implementation of either scenario would be reflected in lower ridership performance until all facilities and services are operating. On the other hand, performance of the HOV/BRT system would be highly dependent on the actions of other parties to keep the running ways operating well, while performance of the Light Rail scenario would be less dependent on others because the running ways would be managed only for light rail.

2. Study Purpose & Approach

Sound Transit has undertaken this issue paper to respond to questions raised by the Expert Review Panel at their April 4-5, 2005 meeting. The Panel asked two basic questions based on Sound Transit's presentation of the Long-Range Plan issue paper entitled *I-5 Corridor Northgate to Everett High Capacity Transit Assessment*, which examined light rail alignment choices north of Northgate, but did not address alternative HCT technology choices:

- Have mode choices been reviewed since the 1990s? and
- Why is bus rapid transit not being considered?

The Panel suggested that additional information about HCT mode choices north of Northgate might be useful for informing the Sound Transit Board's thinking as it updates the Long Range Plan. This study is intended to provide that information by comparing the long-range tradeoffs of light rail and two HOV lane-based bus rapid transit (HOV/BRT) scenarios in the I-5 corridor between Northgate and Everett. Comparisons are drawn between these scenarios based on forecast 2030 travel times and ridership potential, capital and operating costs, and system integration and reliability factors.

With the completion of this issue paper, Sound Transit has now examined a broad range of HCT mode and alignment issues in the major north-south travel corridors north of Northgate. These include:

- Light rail along I-5 from Northgate to Everett (Issue Paper N.2 and this paper)
- Light rail deviations to Paine Field and portions of SR 99 and 15th Ave. NE (Issue Paper N.2)
- Light rail along SR 99 from Northgate to Everett (Issue Paper N.2.S)
- HOV/BRT along I-5 from Northgate to Everett (this paper)
- Arterial BRT along SR-99 from downtown Seattle to Everett (Issue Paper N.1)

3. Current Transit Along I-5 North

Transit service along the I-5 North corridor today includes all-day two-way express bus services between downtown Seattle, the University District, Northgate, Lynnwood and Everett as well as a number of peak-period, peak-direction commuter express bus routes between these and intermediate communities focused on downtown Seattle and the University District. Many of the services are designed around park and ride lots along or just off of the I-5 corridor. Services are operated by King County Metro (in King County) and Community Transit (CT and Sound Transit services between Snohomish County and King County). In 2003, Sound Transit ST Express bus services served an average of almost 3,000 daily boardings along I-5 between Everett and Seattle[1], and Community Transit's peak period, peak direction commuter services along I-5 served an average of over 7,000 daily boardings[2].

Sound Transit has spent the last eight years building and delivering HOV/BRT facilities and services along the I-5 North corridor. These include five ST Express regional bus routes connecting Everett and Lynnwood with Seattle and Bellevue, new HOV lane direct access ramps at the Lynnwood and Ash Way park and ride lots, new in-line transit stations in south Everett and Mountlake Terrace, and additional park and ride capacity at Lynnwood, Ash Way, south Everett and Everett Station.

All of these services use the bi-directional HOV lanes north of Northgate and/or I-5 reversible express lanes between downtown Seattle and Northgate for a significant portion of their trips. These lanes currently have a minimum occupancy requirement of two or more persons per vehicle. According to the WSDOT, some stretches of the I-5 HOV lanes do not operate to department standard today[3], primarily due to steep grades or merge points. The standard is that traffic in the HOV lanes should operate at least 45 miles per hour 90 percent of the time during the peak hour, measured over a consecutive six month period[4]. Some services originating in Snohomish County have or soon will have transit/HOV direct access connections in to and out of the inside HOV lanes, which will reduce bus travel times and improve reliability. In combination, these services, HOV lanes, access facilities and commuter parking comprise an HOV-lane based BRT system.

[1] Sound Transit, *2003 4th Quarter Ridership Report*, January 2004
[2] Community Transit, *2003 Year End Performance Report*, January 2004
[3] WSDOT, *Washington State Freeway HOV System brochure*, March 2005
[4] WSDOT, Washington State Freeway System HOV Policy, November 1992

4. Mode Scenarios

In 1996, area voters approved light rail as the HCT mode between downtown Seattle and Northgate, and the Long-Range Plan adopted by the Sound Transit board of directors at that time designated the corridor between Northgate and Everett for a future light rail extension. The Puget Sound Regional Council's recent re-assessment of potential HCT technologies in the region's major travel corridors[5] and its companion American Public Transportation Association (APTA) peer review concluded that the "North Corridor has a tremendous capacity for development" and "presents opportunities for the application of several technologies."[6] While there are a number of potential transit modal technology choices and combinations that could be considered north of Northgate, this study compares only the presumed technology in Sound Transit's Long-Range Plan (extending light rail) and the technology of most apparent interest to the Expert Review Panel (bus rapid transit).

Neither monorail nor busway-based BRT are examined here as HCT technology choices. The Light Rail and HOV/BRT scenarios likely capture the range of tradeoffs that these other modal technologies might present. Monorail is a possible mode choice, particularly if the Seattle Monorail Project were ever to extend its planned Green Line from Ballard to Northgate, but it would likely have transfer and ridership impacts similar to those of the HOV/BRT Scenario examined here. Busway BRT, utilizing fully-exclusive bus running ways, might provide similar operating performance as light rail or monorail due to its exclusivity, but capital costs are likely to similar as well. A Busway BRT scenario would also likely have transfer and ridership impacts similar to the HOV/BRT Scenario.

This analysis does not revisit HCT options for the I-5 North corridor between Northgate and downtown Seattle. Regional decisions made up to this point, including voter approval of Sound Transit's first phase of investments (Sound Move), have repeatedly affirmed that light rail operating in fully exclusive rights-of-way is the mode of choice for that segment. Revisiting those decisions now would beg better, feasible solutions to issues such as adequate transit capacity, speed and reliability, and market access in this segment, and in the downtown Seattle and University District urban centers, that light rail was chosen to address. Consequently, light rail is the presumed high capacity transit mode between Northgate, the University District and downtown Seattle in both scenarios examined in this study. The same access and service characteristics in this segment are assumed for both mode scenarios north of Northgate.

4.1. Light Rail

This scenario would extend light rail along I-5 between Northgate Station and Everett Station, running generally along I-5 in exclusive running ways protected from other traffic. The line would be constructed at-grade as much as possible to minimize capital costs, but would include grade-separation where necessary to clear existing structures and

[5] Puget Sound Regional Council, *Central Puget Sound Region High Capacity Transit Corridor Assessment*, August 2004
[6] American Public Transportation Association, *High Capacity Transit Corridor Assessment for Puget Sound Regional Council*, May 2004

address right-of-way constraints. Bus services that replicate the service access, level and coverage of light rail along I-5 would be eliminated or truncated at the light rail station nearest the route origin at all times. Local bus services connecting to the stations would be improved with resources redeployed from eliminated or truncated services, and possibly new operating funds from the local transit agencies. The general alignment and station locations are depicted in Figure 1. The assumed connecting transit service structure is shown in Figure 2.

4.2. HOV/BRT

There are many possible variations and approaches to defining a bus rapid transit scenario, but to provide the basis for an even comparison of mode alternatives that are designed to achieve the same transportation goals, the BRT service network in this analysis has been defined to replicate the system functionality of the trunk light rail line along I-5 in the Light Rail Scenario. This includes the current multi-operator HOV lane-reliant bus/BRT service structure along I-5 north of Northgate Station with service improvements to accommodate forecast demand, and the addition of an all-day, two-way trunk BRT route that would operate between Northgate and Everett Station. The HOV lanes provide semi-exclusive running ways shared with other high occupancy vehicles. Additional HOV lane direct access ramps and/or in-line stations would be built to provide comparable access at all of the locations where potential rail stations are assumed in the Light Rail Scenario. The general alignment, HOV access improvements and station locations are depicted in Figure 3.

To minimize transfer impacts during higher demand peak periods, peak direction commuter express bus services that duplicate the trunk route along I-5 would continue to operate as far south as Northgate during those periods. During lower-demand off-peak periods, I-5 bus services that replicate the service access, level and coverage of the I-5 trunk route would be eliminated or truncated at the I-5 BRT station nearest the route origin. Local bus services connecting to the stations would be improved with resources redeployed from eliminated or truncated services, and possibly new operating funds from the local transit agencies. A diagrammatic representation of the assumed peak period transit service structure is shown in Figure 4. Only connecting local services would operate during off-peak periods; no services to Northgate other than the I-5 BRT trunk route would operate during those times.

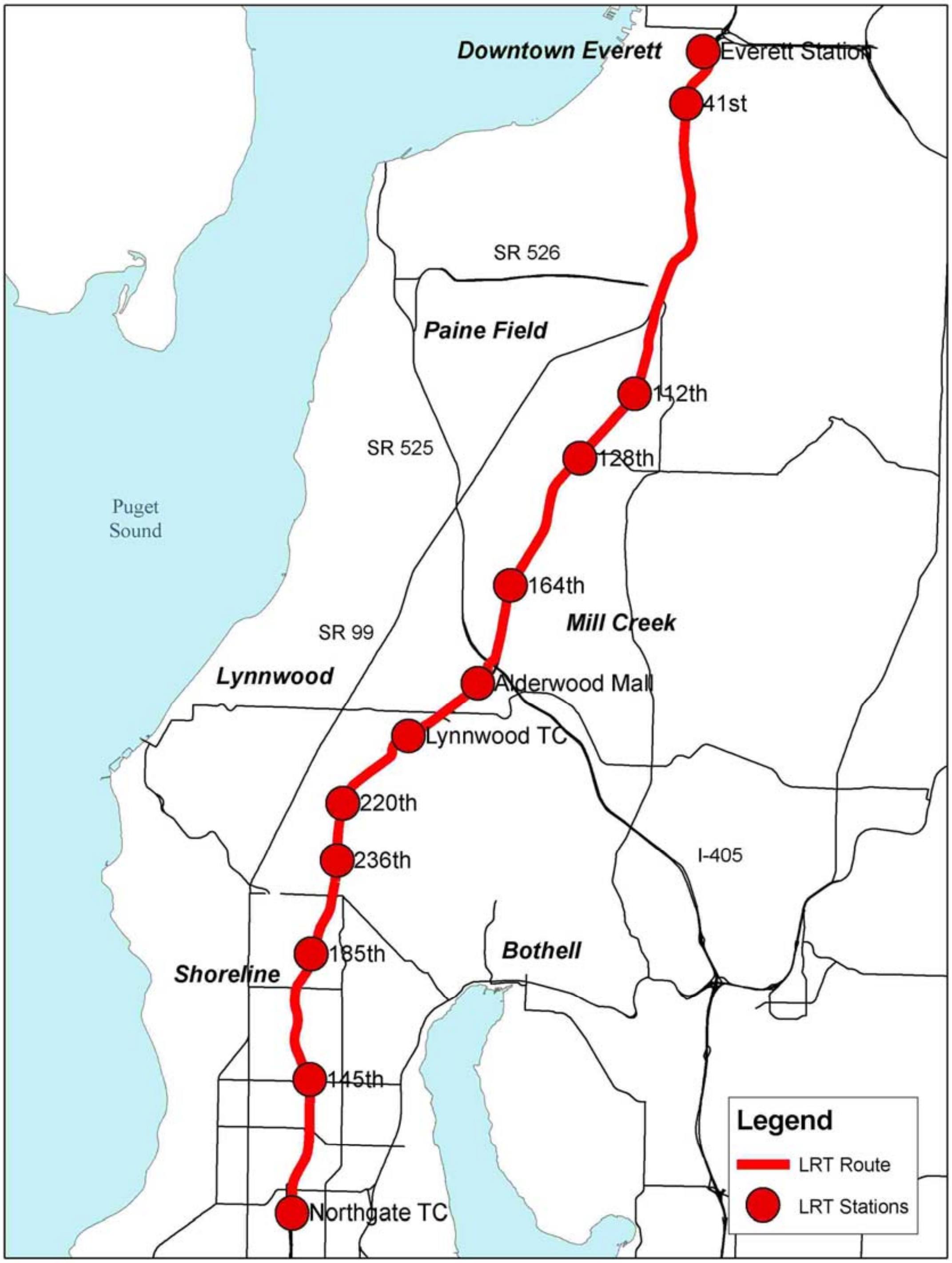

Figure 1. Light Rail Route & Stations

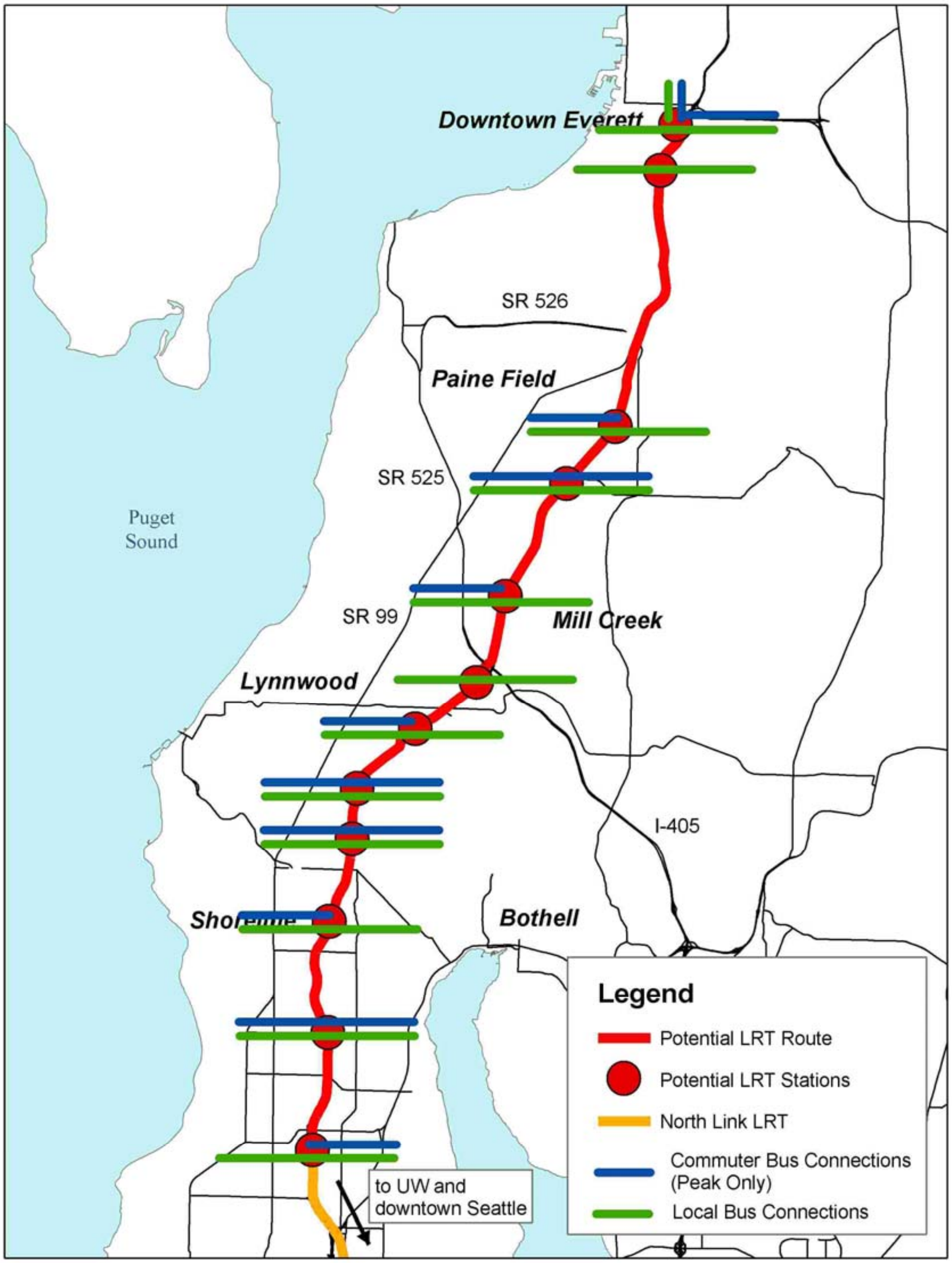

Figure 2. Light Rail A.M. Peak Period Service Structure

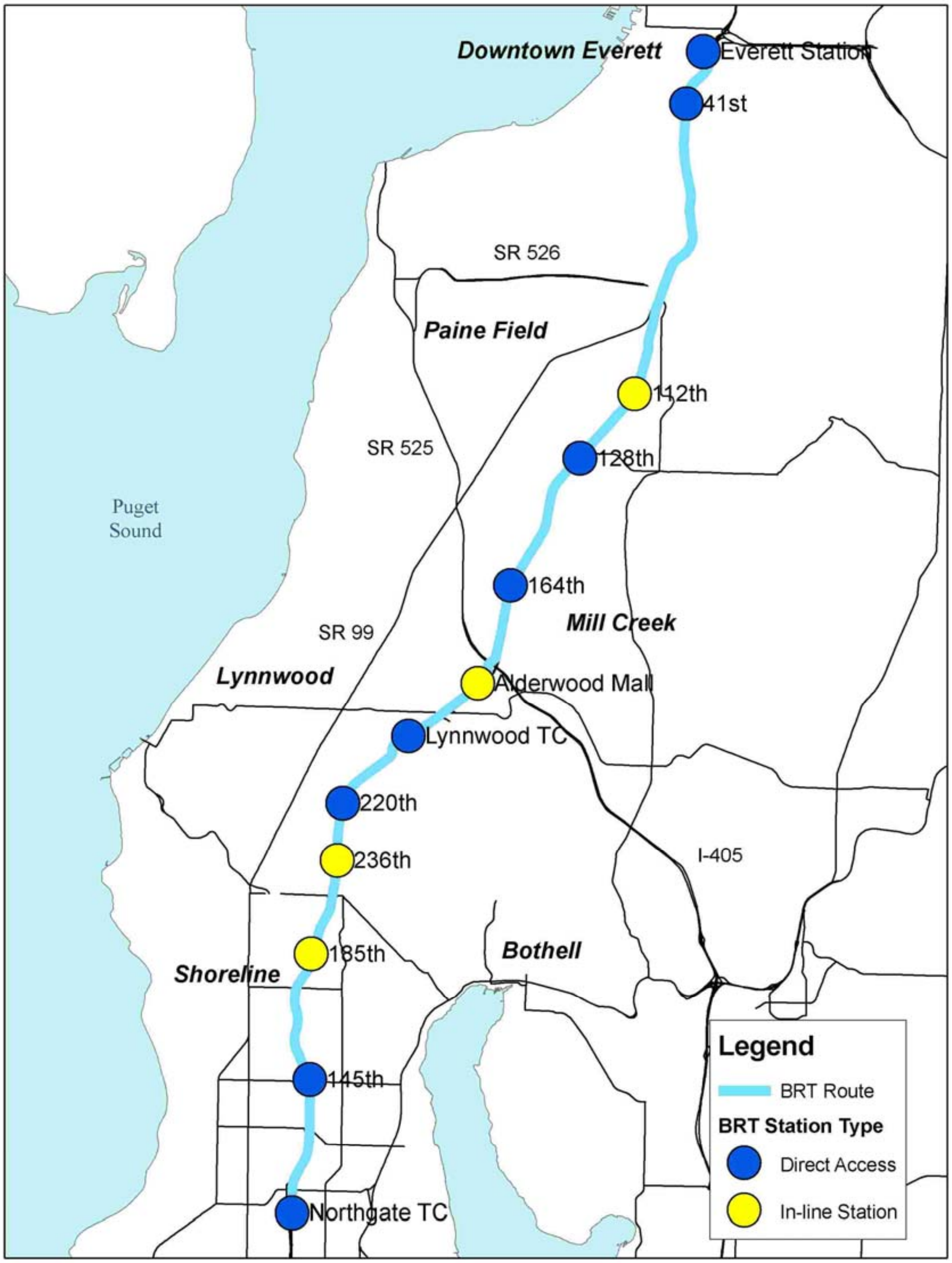

Figure 3. HOV/BRT Route, Stations & HOV Lane Access

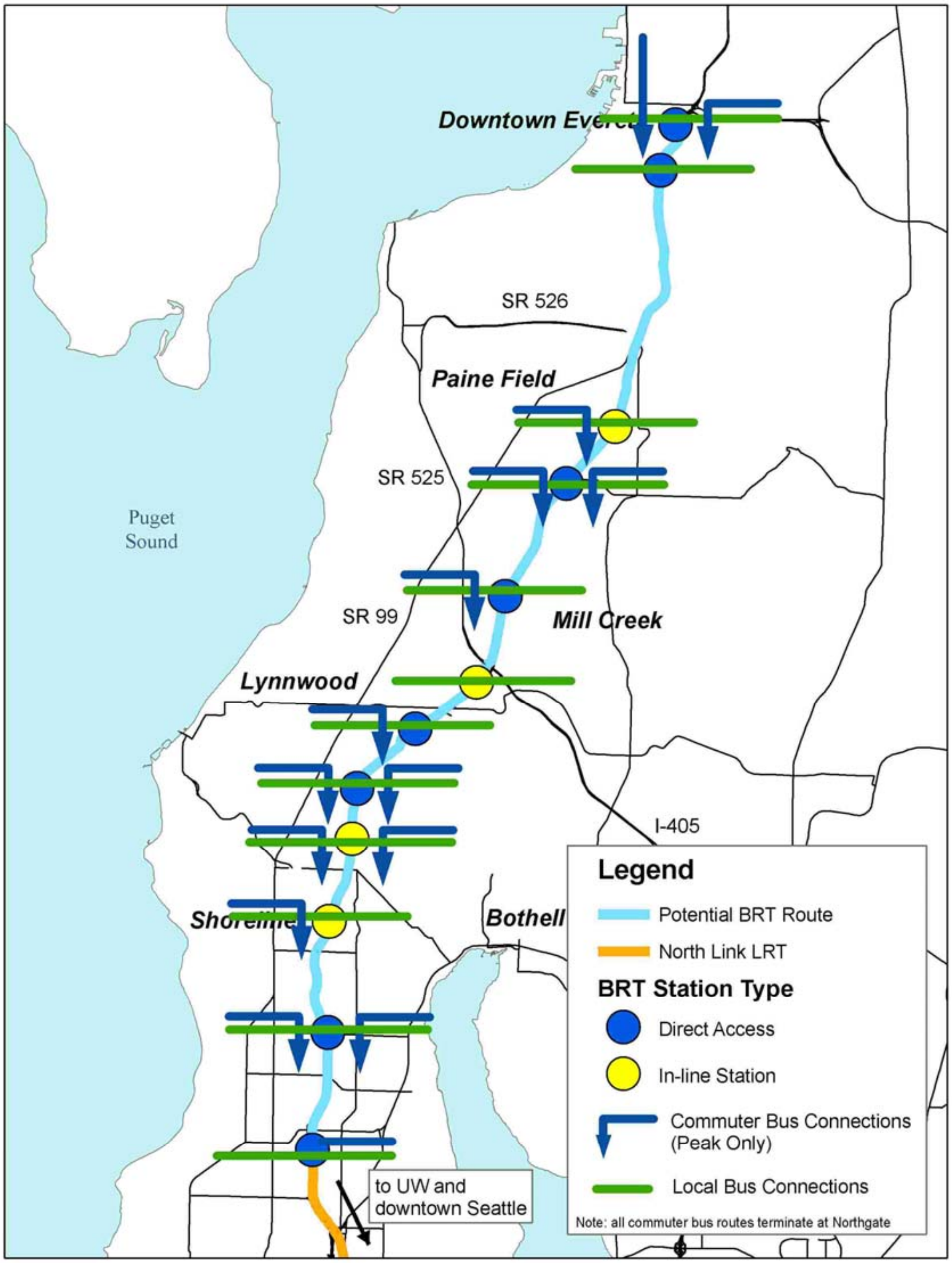

Figure 4. HOV/BRT A.M. Peak Period Service Structure

5. Scenario Comparison

This section describes the assumptions, methodologies and results of comparing future travel times and ridership potential, capital and operating costs, and other factors. Ridership and capital and operating costs could vary significantly from the levels presented in this paper depending on the extent of the regional HCT system that is in place and operating if and when HCT is extended from Northgate to Everett. This is because other HCT connections in the system could attract riders that otherwise might use HCT in this corridor, and provide capacity that otherwise might be needed on this segment.

5.1. Ridership, Travel Times & Reliability

5.1.1. Assumptions, Methodology & Limitations

Ridership potential of the scenarios was estimated by running Sound Transit's ridership forecasting model with specific sets of assumptions and inputs.

Common Inputs

Forecast 2030 population, employment, land use, transit fares, parking fees, and other basic ridership forecasting inputs have been held constant between the scenarios to avoid advantaging or disadvantaging either one based on these factors.

Speed & Reliability

One set of inputs that is not constant are the travel times of the two modes. Light rail operating in exclusive rights-of-way separated from all other traffic will always provide the same travel times and reliability, and will only be impacted by operations of light rail itself (e.g. breakdowns, excessive dwell times to accommodate unusual loading/unloading activity, etc.). The speed and reliability of HOV/BRT, however, would be highly dependent on the day-to-day performance of the I-5 HOV, reversible express and general purpose lanes, and access roadways to stations. Over time, speed and reliability can be expected to worsen as congestion increases. Further, there will always be the potential for random accidents that can interrupt service.

The ridership model requires engineers and operations specialists to estimate travel times for each route specified in each scenario based on the operating environment in which the vehicle must run. In a route from point A to point B, that route could be made up of a flat, straight segment where a bus can run at cruising speed, and hills and/or curves, where the bus must slow down. Part of the judgment that is applied here is based on existing transit schedules and run times; if improvements are made to the system (like the addition of HOV direct access ramps), an estimate must be made about how many minutes would be saved in a particular segment because of the improvement. Existing transit travel times, future congestion on unprotected portions of the route, proposed routing changes and assumed new facilities all figure into the changes to observed travel times.

Because the level of future travel time degradation cannot be known, the HOV/BRT Scenario has been modeled in two ways to help bracket a range of possible HOV lane operating speed conditions. The first variant assumes that the WSDOT will keep the HOV lanes operating as well as today in 2030 – "Faster" BRT. The method(s) that the WSDOT might use to maintain this level of performance is not specified nor recommended in this analysis. Techniques that might be used to improve traffic flow and/or reduce the potential for accidents include, but are not limited to:

- Increasing the number of vehicle passengers required for use of the HOV lanes;
- Improving the lane geometry of sub-standard sections of the freeway;
- Congestion pricing (e.g. high occupancy toll lanes)
- Buffering the HOV lanes from adjacent general purpose traffic to reduce friction/slowing caused by the uncertainty of whether vehicles ahead will unexpectedly enter or exit the lanes;
- Eliminating non-professional drivers from the HOV lanes (i.e. make them transit-only), and/or
- Adding general purpose lane capacity to ease overall freeway operations.

The second variant assumes that HOV system travel times will not be maintained at today's levels, and will continue to degrade over time – "Slower" BRT. There is not enough historical data to allow a corridor-specific degradation trend to be defined. Therefore, as population and travel grow, the level of transit travel time degradation along I-5 assumed in this analysis is arbitrary, and is intended only to show the potential effects of slower transit travel times for comparative purposes only. This analysis assumes for this variant that bus/BRT travel times in the I-5 HOV lanes would slow an average of one percent per year, or 25 percent by 2030.

Reliability is not an input to the ridership model and is therefore not considered or reflected in either the travel time or ridership estimates. However, as described above, transit operating in rights-of-way shared with, or adjacent to but unprotected from other vehicles, will be subject to random, unpredictable delays due to traffic friction and accidents. This unpredictability can negatively affect ridership.

Transit Network & Service Levels

As noted in the description of the scenarios, assumptions about the basic structure of the transit network differ between the scenarios because of the required transfer from bus to rail or rail to bus at Northgate, and the manner in which two-way all-day trunk transit service is provided along I-5. However, the analysis attempts to hold other transit network and service assumptions constant between scenarios. For example, both scenarios assume the same local connecting service structure, headways and spans. Since the bus services that might be running if and when either scenario were implemented would most likely be an evolution of today's service network, it seems prudent to base the transit service network structure in both scenarios on today's known geographic route structure rather than a different structure with different coverage.

In initial model runs, directional transit headways along I-5 were sized to be approximately the same between the alternatives by time of day. After results of the initial runs were reviewed, service levels for each alternative were modified (equilibrated) to better match the forecast levels of rider demand. These modifications were necessary to avoid over-estimating the fleet size and annual operating investment necessary to accommodate the forecast ridership. The equilibration resulted in somewhat different levels between the alternatives, as shown in Table 2.

Table 2. Equilibrated Service Levels (Minutes between Vehicles)

	Light Rail			BRT/Bus		
	Peak Peak Direction	Peak Off-Peak Direction	Midday	Peak Peak Direction	Peak Off-Peak Direction	Midday
Station	Rail Only	Rail Only	Rail Only	BRT + Ex Bus	BRT Only	BRT Only
Everett	7.5	7.5	15.0	5.5	5.5	7.5
41st	7.5	7.5	15.0	5.5	5.5	7.5
112th	7.5	7.5	15.0	5.5	5.5	7.5
128th	7.5	7.5	15.0	2.1	5.5	7.5
164th	3.0	3.0	15.0	1.8	5.5	7.5
Alderwood	3.0	3.0	15.0	4.0	5.5	7.5
Lynnwood TC	3.0	3.0	15.0	2.2	5.5	7.5
220th	3.0	3.0	15.0	3.1	5.5	7.5
236th	3.0	3.0	15.0	2.6	5.5	7.5
185th	3.0	3.0	15.0	2.9	5.5	7.5
145th	3.0	3.0	15.0	2.5	5.5	7.5

It is important to note, however, that off-peak direction service during peak periods differs between the scenarios. Because light rail is most efficiently run as two-way service serving the same stops in both directions, rail would offer the same service level in the off-peak direction as the peak direction. This approach generally requires fewer vehicles but more operating hours. In contrast, bus/BRT services can be more efficiently run with higher service levels in the peak direction, and lower service and fewer stops in the off-peak direction. This approach generally requires more vehicles but fewer operating hours.

5.1.2. Findings

Ridership of the Light Rail Scenario would be higher than the HOV/BRT Scenario, again because the latter requires more transfers. As shown in Table 3 below, light rail increasingly attracts more riders than HOV/BRT further south on the alignment. At Lynnwood, light rail would attract 16 percent more riders, and 19 percent more at 175th Street in Shoreline. If the HOV lanes were to operate 25 percent slower in the future (“slower” BRT), the differentials become even greater -- over 38 percent more on rail than HOV/BRT at both Lynnwood and Shoreline..

Table 3. Forecast 2030 Daily Transit Ridership Volumes along I-5

	Light Rail	Faster HOV/BRT*	Slower HOV/BRT**
South of Lynnwood	50,000	43,000	36,000
South of 175th	66,000	57,000	48,000

* HOV lanes assumed to operate, on average, as fast as today
** HOV lanes assumed to operate, on average, 25percent slower than today

Forecast transit travel times between locations north of Northgate and locations south of Northgate, summarized in Table 4 below, would generally be longer under the HOV/BRT Scenario because of the transfer to light rail at Northgate. This is true if the HOV lanes operate as well as today and is further intensified if they don't, and is true of both all-stop BRT trunk and non-stop peak period commuter express bus services between Everett and Northgate.

Travel time differences between the scenarios would be most acute during off-peak periods when two transfers (local bus to I-5 BRT trunk to light rail) might be necessary for riders from north of Northgate to reach destinations south of Northgate, and vice versa. Transfer times between bus/BRT and light rail at Northgate would be reduced by adding direct HOV lane access between Northgate and I-5, and bus circulation and passenger facility improvements at the transit center. However, the impact on travel times will still be greater than if no transfer at Northgate were required, as would be stations north of Northgate would also be longer under the HOV/BRT Scenario because the freeway HOV lanes, even operating in the future as well as today, would not provide as fast and reliable a trip as light rail.

Table 4. Forecast 2030 Transit Travel Times (Minutes)

	Northgate – Everett HCT Scenarios				
	Light Rail	*Faster HOV/BRT**		*Slower HOV/BRT***	
2030 Travel Times (mins)	**All Stop**	**All Stop**	**Non Stop**	**All Stop**	**Non Stop**
Everett – Northgate	38	55	37	66	48
Everett – U District	45	67	49	78	60
Everett – Seattle	53	75	57	86	68
Lynnwood - Northgate	13	24	17	29	21
Lynnwood – U District	20	36	29	41	33
Lynnwood – Seattle	28	44	36	48	41

* HOV lanes assumed to operate, on average, as fast as today
** HOV lanes assumed to operate, on average, 25percent slower than today

5.2. Capital Costs

The detailed discussion below covers only the HOV/BRT Scenario, since the capital costs of extending light rail along I-5 between Northgate and Everett are discussed in *Issue Paper N.2: I-5 Corridor Northgate to Everett HCT Assessment*. Only summary information from that paper about the Light Rail Scenario capital costs are provided here. Please refer to that paper for more detailed information about the capital costs of the Light Rail Scenario.

5.2.1. Assumptions, Methodology & Limitations

The cost estimates were developed using quantifiable construction items, to capture and sufficiently represent the total capital cost. The gross generalizations used to develop these comparative cost estimates do not allow sufficient accuracy to develop specific project budgets. These cost estimates were solely intended to permit relative comparisons among the studied scenarios. The estimated capital costs have been provided as a range between –5 percent to +30 percent of the developed estimate. The capital cost estimates attempt to capture the full project costs of implementing the alternative modes. These costs include:

- Infrastructure, including guideways, stations, parking, systems, traffic control, stormwater management, and roadway modifications;
- Traffic maintenance during construction;
- Environmental mitigation (e.g., noise abatement, hazardous material disposal and wetlands replacements);
- Agency costs including design and environmental documentation, construction engineering, and administration;
- Right-of-way acquisition, including administrative and legal costs;
- Vehicles and maintenance yards.

The general methodology used for this report is similar to that used for the *Issue Paper E.1: I-90 Corridor / East King County High Capacity Transit Analysis* cost estimate. Roadway costs not included in items noted above were determined by identifying standard WSDOT items and the typical costs for those items. All costs were adjusted to 2005 dollars.

Special traffic control and environmental mitigation costs were difficult to quantify due to the conceptual nature of the design. Allowances for these items were accomplished by assigning a percentage ranging between 5 percent and 20 percent of the total cost of the select construction items. Environmental mitigation (e.g., wetland mitigation, noise abatement, and hazardous waste disposal) was assumed to be 15 percent of the total construction cost. Other recent corridor studies, including the I-405 corridor project, estimated a similar level of environmental mitigation cost.

Depending on the type of facility, design contingencies ranging from 15 percent to 35 percent were applied to account for the conceptual nature of the design. A construction contingency of 10 percent for above ground construction was applied to account for unforeseen conditions arising during construction. Agency costs to deliver the transit project include design engineering, environmental documentation, permitting, agency management and administration, construction management, design support during construction, and third-party construction assistance. Thirty five (35) percent of all construction cost (extended cost plus design and construction contingencies) was used to approximate agency costs.

Unit prices for right-of-way acquisition were obtained from the WSDOT's *Trans-Lake Washington HCT Capital Cost Methodology report*. The unit prices include relocation costs, administrative costs, and contingency equivalent to 100 percent of the purchase value. The report categorized right-of-way acquisition unit prices as suburban takes (when compared to the East corridor which has both Urban and Suburban). The suburban unit prices applied to all other areas including commercial, industrial, and retail takes as this corridor is outside of the urban core. Right-of-way prices developed by the Trans-Lake Washington Project for HCT capital costs were adjusted from 2001 dollars to 2005 dollars by using an inflation rate of 7 percent per year, provided by ST. All construction cost regardless of their sources, were adjusted to 2005 dollars using the average inflation rate based on:

- Seattle's Building Cost Index (BCI);
- Seattle's Construction Cost Index (CCI)

5.2.2. Findings

Capital costs for the HOV/BRT Scenario would be significantly lower than for the Light Rail Scenario, largely because the majority of the HOV/BRT running ways already exist in the form of the I-5 HOV lanes, while new running ways would have to be constructed for light rail. The combined costs of constructing the remaining HOV lane direct access and in-line station improvements, building bus stations and a larger Northgate bus-rail transfer facility, buying buses, and building adequate bus maintenance capacity would still be cheaper than building additional light rail tracks, stations, power systems and maintenance facilities, and buying trains. Keeping the HOV lanes operating as well as today adds costs to the HOV/BRT Scenario. This analysis assumes minimal lane and shoulder widening as the method at relatively modest cost, though other treatments identified in Section 5.1.1 might be more effective at likely higher cost.

Northgate

In the HOV/BRT Scenario, Northgate serves as a major regional intermodal transfer location between bus/BRT along I-5 to the north and light rail to the south. Making those transfers as seamless as possible is critical to making the HOV/BRT Scenario work as well as possible, but achieving that integration requires a number of improvements. The costs of improvements necessary at Northgate have been called out separately to emphasize this need. Major improvements include an expanded bus transfer/staging/layover facility, structured park and ride capacity at the station, transit-only direct access ramps between the transit center/light rail station and the I-5 HOV lanes, and necessary reconfiguration and reconstruction of I-5 in the Northgate area necessary to accommodate the added direct access ramps.

Figures 5 and 6 depict the sectional profile and ground level plan view of the conceptual multi-level bus transfer facility assumed in this analysis. The facility would be constructed around the planned light rail station at Northgate, and designed to minimize additions to surface street bus traffic and impacts to adjacent developments. It would require at least 20 bus bays to accommodate the roughly 130 peak hour buses that would need to be staged during the afternoon rush hour to receive riders transferring from light rail. For context, this is almost as many buses as currently operate through the downtown Seattle transit tunnel during the afternoon peak hour. Figure 7 shows a conceptual design for integrating transit direct access ramps between the I-5 HOV lanes and the transit center. The total capital cost of this group of improvements is shown in Table 5.

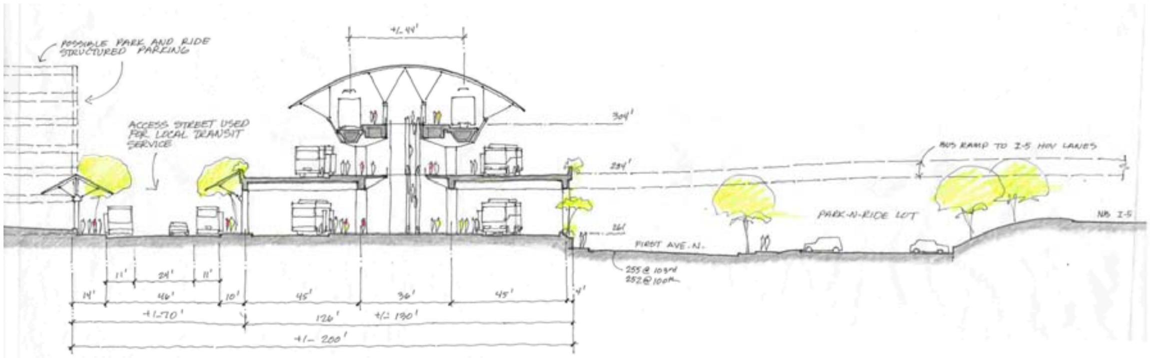

Figure 5. Conceptual Northgate Bus Intercept Facility – Section

North of Northgate

Other improvements necessary to support the HOV/BRT Scenario along I-5 north of Northgate include transit-only or in-line and off-line stations (see Figure 3 for locations), reconfiguration and/or reconstruction of I-5 in selected areas to accommodate those facilities, and expanded park and ride capacity. The capital cost of these improvements are shown by segment in Table 5.

Vehicles & Maintenance Facilities

It is estimated that the HOV/BRT Scenario would require a net addition of 73 - 96 buses to the system, depending on the speed of HOV lane operation. The cost of these buses, plus the maintenance base capacity necessary to support them, is shown in Table 5.

Total Costs

Total capital costs of the HOV/BRT Scenario are summarized by segment in Table 5. For comparison, the capital costs of the same segments for the Light Rail Scenario from Issue Paper N.2 are shown in Table 6.

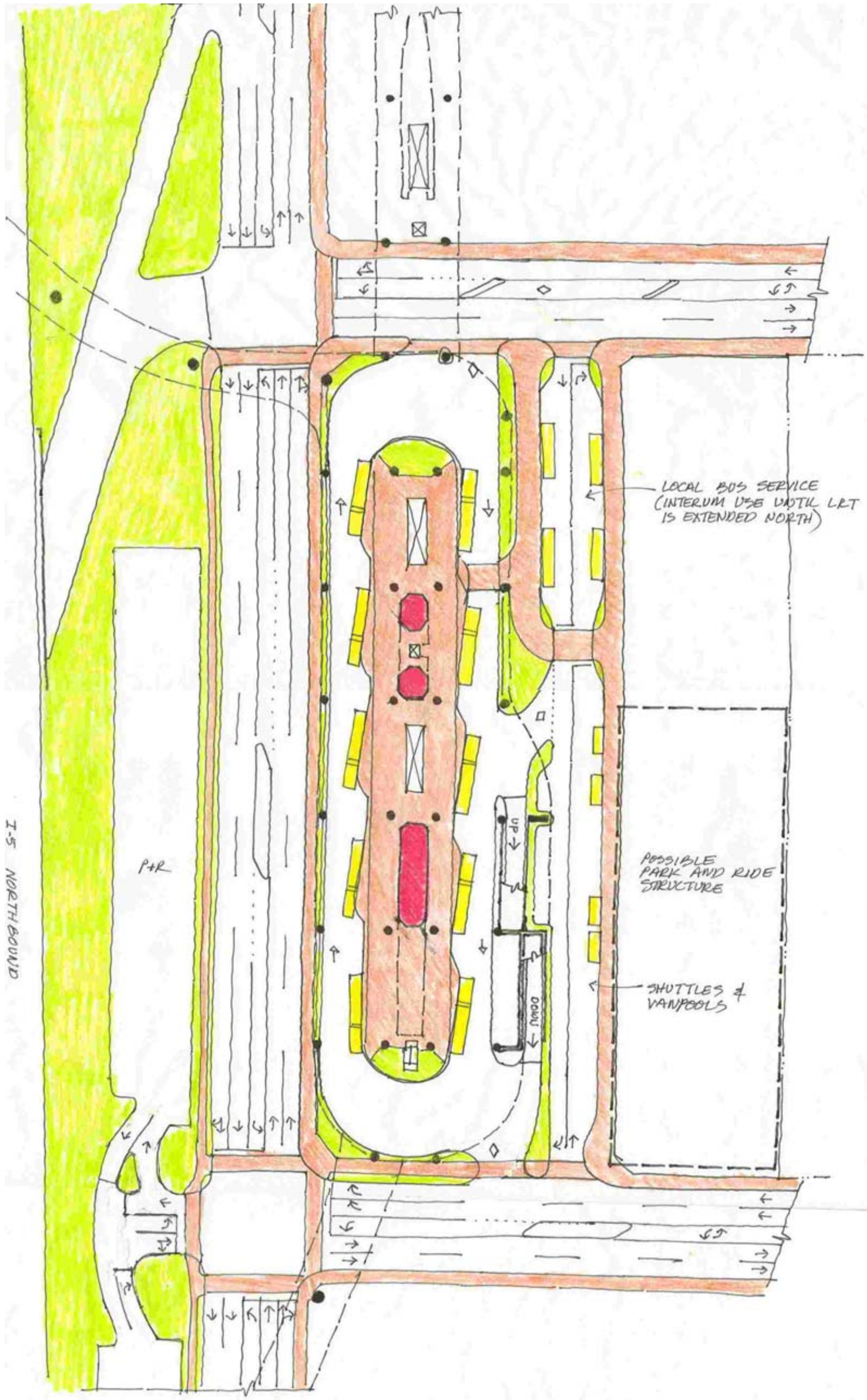

Figure 6. Conceptual Northgate Bus Transfer Facility – Ground Level Plan

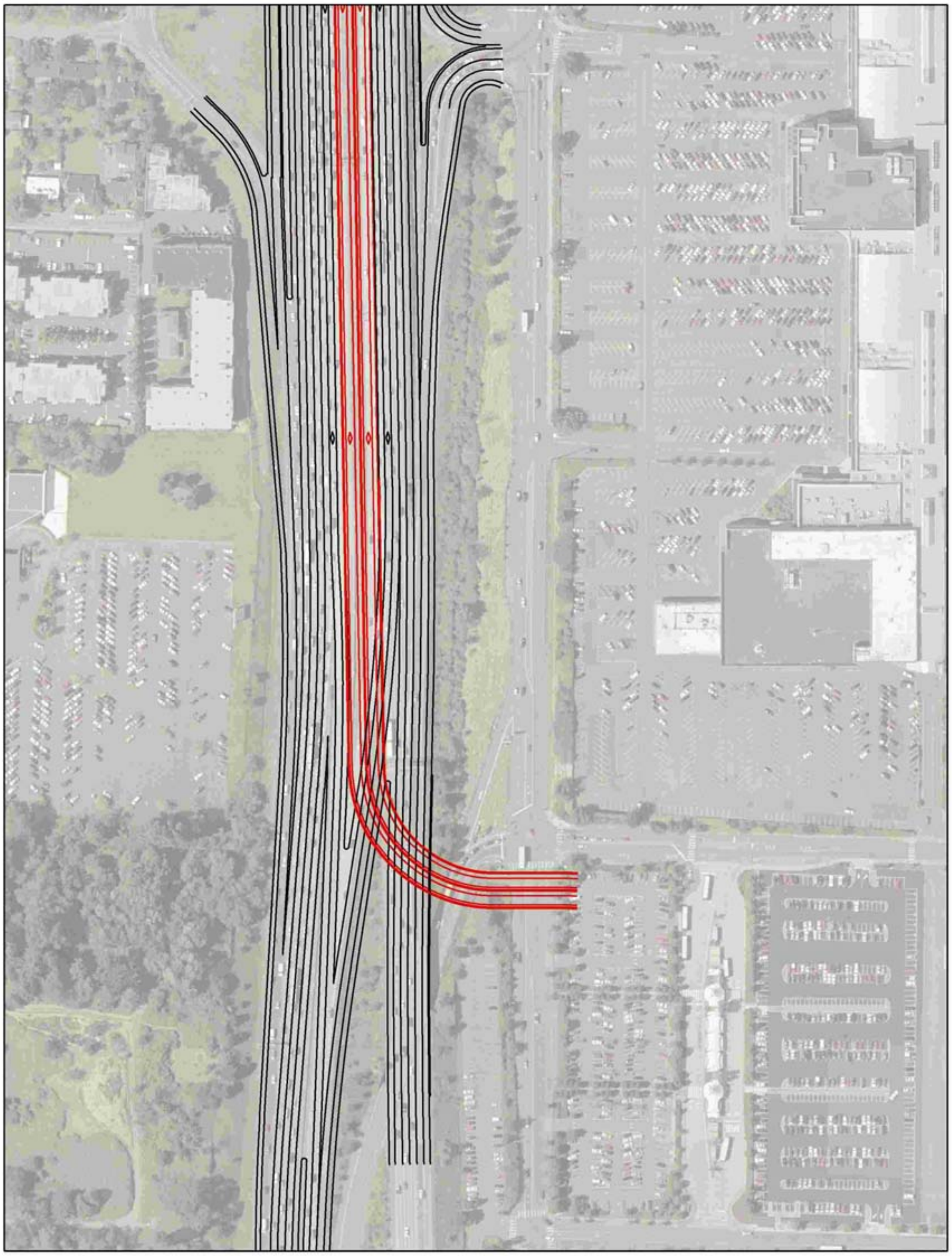

Figure 7. Conceptual Northgate I-5 HOV Lane Direct Access Facility

Table 5. HOV/BRT Scenario Capital Cost Estimate Range

Segment	Cost Estimate Range		
Construction			
Total Park and Ride Cost	$540 M	to	$740 M
Northgate Station and Access	$160 M	to	$220 M
Northgate – Mountlake Terrace (236th St)	$150 M	to	$210 M
Mountlake Terrace – Lynnwood P&R	$120 M	to	$160 M
Lynnwood P&R – Ash Way P&R (164th St)	$50 M	to	$70 M
Ash Way P&R – SR 526	$90 M	to	$120 M
Maintain HOV operations on I-5 from 117th to 175th	$20 M	to	$30 M
SR 526 – Downtown Everett	$150 M	to	$210 M
Total Construction	*$1,280 M*	to	*$1,760 M*
Vehicles & Maintenance Facilities	$100 M	to	$140 M
Total Cost Estimate	***$1,380 M***	to	***$1,900 M***

Table 6. Light Rail Scenario Capital Cost Estimate Range

Segment	Cost Estimate Range		
Construction			
Total Park and Ride Cost	$720 M	to	$980 M
Northgate – Mountlake Terrace	$470 M	to	$640 M
Mountlake Terrace – Lynnwood P&R	$210 M	to	$290 M
Lynnwood P&R – Ash Way P&R	$250 M	to	$340 M
Ash Way P&R – SR 526	$380 M	to	$520 M
SR 526 – Downtown Everett	$350 M	to	$490 M
Total Construction	*$2,380 M*	to	*$3,260 M*
Vehicles & Maintenance Facilities	$950 M	to	$950 M
Total Cost Estimate	***$3,330 M***	to	***$4,210 M***

5.3. Operating Costs

5.3.1. Assumptions, Methodology & Limitations

Unit cost factors for light rail were developed based on current light rail operations in Portland, Oregon and Salt Lake City, Utah. Annual costs for operations and maintenance were estimated using the following formula:

Annual LRT Operating Cost = (($86.88/hr.) X (Annual Revenue Hours)) + (($8.21/mile) X (Annual Vehicle Revenue Miles) X (# of Vehicles))

Cost factors for BRT/bus operations are based on King County Metro's 2002 "average" cost per platform hour, inflated to current 2005 dollars. The average cost per hour is essentially the marginal cost of labor, fuel, parts plus a small proportion of overhead, to reflect the fact that large amounts of service require some additional administrative expense that small amounts of service do not. Though the average cost per hour of Community Transit services -- which are the majority of the bus services affected by this analysis – may be different, the Metro unit cost is adequate for comparative purposes at this level of examination. Annual costs for operations and maintenance were estimated using the following formula:

Annual BRT/Bus Operating Cost = ($84.60/hour) X (Annual Platform Hours)

5.3.2. Findings

If the goal is to optimize service levels to match forecast demand, total annual operating costs for the HOV/BRT Scenario -- including both bus/BRT service and increased light rail service south of Northgate to accommodate transfer demand -- would be substantially less than for the Light Rail Scenario. This is because bus service can be more easily tailored than rail service to directional demand levels, and demand forecasts indicate substantially less service would be needed in the off-peak direction. However, this service design would result in less off-peak direction service and accessibility than in the Light Rail scenario.

In contrast, the Light Rail Scenario presumes equal service levels in both directions at all times, a requirement of making sure trains are available in the right places at the right times to meet peak direction demand. Though this light rail service design is more expensive to operate because of added vehicle mileage, it may better support land use densification and economic development activities along outlying portions of the line and attract additional riders to the system by providing a frequent, reliable option for travelers in the off-peak direction.

If the goal were instead to provide the same level of land use and economic development support in both scenarios by providing equal service capacity and accessibility in both directions, HOV/BRT operating costs would be higher than light rail. This is due to a substantial increase in the bus vehicle hours and miles necessary to provide comparable service levels to light rail. Capital costs for bus fleet and maintenance capacity would also rise if this were the goal.

Table 7. Estimated Annual Operating Costs (2005 $)

	Light Rail	Faster HOV/BRT*	Slower HOV/BRT**
Optimized Capacity*	$90 M	$61 M	$65 M
Equalized Capacity**	$90 M	$94 M	$105 M

* Light Rail and HOV/BRT capacity sized separately to meet estimated directional ridership demand for each
** HOV/BRT capacity sized to match Light Rail

5.4. System Integration

Providing continuous service along the corridor with one mode reduces the number of transfers in the system, and may consequently reduce the size and complexity of facilities required to accommodate those transfers. In the HOV/BRT Scenario, construction of a larger bus terminal/layover facility to accommodate peak period bus transfers to/from light rail could require a substantial amount of space at the Northgate station. The facility design concept developed for this analysis would not require significant changes to the proposed light rail station, but might require significant changes to the current design concepts for local bus transfer, park and ride expansion, and transit-oriented development at or near the station.

5.5. Implementation

The HOV/BRT Scenario would provide more implementation flexibility because facilities could be constructed and service added incrementally along the entire corridor. In contrast, light rail would be implemented in a series of phases, each of which require relatively full completion of all capital infrastructure as each extension of the system is added. Incremental implementation of either scenario would be reflected in lower ridership performance until all facilities and services are operating. On the other hand, performance of the HOV/BRT system would be highly dependent on the actions of other parties to keep the running ways operating well, while performance of the Light Rail scenario would be less dependent on others because the running ways would be managed only for light rail.