

Northgate Pedestrian Bridge Feasibility Study Report

DRAFT

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Road Services Division
Bridge and Structural Design Unit

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1. EXECUTIVE SUMMARY

The overall objective of this study is to evaluate and recommend alternatives for bridge design and alignment for a new pedestrian and bicycle bridge crossing Interstate 5 (I-5) and linking North Seattle Community College and the surrounding area on the west side of the freeway to a future regional transit center on the east side of the freeway. The first phase of the project will be to construct a bridge that crosses the freeway and extends as far as the parking lot at the east side of the freeway. The second phase will be to extend the bridge to connect to the future Sound Transit North Link station. This study addresses the first phase of the project.

The proposed location for the new bridge is just north of North Seattle Community College on the west end and between Northeast 100th Street and Northeast 103rd Street on the east end. Three alternative alignments were selected for initial study and after scrutiny, two final alignments were chosen for more detailed evaluation. Consideration was given to potential bridge span lengths, horizontal and vertical clearance from I-5 lanes and city streets, Americans with Disabilities Act (ADA) requirements for slopes and landings, impacts to traffic on I-5 during construction, street access via stairways and elevators, aesthetics, economics, environmental impacts, constructability, and durability.

Various bridge structures and configurations have been reviewed and evaluated. For the main bridge spans over I-5, cable-stayed or steel truss structures are feasible. For the approach bridge spans, conventional structures including precast concrete Box girder, I-girder, Bulb-T girder, and steel plate girder are viable and economic solutions. At the earth-filled bridge approach, a flexible retaining wall system or a combination of wall and sloped fill can be considered to minimize project costs.

The recommended bridge cross section has a concrete deck surface with a minimum width of either 14 feet or 12 feet depending on structure type and economics. The minimum clear height for pedestrians and bicycles using the bridge will be ten feet to any overhead structure. The current criteria assumed for this study are handrail heights at 4'-6", and 8'-0" to 10'-0" high screens on each side of the bridge over I-5 lanes.

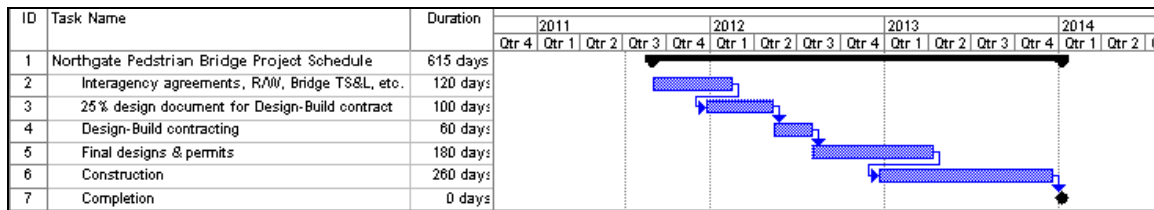
A table that summarizes and compares various bridge alignments, structural types, and other factors, including design, constructability, aesthetics, future maintenance, and traffic and environmental impacts has been included in Section 10 of this report. In addition, the table provides construction and project cost data that should be useful for consideration of an appropriate balance among cost, function, and aesthetics for the project. The estimated cost for the project, including design costs and construction costs, is in the range of \$16,300,000 to \$18,500,000.

One considerable advantage for this project is the fact that the property for the right-of-way (ROW) is expected to be obtained for no cost. The alignments for the bridge are located on public lands owned either by North Seattle Community College or the State (I-5 ROW). We expect the ROW for the new pedestrian bridge to be donated by these public agencies, with no ROW needing to be obtained from private lands.

In order to minimize the time required for design and construction, an alternative process involving a design-build contract could be considered for this project. The design-build contract is an alternative approach to the conventional design-bid-build process normally used by the County for new projects. The design-build approach can result in a reduction of the overall time required to complete the project since the design engineers and the builder work together allowing critical design decisions to be made with regard to structure configuration and materials in a collaborative environment where all parties participate at the same time. This process often can also result in a reduction of the overall cost to design and construct the project if the design-build contract is properly prepared.

To assist project planning, a preliminary design and construction schedule for either the steel truss bridge or the cable-stayed bridge, based on a design-build approach, is shown below. The schedule incorporates a rough breakdown of tasks and the estimated duration for each task in months:

<i>Items</i>	<i>Est'd duration (Month)</i>
Interagency agreements, R/W, Bridge Type, Size & Location	4 - 6
25% Design Document for Design-Build Contract	4 - 6
Design-Build Contracting	3
Project Final Designs & Permits	8 - 10
Project Construction	12 - 16
Estimated project design and construction	2.5 - 3.0 yrs



A more detailed breakdown of the tasks and estimated duration has been included in an appendix.

2. INTRODUCTION AND PROJECT GOAL

King County will implement a transit oriented development plan of regional significance in Seattle's 500-acre Northgate Regional Growth Center, one of 27 designated regional centers intended to accommodate a significant amount of growth. The Northgate Transit Oriented Development (TOD) plan, partially funded by the U.S. Dept. of Housing and Urban Development's Sustainable Communities Regional Planning grant for 2011-2013, will combine workforce TOD housing, enhanced multimodal access for transit users, and pedestrian and bicycle improvements. This will also directly support regionally adopted growth management plans that emphasize high-density, transit-supported mixed-use growth centers.

A new pedestrian bridge, as part of the Northgate TOD Catalyst Investment Strategy, and in partnership with the City of Seattle, Sound Transit, Seattle Housing Authority, North Seattle Community College (NSCC), and other key public agencies is intended to be an integral part of dramatic mobility improvements and regional accessibility benefitting the transit-dependent community college population, the local neighborhoods, and retail/service workers in the Northgate area as well as the public at large. KCDOT has led pre-development and conceptual design work for this project. This effort is aligned with the critical path set by Sound Transit's Northgate Station design completion in the next two to three years with construction to begin in 2016.

A recent study of an overcrossing of I-5 at this location indicates that there would be a 30% reduction in average walking time to the Northgate Transit Center and Light Rail Station and would effectively expand the area walk shed (0.5 miles) to more than 150 buildings and bike shed (3.0 miles) to more than 3,000 additional buildings. This study is to identify favorable alignments for the bridge and to recommend structure types that meet the project requirements with respect to the following criteria:

- Provide pedestrian and bicycle bridge to enhance multimodal access to regional transit center.
- Support city's larger growth strategy for transforming Northgate into a full-fledged urban center.
- Least environmental impact.
- Aesthetics
- Minimal disruption to traffic during construction.
- Sustainability and minimum maintenance.
- Economical
- Public safety

The project is intended to reduce the walking distance from the transit center to the community college from 1.2 miles down to approximately 0.25 miles. The effect will be to reduce single-occupancy vehicle congestion on the surrounding streets, reduce greenhouse gas emissions, and reduce the consumption of fossil fuels. In addition, construction of the pedestrian bridge will result in a lower demand for parking adjacent to the transit center and a reduction in costly investments required for construction of parking facilities.

3. PROJECT LOCATION

The project is located along the I-5 corridor between North Seattle Community College west of I-5 and the Northgate park-and-ride lots on the east side of I-5. The proposed alignments fall in a zone from Northeast 100th Street on the south to Northeast 103rd Street on the north. The attached Figure 1 shows the project location relative to the surrounding roads and streets.

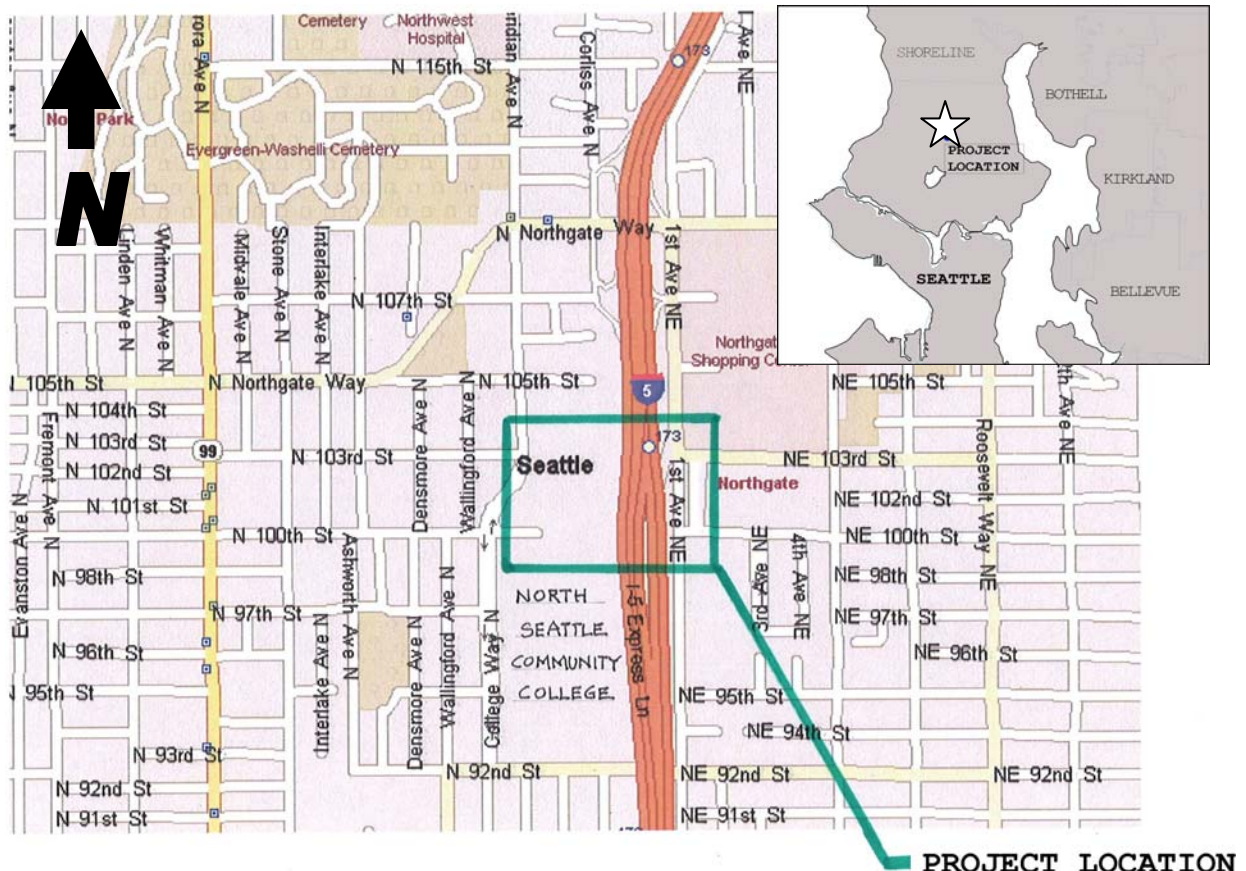


FIGURE 1 – PROJECT LOCATION

4. DATA RESEARCH AND REFERENCES

Information providing the basis of this study was obtained in part from the following sources and/or documents:

4.1 Northgate TOD Catalyst Project Description and Project Diagram

This information was obtained early in the study and shows a conceptual layout for the proposed bridge location and the proposed location for the future Sound Transit North Link station.

4.2 Washington State Department of Transportation (WSDOT)

Right-of-Way Plans for I-5 corridor showing north-bound and south-bound lanes and express lanes. In addition, areas in the landscaped zones located between the lanes are shown where bridge column supports could be considered. In addition, the state has provided the following information and documents:

- Soil boring logs and foundation type for the Northeast 103rd Street over-crossing bridge.
- I-5 corridor topographic map between Northeast 103rd Street and Northeast 100th Street. This map provides information of acceptable new bridge pier locations (see Appendix).
- Northeast Northgate Way Overcrossing No. 5/588 E&W, and First Avenue NE and NE 103rd Street signal structure foundation and soils information.
- Mountlake Terrace Freeway Station plans and cost data.
- WSDOT Design Manual M 22-01.07 regarding design guidelines for Pedestrian Bridge width, vertical clearance, and grade considerations.

4.3 North Seattle Community College (NSCC)

NSCC has provided information regarding potential locations for the west portion of the bridge, including possible wetland locations, approach fills, and the history of the area. NSCC also provided information regarding the extent of soft soils and peat due to the likely presence of a lake sometime in the past.

4.4 City of Seattle

The Seattle Department of Transportation provided the required minimum lateral and vertical clearance dimensions for city streets and obstructions such as light poles along 1st Avenue Northeast relative to potential bridge pier locations. They also provided a copy of the Seattle Right-of-Way Improvement Manual.

4.5 Sound Transit

Preliminary layout plans and elevations for the future Sound Transit North Link station were obtained from Sound Transit. These plans and elevations provided information regarding the location and potential elevation of the future connection between the pedestrian bridge and the station. However, it was decided that the final determination would have to be made in the future when the station plans become more finalized.

4.6 King County

A preliminary site survey was completed by King County survey crews to supplement I-5 corridor data provided by WSDOT and help establish existing elevations along proposed alignments.

4.7 Others

Case Histories, Plans, Specifications, and cost estimates from various past pedestrian bridge projects were obtained to help determine appropriate structure types and relative costs. Some of these references are:

- Sound Transit Canyon Park Pedestrian Bridge Overcrossing from Tetra Tech INCA, including project plans and cost estimates.
- Delta Ponds Pedestrian Bridge, City of Eugene, OR. (OBEC Engineers) (cable-stayed pedestrian bridge).
- I-5 Gateway Pedestrian Bridge, Oregon Dept. of Transportation (OBEC Engineers), including cost data for cable-stayed pedestrian bridge.
- Steel Truss Pedestrian Bridges by Contech Construction Products, Inc. This information included various kinds of truss options for long-span pedestrian bridge structures. The data included fabrication costs and truss plans and sections for their Gateway Truss and Keystone Truss type structures.
- Interurban Trail 124th Street Bicycle/Pedestrian O’Xing bridge plans by ABKJ.

4.8 Design Codes and Guidelines

- American Association of State Highway and Transportation Officials (AASHTO) Load and Resistance Factor Design (LRFD) Guide Specifications for the Design of Pedestrian Bridges, December 2009.
- AASHTO LRFD Bridge Design Specifications, 4th Edition, 2007, with latest interims.
- International Building Code (IBC) latest edition (for the elevator/stair structure).
- National Cooperative Highway Research Program (NCHRP) Synthesis 353, Inspection and Maintenance of Bridge Stay Cable Systems, Transportation Research Board, 2005.
- Federal Highway Administration Technical Advisory 5140.25, Cable Stays of Cable-Stayed Bridges, June 17, 1994.
- Manufacturer’s data for prefabricated truss bridges.
- Manufacturer’s data for cable stays.
- Washington State Department of Transportation (WSDOT) Bridge Design Manual (2010).

5. PROJECT DESIGN CONSIDERATIONS

5.1 Bridge Design Criteria

The design criteria for the proposed pedestrian bridge include the following:

- Minimum vertical clearance on I-5 lanes shall be 20 feet. Minimum vertical clearance over city streets shall be at least 16'-6".
- All new bridge piers or abutments shall be located at least 15 feet away from existing traffic lanes and shall consider future additional lane and full shoulder in the south bound I-5 direction and allow for some widening of north bound off ramps.
- Preferable clear width of the walking surface on the bridge shall be 14 feet. A 12-foot width may be acceptable if significant cost reductions and reduced traffic impact during construction can be achieved.
- The bridge shall have screens and handrails with a height approved by the State Architect. Current criteria assumed for this study has handrail heights at 4'-6" and a wire mesh screen height of 8'-0" to 10'-0".
- Design loads should allow for sign structures to be placed on the bridge (details to be discussed during final design stage).
- Bridge shall meet ADA requirements (profile grade and landing, etc.). This includes a maximum 5-percent slope without landings and a maximum 8-percent slope (6.25-percent is preferred) with landings spaced at 30 feet maximum. The length of landings shall be at least 60 inches.
- No construction staging will be allowed on the freeways.
- Night time closure of lanes on the freeway between 10 PM and 5 AM could be considered as long as two lanes each way remain open at all times. For express lanes, closure of one lane may be acceptable. Short term (2 to 4 hours) closures are possible but should be reviewed and approved by State Department of Transportation (DOT).
- Consideration should be given to ease of bridge inspection and inspection frequency.
- Current design study shall include a stairway and elevator at the east end of the bridge near the park-and-ride lot to allow access to and from street level. The design shall also allow for a future connection to the proposed future light rail station. This may entail an extra stop for the elevator and/or an extra landing for the stairway.
- All new bridge piers or abutments to be located adjacent to city streets shall comply with clearances as required by City of Seattle DOT. This includes minimum clearance of 3'-0" from face of curb to face of column, and a minimum clear sidewalk width of 5'-0".
- Design of the bridge shall allow for a concrete walking surface, and shall allow for access by bicycles.
- Bridge type and aesthetics shall be reviewed and approved by State Architect.
- Design shall minimize environmental impacts to wetlands and sensitive areas.
- Design shall take into account constructability and durability, and shall consider lower cost alternatives as well as "signature type" structures.

- Design shall comply with the AASHTO LRFD Guide Specifications for the Design of Pedestrian Bridges, December 2009. The dynamic response of the bridge structure to pedestrian loads and to wind loads must be considered in the design.
- Where applicable, the design shall comply with the AASHTO LRFD Bridge Design Specifications, 4th Edition 2007, including all current interims. Fatigue and fracture resistance shall be considered, and for cable-stayed bridge types, the most current recommendations from the Federal Highway Administration, Post Tensioning Institute (PTI), and other recognized technical experts shall be considered for the design of the stay cables and for corrosion protection of the stay cables.
- Design shall provide for lighting system along the bridge for public night time access and safety.

5.2 Design Criteria for Alignments

A number of factors were considered as follows:

- Routes providing the shortest clear-span lengths for crossing the freeway. This involved researching potential locations for intermediate piers located on the State ROW.
- Routes providing the shortest over-all length for the elevated sections of the bridge.
- Routes that take advantage of the natural hillside adjacent to North Seattle Community College to gain elevation using a path constructed on grade or on shallow fill. This affected both the horizontal and vertical aspects for the alignment.
- Routes that provide the most direct connection to the desired destination point on the east side of the freeway and to the area that can minimize impacts to the existing road and school parking on the west of the freeway.
- Routes that are on a tangent alignment that could allow erection of long span steel trusses by launching methods.
- Consideration was given to the maximum slope of the walkway per ADA requirements without having intermediate landings. We considered the alignment length versus the length required to meet a prescribed elevation at the connection to the future light rail station given the slope limitation per ADA requirements. The height of the structure required to provide the necessary clearance of twenty feet above the freeway was also considered for several different alignments. The truss superstructures require a somewhat higher vertical alignment than the cable-stayed superstructure due to the depth of the trusses.
- Additional factors included potential changes in the location where the bridge would connect to the future light rail station, possible areas of wetlands, potential staging areas for construction, etc.

5.3 Bridge Types and Approach Fills

Since the span lengths for the main spans over the freeway are quite long compared to the typical approach spans, different bridge sections were studied for the main spans and for the approach spans. The main spans over the freeway vary from about 140 feet to 230 feet depending on the particular alignment chosen. The spans for the approaches were generally assumed to be about 100 feet in length. The typical bridge sections selected for this study for the main spans include steel trusses of various configurations with concrete decks, and cable-stayed structures constructed with segmental precast deck units. The cable-stayed sections include post-tensioning of the segmental deck units that will provide added durability and resistance to cracking. Corrugated steel decking should not be used to support a cast-in-place concrete deck slab due to corrosion concerns after the galvanized coating of the corrugated steel deck loses effectiveness and because of inspection difficulties for the deck slab.

It is recommended that structural steel for the steel truss bridge alternate be coated with a high quality paint system to provide corrosion resistance. As an alternate, the steel truss members could be hot-dipped galvanized and then painted; a double protection system to corrosion that can minimize future maintenance efforts and can increase structural lifespan.

Approach spans could be made continuous for live loads. This will increase the efficiency and eliminate expansion joints which will make the structure more durable and maintenance free.

Walls at the west end of the alignment approaches are shown on the bridge alignment profile views but it could be constructed on fills if grading is acceptable to school. Structural earth walls (SEW walls), gravity block walls, or mechanically reinforced steepened slopes (landscaped slopes) may be considered to support the taller fill sections. Due to a possibility of poor soils (peat) in the area, over-excavation, pre-loading of the soils, light-weight fill material, and/or soil improvements such as rammed-aggregate piers may be evaluated and considered to limit potential settlement of the fills.

Additional information on bridge types and approach fills has been included in Section 6.

5.4 Right-of-Way

The current proposed alignments are located entirely on public property. The west portion of the bridge and the approaches are located on property owned by North Seattle Community College. The remaining portions of the bridge over the freeway and terminating in the parking lot just east of the freeway are located on State-owned property (WSDOT ROW and the park-and-ride lot). We expect the ROW for the new pedestrian bridge to be donated by these public agencies, with no ROW needing to be obtained from private lands. This will result in a considerable cost savings for the project.

5.5 Utilities

Based on information provided by the State DOT, it is expected that no major utilities are located along the proposed bridge alignments or at the proposed locations for pier and abutment foundations. A more thorough investigation for possible utilities should be made during the final design phase.

5.6 Permits and Environmental Impacts

The current proposed alignments are intended to avoid impacts to wetlands. The area just north of the north parking lot for North Seattle Community College contains wetlands. The proposed alignments are intended to skirt these wetland areas. Other environmental impacts that will need to be considered include the following:

- The effect of lighting along the bridge alignment, especially any decorative stay/pylon lighting. This may affect the surrounding residential areas and also the traffic on I-5.
- Potential for increased traffic and parking west of I-5 due to the access provided by the new bridge.
- Safety of aviation and approval due to height of cable-stayed pylons.
- Additional studies and permitting that may be required before project construction include the following list:

SEPA Environmental Review (State Environmental Policy Act of 1971)

ECL (Environmental Checklist)

DNS (Determination of Non Significance)

NAT (Notice of Action Taken)

NEPA Environmental Review (National Environmental Policy Act of 1969)

Documented CE (Categorical Exclusion)

ESA Evaluation (Endangered Species Act of 1973)

4(f)/6(f)

Cultural (Section 106)

Air

EJ (Environmental Justice)

Permits and Approvals

Ecology NPDES (National Pollutant Discharge Elimination System)

SWPPP (Storm Water Pollution Prevention Plan)

Seattle Building Permit

ROW Permits

Clearing and Grading Permit

Environmental Studies

Aquatic Environment

Wetland

Stream

Geotech Review

Air Quality Review

Noise Review

At the present time environmental studies have not been completed that address the environmental impacts of the proposed alignments. These studies will need to be completed prior to or during the final design phase for the project.

5.7 Bridge Foundation

This study has no detailed soils information at the proposed locations for abutments and piers along the proposed alignments. Geotechnical investigations at the proposed pier locations will need to be completed prior to the final design phase for the project. We have obtained soil boring information from the foundation plans for the existing bridge at Northeast 103rd Street Over-crossing on the north-bound lanes of the I-5 freeway in the immediate vicinity of the north alignment. In addition, based on inputs from North Seattle Community College, we understand that the area located west of the freeway may be underlain with soft soils and peat deposits. Foundation construction activities for some of the buildings at NSCC encountered these peat deposits.

Based on the above limited information, we anticipate the foundations for the bridge piers will require deep foundation elements. Most likely these elements will be drilled shafts that penetrate the soft soil layers and extend into the hard soils below. The shafts will be drilled and cased with steel casing if needed to avoid collapse of the side walls during excavation. After the shafts are completely cleaned of soft material at the bottom of the excavation, a cage of reinforcing steel will be installed and will extend the full depth of each shaft. The shafts will then be filled with concrete to complete the installation. The diameter of the shafts will vary depending on the loading demands of the structure. We anticipate a single shaft can be used for the piers under the approach spans with diameter between 6 and 8 feet. The piers under the long main spans will likely require two drilled shafts under each pier, and the diameter may range from 6 to 10 feet.

5.8 Seismic Hazard Areas

The seismic hazard at the bridge site can be characterized by the acceleration response spectrum for the site and the site factors for the relevant site class. The acceleration response spectrum can be determined per the AASHTO LRFD Bridge Design Specifications by either a General Procedure or a Site-Specific Procedure. A Site-Specific Procedure is required if any of the following conditions exist:

- Site is within 6 miles of an active fault.
- Site is classified as Site Class F (this applies if the depth of peat at the site exceeds 10 feet).
- Long-duration earthquakes are expected at the site.
- If the bridge is an important one requiring a lower probability of exceedance than normally used for typical design.

The General Procedure requires an analysis for earthquake ground motions that have a 7-percent probability of exceedance in 75 years. Bridges that are designed and detailed in accordance with these provisions may suffer damage, but should have a low probability of collapse due to seismically induced ground shaking. The geotechnical investigation will determine the Site Class and if any of the above conditions exist that will require a Site-Specific Procedure. In addition, the investigation will determine if there is a potential for liquefaction to occur during a strong earthquake. The Site-Specific Procedure is more involved and requires the development of ground motions that are more accurate for the local seismic and site conditions than can be obtained from national ground motion maps.

The City of Seattle has mapped the area associated with the Seattle Fault Zone. The location for the proposed pedestrian bridge does not fall within the mapped area of the Seattle Fault Zone. In addition, the City has mapped areas that may be subject to settlement from peat deposits. The proposed location for the bridge does fall within the predicted zone subject to peat settlement.

5.9 Traffic Impact

Impact to traffic on I-5 during construction of the new bridge must be kept to a minimum. Per discussions with WSDOT representatives, the following criteria must be met:

- No construction staging will be allowed on the freeways.
- Night time closure of lanes on the freeway between 10 PM and 5 AM could be considered as long as two lanes each way remain open at all times. For express lanes, closure of one lane may be acceptable. Short term (2 to 4 hours) closures are possible but should be reviewed and approved by State DOT.

5.10 Future Maintenance and Inspections

5.10.1 Maintenance

Maintenance needs will vary depending on the type of structure selected and the materials used to construct the bridge. In general, a steel structure will require more maintenance than a concrete structure. This is particularly true for precast prestressed concrete structures where maintenance requirements are usually minimal due to added prestressing or post-tensioning forces and its serviceability and sustainability have been well documented. Structural steel elements generally require painting at intervals determined by the type of coating system and the environmental conditions at the site. Stay cables may be vulnerable to corrosion unless they are protected. A variety of systems have been developed in recent years by cable suppliers that usually involve multiple barrier systems. One system employs epoxy coated and filled strands where the interstices of the strand are filled with epoxy, and then the strands may be sheathed in high-density polyethylene pipe. Another system uses a corrosion resistant barrier such as grease or wax combined with individually sheathed strands and finally

enclosed in a high-density polyethylene (HDPE) pipe. Cables protected by these multiple barrier systems have shown superior performance over previous single barrier systems.

5.10.2 Inspections

Future bridge inspections after the structure has been completed may disrupt traffic to enable the inspection crews to accomplish their work. The type of bridge superstructure selected for the final design and construction can affect the frequency of required inspections, particularly if the structure is classified as “fracture critical”. A fracture critical structure generally needs to be inspected twice as often as a non-fracture-critical structure. A vehicular bridge with a steel truss superstructure with two main trusses would likely be classified as “fracture critical”, however, since the live loads on a pedestrian bridge are generally smaller relative to the dead loads than for a vehicular bridge, it is unlikely that the steel truss alternate would be considered “fracture critical”. A cable-stayed superstructure that has been designed so that one of the stays can be removed without affecting the load-carrying ability of the bridge would not be considered as “fracture critical”.

5.11 Future Light Rail Station and Mezzanine

The proposed future light rail station is being planned at the intersection of 1st Avenue NE and NE 103rd Street with the station extending for some distance south of Northeast 103rd Street. In addition to the platform level, the station may have a mezzanine level midway between the street level and the platform level. Current preliminary plans indicate the mezzanine level to be at about elevation 282’-0”. This elevation locates the mezzanine approximately 22 feet above street level at Northeast 103rd Street.

At the time of this study, it is anticipated the new pedestrian bridge will eventually tie into the mezzanine level of the station at a location some distance south of Northeast 103rd Street. The final location is yet to be determined, and will be the subject of the second phase of construction for the pedestrian bridge. In the interim, the east end of the pedestrian bridge will terminate at an elevator and stair tower near the parking lots to provide street access.

6. BRIDGE ALIGNMENT AND TYPE EVALUATIONS

6.1 Alignments

6.1.1 Alignments Studied

Three trial alignments were initially reviewed as shown on Figure 2.

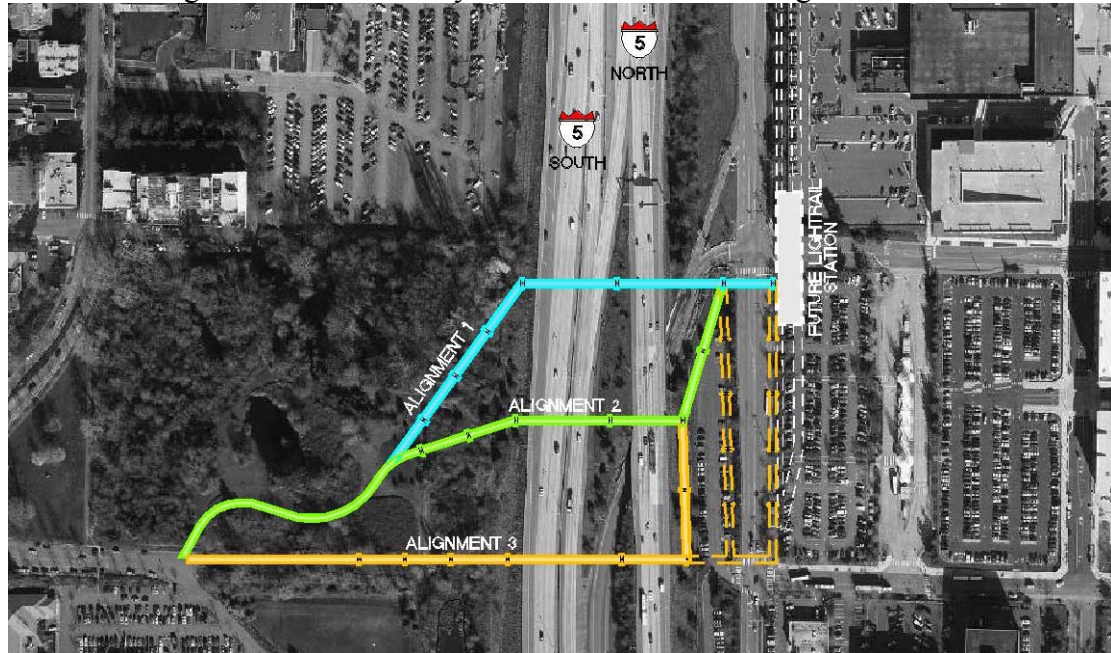


Figure 2 – Initial Alignment Study

The Alignment 1 at the extreme north shown in Figure 2 above allows somewhat shorter spans over the freeway, however the east end of the bridge on this alignment is very close to the location of the future light rail station and there is insufficient length to allow the vertical alignment to slope down to the desired elevation for the connection to the future station. Long ramps would be required to allow for the ADA connection. In addition, there is a difficulty to find a space to place a pier between I-5 lanes and the future connection will more likely be desired farther south and closer to mid-way between Northeast 103rd Street and Northeast 100th Street. For these reasons Alignment 1 was eliminated and the study concentrated on Alignment 2 and Alignment 3. At the south alignment (Alignment 3), three separate locations were considered where the bridge turns north and extends toward the future light rail station. The extension located farthest east parallels the east side of 1st Avenue Northeast. This extension was eliminated from further consideration because it is too close to the light rail line. Another extension was considered along the west side of 1st Avenue Northeast just east of the parking lot along the freeway. However, this location was determined to be a wetland and therefore this extension was eliminated also. The third extension is located between the freeway and the parking lot and this extension has been kept for further study.

6.1.2 Alignments Recommended for Further Consideration

Alignment 2 and Alignment 3 (as shown in Figure 2 above) are recommended for further consideration. For clarity, Alignment 2 has been re-named as the North Alignment and Alignment 3 has been re-named as the South Alignment. This study assumes that during the first phase of construction, the bridge will terminate near the parking lot at the east side of the freeway. The elevated connection from the parking lot to the future light rail station will be accomplished in a second phase of construction. The current study concentrates on the first phase of the project since there are a number of unknown issues regarding the connection for the second phase. It is assumed that the first phase will provide an elevator and stairway at the east terminus for the bridge to enable access to the street level. The North Alignment and the South Alignment are discussed in more detail in the following sections of this report.

a. North Alignment (Option 1)

The North Alignment was called Alignment 2 in the initial study phase. The west end of the North Alignment begins at the east end of North 100th Street (approximate elevation 257.70 ft.) , where the street becomes an approach road for the north parking lot at North Seattle Community College.

The alignment follows a curving path up the gentle hill side to a high point about 200 feet west of the freeway right-of-way (approximate elevation 277.2 ft.). This first section of the alignment is to be built on-grade with minimum fill sections where required. The curving path maintains a maximum grade of 5 percent per ADA requirements. From the high point at the top of the hill, the alignment turns slightly to the right and runs straight over the freeway to terminate at an elevator and stairway structure near the parking lot along the east side of the freeway. This section of the alignment is entirely elevated on the bridge structure. The highest point on the bridge deck occurs at Pier 4 for the cable-stayed and for the steel truss bridge with an elevation of about 307.0 feet. From the high point, the bridge deck slopes downward with a 5-percent grade to a final elevation at the east end of approximately 299.4 feet. The total length of the alignment is approximately 1124 feet for either bridge types. The elevated portion is comprised of four spans. The first two spans of 105 feet each are approach spans. The main spans crossing the freeway are 200 feet and 150 feet in length. Pier No. 4 is located in the landscaped zone between the express lanes and the northbound lanes of the freeway. The attached Figure 3 shows an aerial view of the North Alignment.

Plan, Elevation, and Section views can be found in Appendix C-1 and C-2. Rendering views of North Alignments with Cable-Stayed and Steel Truss Bridge over I-5 can be seen in the Appendix D.



Figure 3 - North Alignment (Option 1)

b. South Alignment (Option 2)

The South Alignment was called Alignment 3 in the initial study. The west end of the South Alignment begins at the same point as the North Alignment. From this beginning point, the alignment proceeds directly east on a tangent alignment for approximately 1024 feet for steel truss and 1008 feet for cable-stayed bridges. The alignment follows North 100th Street, but is offset about seven feet north of the centerline of the street to provide room for a pathway on grade. The same tangent alignment is maintained for crossing the freeway lanes to a point just east of the northbound lanes.

The beginning elevation at the west end of the South Alignment is approximately 258.2 feet. The first 228 to 244 feet of the alignment will be constructed with fill that is retained by structural earth walls on each side. In order to meet ADA requirements and minimize impacts to the existing roads, a maximum 8% slope with 6' landing spaced 30 feet are considered. The remaining portion of the alignment is all elevated on the bridge structure. The bridge structure consists of six spans of varying length. The slightly longer alignment is required for the truss bridge to account for the depth of the truss and the clearance required above the freeway.

Depending on the type of bridge structure, there will be either three or four approach spans of roughly 100 feet each at the west end of the elevated portion. The main spans over the freeway are approximately 230 feet and 140 feet. Uniform slopes of five percent are maintained for approaches and for the main spans. The high point occurs above Pier 6 which is located in the landscaped area between the express lanes and the northbound lanes of the freeway. The deck elevation at the high point will be

approximately 306.7 feet for the cable-stayed superstructure and 307.7 feet for the steel truss superstructure. The attached Figure 4 shows an aerial view of the South Alignment.

Plan, Elevation, and Section views can be found in Appendix C-3 and C-4. Rendering views of South Alignments with Cable-Stayed and Steel Truss Bridge over I-5 can be seen in the Appendix D.



Figure 4 - South Alignment (Option 2)

6.2 Structure Types

6.2.1 Bridge Types on the North Alignment

6.2.1.1 North Alignment with steel truss bridge over I-5

For the main spans over I-5 on this alignment we investigated a steel truss superstructure fabricated from steel tube sections. There are several companies that specialize in steel truss pedestrian bridge structures, and for this feasibility study we have used information provided to us by CONTECH Construction Products, Inc. This company has recommended their “Gateway” or “Continental” type trusses for the long spans crossing over I-5. The depth to span ratio of the trusses will be approximately 0.05 for structural needs, however it is expected that the shorter truss span height will be controlled by 10’ minimum vertical clearance between the top and the bottom truss bracing members or any light features.

6.2.1.2 North Alignment with cable-stayed bridge over I-5

The second type of structure we investigated for the long spans on this alignment is a precast segmental concrete cable-stayed type bridge. For this structure we contacted OBEC Consulting Engineers in Eugene, Oregon, where they have successfully designed and built at least two similar bridges. One bridge is owned by the Oregon DOT, and the other is owned by the City of Eugene. These bridges use a technology known as a cable-stayed stress ribbon deck which results in a very shallow thickness for the concrete deck. Because of the shallow structure depth, the deck can be located at a lower elevation relative to the freeway beneath the bridge and still provide the required vertical clearance. In addition, the thin deck reduces the dead weight of the structure which in turn reduces the demands on the substructure. The concrete deck segments are erected using a balanced cantilever method that does not require false-work for temporary support during construction since the deck panels are supported by the stays. The deck panels are supplied with adjustable connections that allow relatively quick erection. For the I-5 Pedestrian Bridge in Eugene, the panels were generally 10 feet in length. Approximately 18 panels were erected during three night shifts using a light crane to set the panels. Temporary lane closures were required during the erection of the panels. After the panels have been set, a topping slab is poured and full-length post-tensioning strands are placed in the topping slab. The bridge contains no deck joints, minimizing maintenance requirements.

For the North Alignment, only a single pylon was assumed with two cable-stayed spans, one at each side of the pylon. The span on the west side of the pylon is 200 feet, and the span on the east side of the pylon is 150 feet. Due to the restrictions on where piers can be located because of required clearance from the freeway lanes, the spans are of unequal length. This makes the design and construction slightly more complicated since the loading from the panels will not be symmetric and balanced about the pylon unless additional weight is added on the shorter span to help resist the tension in the stay cables. However, this type of bridge is feasible for this location.

6.2.1.3 North Alignment with cable-stayed truss bridge over I-5

Another option that can be considered for either North or South Alignment would be to provide a cable-stayed truss bridge. The advantage of this type of structure would be to allow the truss to be erected in a single lift instead of segmental construction. This would speed up erection time and minimize disruption to traffic on I-5. In addition, the trusses could be much lighter since they would be supported by the stays for the dead weight of the deck and for live loads. The deck could be constructed after the trusses have been erected and supported by the stays. If enclosure of the bridge with a roof for the long spans over the freeway is desirable, this system would make it very easy to add a roof on top of the bridge truss structure.

6.2.1.4 Structural modeling and verification

In addition to researching the bridges designed by OBEC Engineers, preliminary modeling and investigation has been performed for a cable-stayed segmental concrete bridge. We found the dynamic response of this type of bridge to pedestrian live loads was in a satisfactory range. In addition to the response from pedestrian loads, the dynamic response due to wind and earthquake forces should also be investigated for any bridge alternate that is selected for final design.

Figure 5 below shows the alternate bridge types for the North Alignment.

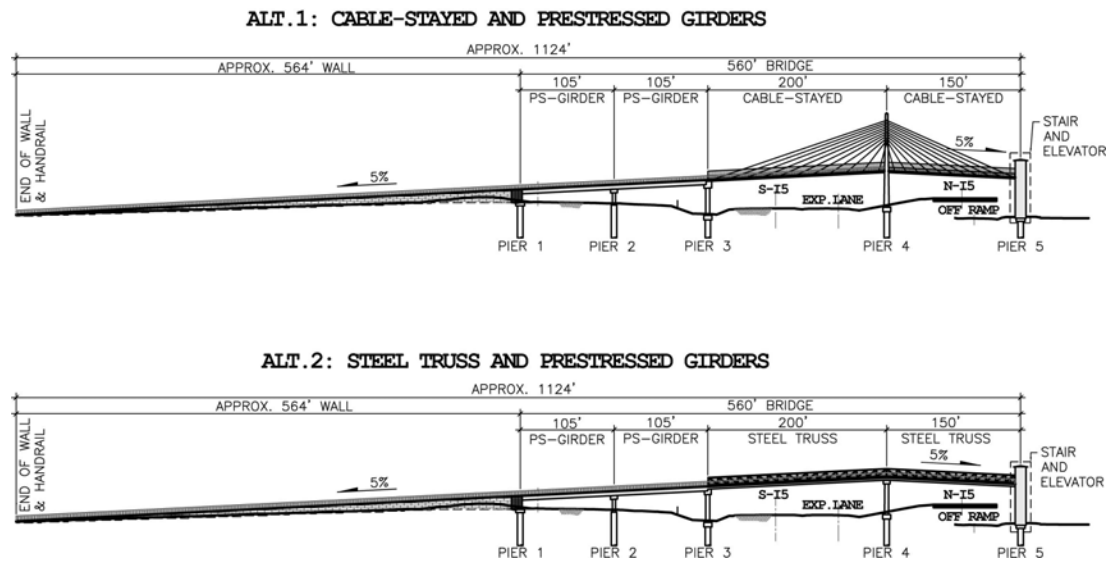


Figure 5 - Bridge Types at North Alignment

6.2.2 Bridge types on the South Alignment

6.2.2.1 South Alignment with steel truss bridge over I-5

For the main spans on this alignment we investigated a steel truss superstructure similar to the one investigated for the North Alignment. The main spans are 230' and 140'. The steel trusses for this alignment will be somewhat deeper and heavier than the trusses at the North Alignment due to the increase in span length. It is expected that the longer span truss and the light features may control the truss height.

6.2.2.2 South Alignment with cable-stayed bridge over I-5

For the main spans on this alignment we investigated a segmental precast concrete cable-stayed bridge similar to the bridge for the North Alignment. For this alignment we were able to achieve a more symmetric arrangement of the spans relative to the pylons. Two pylons are required at this location, with a main span

between the pylons equal to 230 feet, and end spans of 140 feet each. This arrangement allows a more balanced erection of the panels; however the overall number of panels will be larger. Figure 6 below shows the alternate bridge types for the South Alignment.

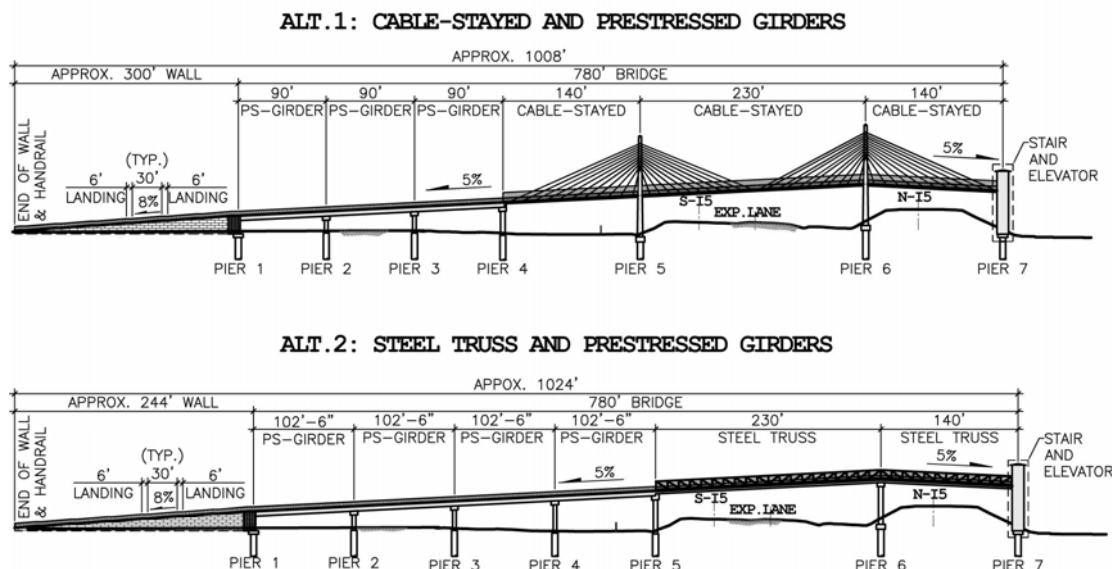


Figure 6 - Bridge Types at South Alignment

6.2.2.3 South Alignment with cable-stayed truss bridge over I-5

As noted above, another option would be a cable-stayed truss bridge on this alignment. All the advantages of this type of structure as described for the North Alignment would also apply for the South Alignment.

6.2.3 Approach bridge spans

The approach bridge spans vary in length from about 90 feet to about 102.5 feet. Our study assumes the approach spans will be constructed from standard WSDOT precast prestressed girders with cast-in-place concrete deck. The type of girder selected and the number of girders in the cross-section will depend on several factors including cost, aesthetics, deck width, continuity, and ease of erection. Standard precast prestressed wide-flange girders or precast prestressed bulb-tee girders will likely provide the most economical solution. However, for aesthetic reasons, precast prestressed trapezoidal tub girders with slightly higher costs may give a more desirable appearance. Any of the above choices can be made continuous for live loads. This will tend to reduce the required depth of the structure and provide a better appearance. In addition, the continuity will eliminate expansion joints and contribute to lower maintenance costs. From an aesthetics standpoint and also from a reduced maintenance standpoint, it will be desirable to set the girders on false-work and cast

the pier cross beams at the same level as the girders. This method also provides for continuity between spans for negative bending over the supports.

Based on a 14-foot wide deck, we anticipate a single trapezoidal tub girder can be used for the approach spans. The number and spacing for wide-flange girders and bulb tee girders can be optimized during final design. For the foundations, we anticipate a single drilled shaft can be used at each pier for the approach spans.

6.3 Approach wall & fill sections and pathway access

Both the north alignment and the south alignment will be constructed on fill sections from the west end of the alignments to a point where the fill approaches a maximum height of about 20 feet or less. The fill will be contained on both sides of the path by a retaining wall. Several wall types can be considered for this application. Possible wall types could include structural earth walls with precast concrete blocks, gravity block walls with or without a facing system that would allow planting (green wall), precast concrete crib-lock walls, and other types. Another couple of options for consideration include maximum 2:1 or steepened slopes on both sides of the approach fill sections if it is acceptable to North Seattle Community College. For the steepened sloped section, the soil fill would be reinforced with geogrid material at both sides of the fill. The steepened slopes can be constructed up to an angle of 70 degrees with respect to the horizontal. All sloped fills can be landscaped with grass or plantings. This approach might work well for the path on the north alignment that is constructed on the existing hillside since the landscaped slope would blend in with the existing hillside.

Due to a possibility of poor soils (peat) in the area, over-excavation, pre-loading of the soils, light-weight fill material (geo-foam fill), and/or soil improvements such as rammed-aggregate piers may be considered to limit potential settlement of the fills. For the alternate using geo-foam fill, the fill could be topped with concrete slab. The various options can be reviewed once soil information is available during final design.

7. CONSTRUCTION ACCESS, STAGING, ERECTION & TRAFFIC IMPACTS

Construction staging areas for crane pads and for on-site assembly of large sections of truss framework are likely to be required on both sides of the freeway. On the east side of the freeway, the most likely location for staging areas includes the parking lot located adjacent to the freeway. On the west side of the freeway, tree covered areas adjacent to the proposed alignments will need to be cleared for crane access and for assembly and lay-down areas. For example, a minimum 50-foot wide area along the north side of the South Alignment would be needed for providing large construction equipment access and staging for drilled shaft construction operation and during erection of the approach span pre-stressed girders on the west end of the bridge. A similar area would be required for approach spans on the North Alignment. For the long span truss structures, it may be possible to field-assemble the sections in the parking lot east of the freeway, then load the truss onto a truck of I-5, and subsequently position the truck on the freeway where two cranes can lift the truss into place during the night.

8. STAIR AND ELEVATOR

8.1 Stair and Elevator at East End of Bridge

For this study we assumed the first phase of construction for the bridge would be to build the portion from North Seattle Community College to a point just east of the I-5 ROW. A future phase will connect the bridge to the future light rail station. The east end of the bridge for the initial phase will terminate at an elevation that will be approximately 45 feet above the street level. An elevator and stairway will be required at this point until such time as the second phase of construction is completed. Several types of stair and elevator can be considered during the project final design phase depending on the space that is available at the east parking lot. Some photos of stair and elevator towers from similar projects are included in the appendix for reference.

8.2 Stair at West End of Bridge

Near the west end of the bridge, a simple stairway will provide access to an on-grade pathway that connects to the parking lot for the Medical Center buildings just north of the Community College.

9. COST ESTIMATES

Construction cost estimates for the various bridge types at both the north and south alignments are shown in the table below. The estimated total project costs are provided to aid project budget planning and preparation.

Refined details for construction cost estimates can be found in the Appendix.

Northgate Pedestrian Bridge Project Cost Estimates Summary

Alignment Options	North Alignment		South Alignment	
Main bridge span over I-5	Cable-Stayed	Gateway Steel Truss	Cable-Stayed	Gateway Steel Truss
Approach bridge span	Precast Box or I-girders	Precast Box or I-girders	Precast Box or I-girders	Precast Box or I-girders
Approach wall structure	Structural Earth Wall	Structural Earth Wall	Structural Earth Wall	Structural Earth Wall
Estimated Construction	\$9,514,170	\$9,278,182	\$10,261,513	\$10,104,434
Contingency/Conceptual (30%)	\$2,854,251	\$2,783,455	\$3,078,454	\$3,031,330
Inspection (20%)	\$1,902,834	\$1,855,636	\$2,052,303	\$2,020,887
Designs (30% Cable-S., 25% Truss)	\$2,854,251	\$2,319,545	\$3,078,454	\$2,526,109
Estimated Project Total =	\$17,125,507	\$16,236,818	\$18,470,723	\$17,682,760

Costs have been assumed based on the following:

1. Drilled shafts supporting bridge & min. soil improvements for walls.
2. No costs for R/W.
3. Future bridge extension to light rail station mezzanine is not included.
4. Estimated in 2011 \$.
5. Minimum lighting and architectural features on walls and bridges.
6. No cover or canopy on bridge.
7. No contaminated material along the construction site.

10. COMPARISON OF ALTERNATIVES

Northgate Pedestrian Bridge Option Data Comparisons

Description	North Alignment		South Alignment	
Type of bridge over I-5	Cable-Stayed	Steel Truss	Cable-Stayed	Steel Truss
Approach bridge spans	I or Box Girders	I or Box Girders	I or Box Girders	I or Box Girders
Walls & fills	SEW & fills	SEW & fills	SEW & fills	SEW & fills
Total length/new crossing	1124'	1124'	1008'	1024'
Total bridge length	560'	560'	780'	780'
Total length/walls & fills	564'	564'	228'	244'
Width of bridge	14'	12' - 14'	14'	12' - 14'
Est'd construction costs	\$ 9.5 M	\$ 9.3 M	\$ 10.3 M	\$ 10.1 M
Est'd total project costs	\$ 17.1 M	\$ 16.2 M	\$ 18.5 M	\$ 17.7 M
Construction duration	12 - 15 months	11 - 14 months	12 - 15 months	11 - 14 months
Bridge designs	Needs specialty for cable-stayed bridge models & designs.	More conventional bridge designs	Needs specialty for cable-stayed bridge models & designs.	More conventional bridge designs
Constructability	Requires special contractor for cable-stayed bridge span construction.	More conventional construction	Requires special contractor for cable-stayed bridge span construction.	More conventional construction
Bridge weight	About 30% to 40% less dead weight; less substructural demands	Heavier	About 30% to 40% less dead weight; less substructural demands	Heavier
Traffic impacts	Slightly higher	Less	Slightly higher	Less
Environmental impacts	About same	About same	About same	About same
Aesthetic	Signature structure	Conventional structure	Signature structure	Conventional structure
Future maintenance and inspection	Expects less maintenance & inspection efforts and less traffic impact during inspection	More inspection & maintenance efforts and more traffic impacts during inspection & painting	Expects less maintenance & inspection efforts and less traffic impact during inspection	More inspection & maintenance efforts and more traffic impacts during inspection & painting

Notes:

1. SEW = Structural Earth Wall system
2. Estimated costs and design and construction durations can be found in the Appendixes

11. CONCLUSIONS

The proposed location for the new bridge is just north of North Seattle Community College on the west end and between NE 100th Street and NE 103rd Street on the east end. Three alternative alignments were initially studied and two of them were chosen for more detailed evaluation. Consideration was given to potential bridge span lengths, horizontal and vertical clearance from I-5 lanes and city streets, ADA requirements for slopes and landings, impacts to traffic on I-5 during construction, street access via stairways and elevators, aesthetics, economics, environmental impacts, constructability, and durability.

Various bridge structures and its configurations have been reviewed and evaluated. For the main bridge spans over I-5, cable-stayed or steel truss structures are feasible for a long span bridge crossing. Steel truss bridge provides more traditional appearance while cable-stayed is a landmark type structure that is visually pleasing and can blend well with the surrounding environment. In addition, the cable-stayed bridge can provide a benefit for sub-structure demand due to its lighter dead weight and can reduce overall bridge span length due to its thin deck. However, higher costs requiring a specialty in cable-stayed bridge designs and construction are expected. Rendering views of these two bridge types along two recommended alignments can be seen in the Appendix.

For the approach bridge spans, more conventional type structures including precast concrete Box girder, I-girder, Bulb-T girder, and steel plate girder are viable and economic solutions. Precast concrete girders in particular can offer good durability and extreme low maintenance over their lifetime. At the bridge approaches, a flexible retaining wall system or a combination of wall and sloped fill can be considered to minimize project construction costs.

It is recommended that the typical bridge cross section have a concrete deck surface with a minimum width of either 14 feet or 12 feet depending on structure type and economics. The minimum clear height for pedestrians and bicycles using the bridge will be ten feet to any overhead structure if a roof is required. The current criteria assumed for this study is 4'-6" handrail height and 8'-0" to 10'-0" high screens on each side of the bridge.

A table that summarizes and compares various bridge alignments, structural types, and other aspects including design, constructability, aesthetic, future maintenance, traffic, and environmental impacts has been included in Section 10 of this report. The table provides construction and project cost data that should be useful for consideration of an appropriate balance among cost, function, and aesthetics for the project.