

How much does the bored tunnel cost?

Short answer

Talking points

- We think this estimate is reasonable due to several factors:
 - The cost per lane mile of the single bored tunnel is approximately \$150 million. This is within the range of other tunnels recently constructed including Changxing, China (less than \$50 million per lane mile); Westerschelde, Netherlands (less than \$100 million per lane mile); Calle 30, Madrid (between \$150 and \$200 million per lane mile); and Lefortova, Moscow (approximately \$200 million per lane mile).
 - The estimate has been reviewed by a wide variety of tunnel experts. Experts representing some design and construction firms have felt the estimate is too high; others have felt that it is conservative, but realistic given the preliminary level of design. Experts that have reviewed the estimate include Arup, Hatch Mott MacDonald, Harvey Parker and John Reilly (past presidents of National and International tunneling associations).

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Background information

	Four-Lane Single Bored Tunnel	Four-Lane Elevated	Six-Lane Alaskan Way Couplet
Inflation	\$166 million		
Risk	\$418 million		
Design, Administration, Mitigation	\$236 million		
Mobilization, Right-of-way	\$212 million		
Labor, Materials, Equipment (2008 prices)	\$880 million		
Total Cost	\$1,912		

**TABLE 1 (DETAILS)
CONSTRUCTION COST ESTIMATE SUMMARY**

ITEM DESCRIPTION	COST (in Millions)
Surface Street Connections @ No. Portal	\$ 45
South Portal	\$ 38
Bored Tunnel-Civil Construction	\$ 380
Bored Tunnel-Systems	\$ 160
North Portal	\$ 42
Allowance for Southbound Ramps	\$ 20
Relocation of Utilities at Portals	\$ 40
Traffic Mitigation	\$ 20
Contaminated Soil Allowance	\$ 5
Environmental Mitigation Allowance	\$ 5
Stormwater and Groundwater	<u>\$ 5</u>
Sub-total	\$ 759
Allowance for Undefined Items	<u>\$ 121</u>
Sub-total	\$ 880
Contractor's Mobilization and Markups	<u>\$ 63</u>
Sub-total	\$ 944
Owner's Administration and Const. Management	<u>\$ 118</u>
Sub-total	\$ 1,062
Engineering and Management	<u>\$ 118</u>
Sub-total	\$ 1,180
Right-of-Way	<u>\$ 149</u>
Sub-total	\$ 1,330
Risk	\$ 418
Escalation	<u>\$ 166</u>
Total	\$ 1,914
Total (Rounded)	\$ 1,900

**TABLE 2 (SOME SUMMARY)
CONSTRUCTION COST ESTIMATE SUMMARY**

South Portal	\$ 38
Bored Tunnel-Civil Construction	\$ 380
Bored Tunnel-Systems	\$ 160
North Portal	\$ 42
Summary of Other Work	<u>\$ 140</u>
Sub-total	\$ 759
Allowance for Undefined Items	<u>\$ 121</u>
Sub-total	\$ 880
Contractor's Mobilization and Markups	<u>\$ 63</u>
Sub-total	\$ 944
Owner's Administration and Const. Management	<u>\$ 118</u>
Sub-total	\$ 1,062
Engineering and Management	<u>\$ 118</u>

	Sub-total	\$	1,180
Right-of-Way		<u>\$</u>	<u>149</u>
	Sub-total	\$	1,330
Risk		\$	418
Escalation		<u>\$</u>	<u>166</u>
	Total	\$	1,914
	Total (Rounded)	\$	1,900

How do the risks associated with the bored tunnel compare to the I-5/surface/transit and SR 99 elevated hybrids previously considered?

Short answer

The risk of building a bored tunnel is higher than either the I-5/surface/transit or SR 99 elevated bypass hybrids considered last year. This risk is quantified and included in the cost estimate of \$1.9 billion presented as part of the executives' January recommendation on how the viaduct and seawall will be replaced.

The percentage of risk that is included in the bored tunnel's most likely cost estimate is approximately 57 percent. This compares to 30 percent for the I-5/surface/transit hybrid and 40 percent for the SR 99 elevated bypass hybrid. The risks of a bored tunnel is higher because this option has a lower level of design; the portal construction will have a higher level of complexity; there is little known today about what ventilation structures will be required; and more investigation of soils conditions under downtown Seattle is required.

Talking points

- WSDOT uses the process known as CEVP to evaluate and quantify known and unknown risks so they can be included in the cost estimate ranges presented to decision-makers and the public. This approach helps ensure a more realistic cost estimate, especially in the early stages of a project when design is still preliminary.
- For example, the estimated cost range of the bored tunnel portion of the recommendation made by the governor, executive, and mayor in January is between \$1.2 and \$2.2 billion with the most likely cost estimated at \$1.9 billion. This wide cost estimate range is typical of a project in its early stages of design.
 - By comparison, the most likely cost of a six-lane surface street (and seawall replacement) is between \$890 million to \$1.1 billion; this narrower range is reflective of less risk associated with this option. The cost range of a new four-lane viaduct is \$1.6 to \$1.9 billion; this narrower range is reflective of less risk and a higher level of design.
- This estimated cost reflects several major components:
 - Labor, materials, and equipment
 - Mobilization, taxes, and right-of-way
 - Design, administration, and mitigation
 - Risk
 - Inflation
- The eight scenarios that were evaluated in 2008 for the central waterfront did not have enough detail nor did time allow for a full CEVP to be completed. A workshop was convened and facilitated by the program estimator, who is also a cost lead for CEVP for

WSDOT. This workshop used the same approach as a full CEVP workshop to identify and quantify risks and contingencies.

- Participants included state, county, and city staff, and consultants who used their knowledge of the projects included in each scenario, past studies and CEVP workshops for previously considered ideas, and knowledge of the study area to assess the risks associated with the scenarios.
- For the risk of the three hybrids considered by the agencies at the end of last year, the following risks were identified that are reflected in the total estimated costs for the SR 99 elements: **NOTE: The percentages below are not correct; they do not match the cost estimate presented in the earlier bored tunnel cost estimate; M. Morrison is continuing to work on it.**
 - 30 percent most likely risk for three-lane couplet portion of the I-5/Surface/Transit Hybrid. This risk factor was lower than the other options because it has less underground work than the other options. However, some level of risk is appropriate because of complicated traffic detours during construction and utility relocation that needed to be completed prior to demolition of the viaduct and construction of the new Alaskan Way.
 - 50 percent most likely risk for the four-lane elevated viaduct portion of the SR 99 Elevated Bypass Hybrid. **This risk factor was agreed to because....**
 - 57 percent most likely risk for the four-lane twin deep bored tunnel portion of the SR 99 Bored Tunnel Hybrid. This risk factor was higher than the other options because this option has a lower level of design; the portal construction will have a higher level of complexity; there is little known today about what ventilation structures will be required; and more investigation of soils conditions under downtown Seattle is required.

Supporting information

HYBRID SCENARIOS WITH ALL ELEMENTS SELECTED INCLUDED (ESCALATED TO YOE)									
SCENARIOS ELEMENTS	L Surface and Transit Hybrid			M Elevated Bypass Hybrid			O Bored Tunnel Hybrid		
	Potential Range *			Potential Range *			Potential Range *		
SR99 Elements	Low	Mid	High	Low	Mid	High	Low	60%	High
1.1 Base Cost	\$ 630	\$ 630	\$ 630	\$1,033	\$1,033	\$1,033	\$1,107	\$1,107	\$1,107
1.2 Risk	\$ 160	\$ 188	\$ 232	\$ 331	\$ 413	\$ 499	\$ 166	\$ 631	\$ 808
Approximate % for Risk	25%	30%	37%	32%	40%	48%	15%	57%	73%
1.3 Escalation	<u>\$ 100</u>	<u>\$ 111</u>	<u>\$ 167</u>	<u>\$ 203</u>	<u>\$ 216</u>	<u>\$ 352</u>	<u>\$ 150</u>	<u>\$ 166</u>	<u>\$ 249</u>
Total with # 1.1 through 1.3 above	\$ 890	\$ 929	\$1,029	\$1,566	\$1,662	\$1,885	\$1,423	\$1,904	\$2,164

* These ranges are designed to simulate a range for a CRA or CEVP Workshop and represent 20% to 80% probability.

- Cost escalation is primarily a result of delays
- It is important to note, however, that not all projects, including those with tunnels, experience cost overruns and there are local and national projects that have been completed on time and within the cost estimate. There were even projects in Boston that were completed on time and on budget that were constructed at the same time as the Big Dig.
- Important large projects that have good cost and schedule experience are listed below Harvey – can we also say something here about the tunnel component of the projects below?
 - Mt. Baker Ridge Tunnel, Seattle – The final cost was five percent below the low bid price, and 46 percent below the engineers estimate. The reason was WSDOT used improved contracting practices and shared risk with the contractor,
 - Mt Baker Ridge Tunnel is still the world's largest diameter soil tunnel with an inside diameter of 63 ft and a length of ¼ mile. The low bid was accepted in 1982 and the project completed in 1986. The project was awarded almost every engineering and construction achievement award given in the year of completion.
 - Mercer Street Combined Sewer Overflow Tunnel, Seattle – The final cost was two percent higher than the bid price and 24 percent below the engineers estimate.
 - This is a 1.2 mile 15-ft-diameter tunnel bid in 1999 about 160 ft deep
 - Combined Sewer Overflow Project, Boston – This project is almost complete with final cost estimated at one percent below the bid price and 19 percent below the engineers estimate.
 - Amy, John Reilly is expected to complete this description
 - Metro Gold Line East, Los Angeles – This project is almost complete and is on budget and slightly ahead of schedule,
 - Six mile long Metro system with 1.7 miles of 21-ft-diameter twin tunnels. Construction began in 2004 and will be complete in 2009.
- There are also examples of large projects that have tunnel components and were completed within the estimate. **Harvey – can we also say something here about the tunnel component of the project?**
 - Milwaukee MMSD CSO Program - Program completed in 1994 at 91 percent of estimated \$1.1 billion in 1982
 - "The Milwaukee wastewater program started in 1977 and construction ran through 1994. The program was quite complex and the tunneling conditions difficult. There were over 300 separate contracts with many tunnels up to 300 ft deep and ranging in size from 8 ft to over 30 ft diameter for an aggregate length of about 20 miles."
 - Metrowest Water Supply, Boston - Program completed at 90 percent of original estimate of \$728 million.
 - Amy, John Reilly is expected to provide this information for Boston projects. Please contact me if he can not complete this on time
 - Boston Red Line North - Program completed at 70 percent of original estimate of \$728 million
 - Boston Southwest Corridor - Program completed at 99 percent of final estimate of \$750 million.

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- In response to worldwide issues associated with managing costs and scope on large transportation projects, WSDOT initiated steps in 2001 to ensure the agency’s projects have reliable cost estimates and are subject to strict cost control standards and accountability.
- This resulted in the development of the Cost Estimate Validation Program and related cost control standards as well as training of WSDOT staff and partners. CEVP has been at the forefront of the development of improved cost estimating procedures nationwide and worldwide.
- CEVP is a real and practical tool to estimate costs of major projects by accounting for the fact that it is impossible to estimate the exact cost of a project. This is due to the fact that there are risks of things going wrong and opportunities that might reduce cost. CEVP takes into account the specific risks that face each project and predicts a reliable probability-based range of costs within which the project can be constructed.
- CEVP and strict cost control standards and accountability has been applied to WSDOT projects since _____ including ____ projects ranging in value from ____ to ____.
- **Amy, I understand John Reilly will provide this information.**
- Recently, WSDOT has demonstrated strong ability to estimate correctly and to manage cost during construction. The Tacoma Narrows Bridge was constructed within budget for \$_____ and is already in service. Also, CEVP has been applied to several projects here in Washington with the following successful results: **Amy, I do not have any of this info but I think it is important to show**
 - _____ - Completed on time and ____ % of CEVP cost
 - _____ - Completed on time and ____ % of CEVP cost
 - _____ - Completed on time and ____ % of CEVP cost
- Finally, WSDOT is incorporating lessons learned and is exercising extreme measures in all aspects of development, design and construction of the bored tunnel to assure control of schedule and cost. Some of the lessons learned and being applied include:
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