PORTLAND-MILWAUKIE
LIGHT RAIL PROJECT

February 2009

Portland-Milwaukie Light Rail Project

WILLAMETTE RIVER BRIDGE TYPE SELECTION PROCESS

Project partners:

Clackamas County · Metro · Multnomah County · The Oregon Department of Transportation · City of Portland · PDC Portland Development Commission · TriMet

WILLAMETTE RIVER BRIDGE ADVISORY COMMITTEE (WRBAC)

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2008 PORTLAND-MILWAUKIE LIGHT RAIL PROJECT STEERING COMMITTEE

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CHANGES TO STEERING COMMITTEE FOLLOWING NOVEMBER 2008 ELECTION:

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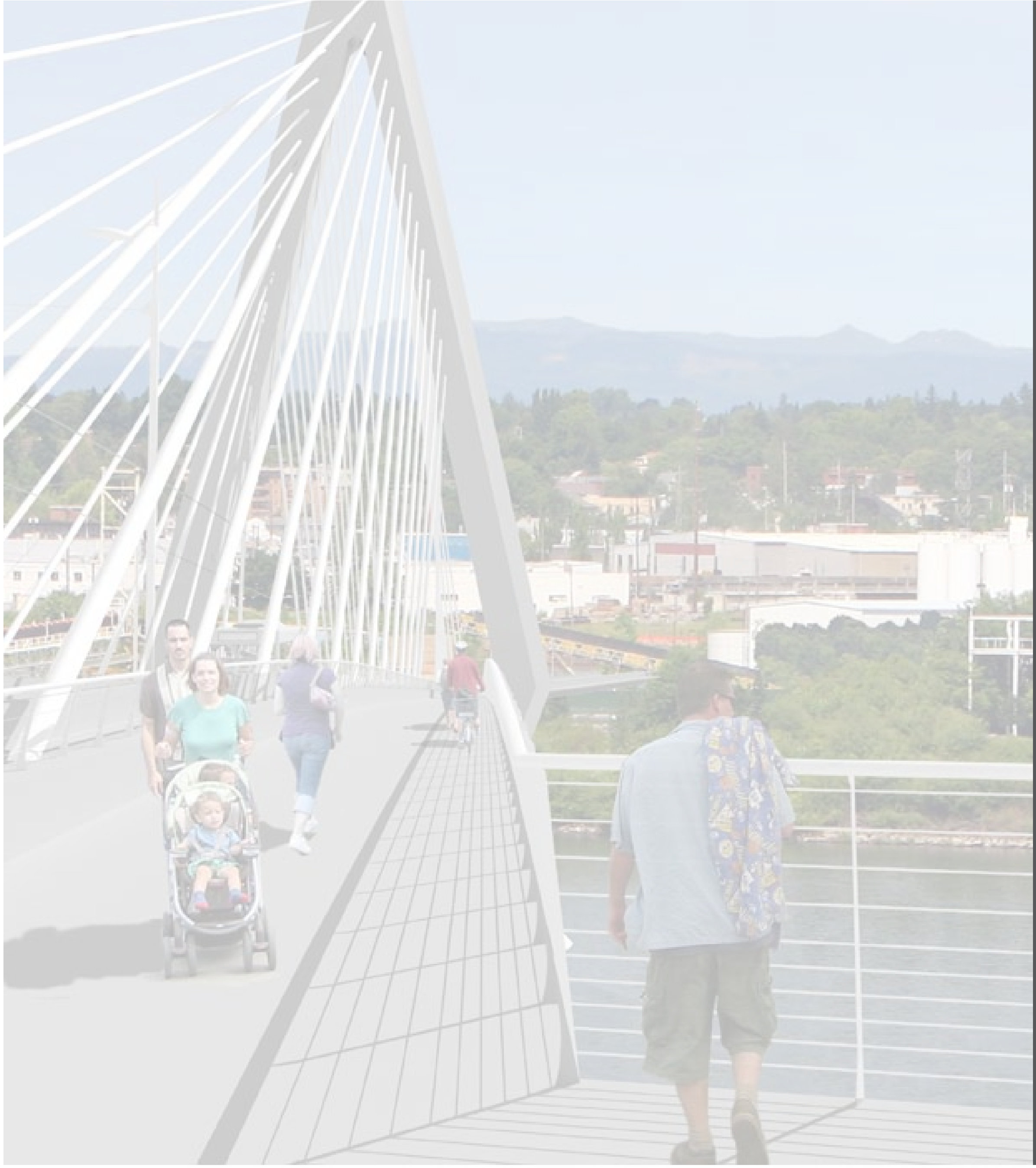

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Executive summary

The Portland-Milwaukie Light Rail Project will create a 7.3-mile light rail line between downtown Portland, Milwaukie and Oak Grove in north Clackamas County. Metro forecasts one million new residents in the four-county Portland region by 2030, and this corridor is expected to experience significant growth in both population and jobs.

When service begins, currently planned for 2015, the project will include 10 new stations and two Park & Ride facilities with 2,000 parking spaces. The Portland-Milwaukie light rail line is expected to carry an estimated 27,400 daily trips by 2030.

A critical component of the project is a new multi-use bridge across the Willamette River between the existing Marquam (I-5) and Ross Island (Hwy 26) bridges. This new bridge will link vital employment, education and research centers in downtown Portland, South Waterfront and inner Southeast Portland with each other and with Milwaukie and Clackamas County.

In May 2008, the Willamette River Crossing Partnership recommended a specific alignment for the bridge to cross the Willamette River. On the river's east bank, this alignment begins at the former SE Sherman St right-of-way just north of Portland Opera, crossing the river to land on the west bank north of the property line between OHSU's future South Waterfront campus and Zidell Marine Corp. property. This recommended alignment was adopted in the project Locally Preferred Alternative (LPA) in July 2008.

The new bridge will carry light rail trains, buses, pedestrians, bicyclists and potentially streetcars, making it a unique long-span bridge in the United States. This bridge also will interface with two riverbank greenways (one existing and one planned), the navigational users of the Willamette River and riparian wildlife habitat.

Given the multi-use purpose of the bridge, its location and its vital importance to Portland-Milwaukie light rail, the project asked a committee of design, transportation, business and community leaders to study all bridge types and recommend to the community only those types appropriate for the context and the budget. From July 2008 through February 2009, a volunteer citizen committee, called the Willamette River Bridge Advisory Committee (WRBAC), under the leadership of former Portland Mayor Vera Katz, met to advise project partners on bridge type selection.

During this eight-month period, the WRBAC studied a wide variety of bridge types and ultimately made its recommendation based on several selection criteria: cost, risk, navigation, fundamental performance, architectural, urban context, greenway impact, environmental-sustainability, operations, miscellaneous technical considerations and opportunities. By considering these criteria, the committee systematically narrowed the list of appropriate bridge types through a series of steps to arrive at its recommendation.

The Willamette River Bridge Advisory Committee recommends the following bridge type for the Portland-Milwaukie Light Rail Project: cable-stayed bridge.

The committee's recommendation on bridge types is being presented to the public at project open houses in February and March 2009. The WRBAC also will make a formal bridge type recommendation to the Portland-Milwaukie Light Rail Project Steering Committee. Design development will occur during the Preliminary Engineering phase of the project in 2009-2010. Construction of the bridge is expected to begin as early as 2011. The PMLR project is currently planned to begin revenue service in 2015.

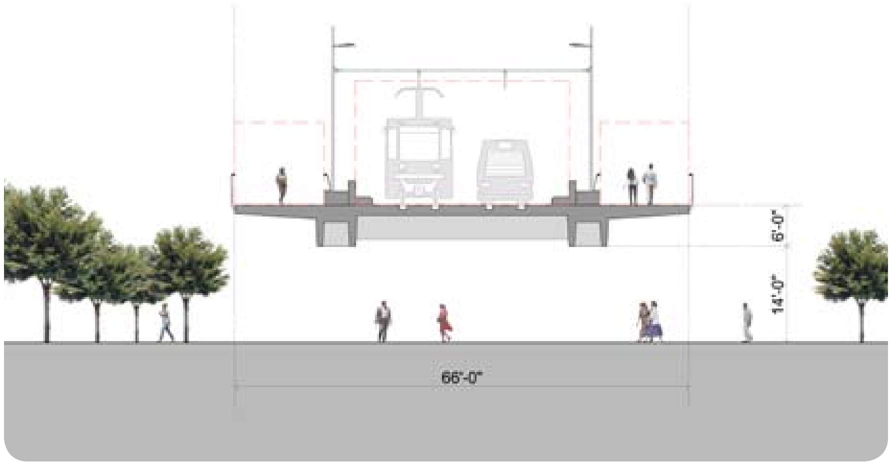
Bridge type study purpose and key issues

Purpose

The opportunity to design a new crossing over the Willamette River in Portland—the City of Bridges—is a rare occurrence. When completed, the bridge portion of the Portland-Milwaukie Light Rail Project will be a significant addition to the city and its riverscape. Additionally, this bridge will carry light rail, buses, pedestrians, bicycles and potentially streetcars, but not private vehicles.

During the course of an eight-month bridge study, the Willamette River Bridge Advisory Committee (WRBAC) considered several key issues in order to recommend bridge types that best met the objectives of project partners and the citizens of the region. The committee, working with technical staff, then used the key issues as a basis for developing bridge type selection criteria.

Bridge study participants agreed on this vision statement to summarize their goal: Deliver a bridge type that embodies the Portland aesthetic, is functional and affordable.



Cross-section design of a conceptual bridge type over a Willamette River greenway.

Key Issues

Environmental Impact

The environmental impact of the bridge raises several concerns and involves many jurisdictions and stakeholders. The bridge will cross over shoreline and the habitat of green sturgeon and endangered salmon species. The bridge approaches and abutments, and the number, location and type of piers in the river were carefully evaluated for their avoidance and minimization of effects on shallow water and riparian habitat, water quality, greenway development and the ability to support plans for hazardous materials clean up in South Waterfront.

Navigation

The bridge study needed to anticipate key factors driving future Coast Guard and Army Corps of Engineers approval of the bridge design. Both entities are concerned with ensuring that the bridge does not present an unreasonable impact to navigational use of the river. Research of navigation conditions, including input from river users, provided minimum horizontal and vertical clearances needed for navigation.

Bridge type study purpose and key issues

Greenway features

The bridge will pass over existing and planned trails and park and recreation facilities on both the east and west Willamette River banks. The bridge provides a major opportunity to extend and enhance the recreational and transportation value of these existing and planned investments in the area. The bridge types recommended needed to artfully reconcile this major new element with the existing features and maximize opportunities for the realization of future plans.

Aesthetics

Portland enjoys an international reputation as the City of Bridges. Adding a new crossing to the existing bridges has important implications for the city's skyline. In addition, the specific location for this bridge has implications for how it will "fit" with other bridges, existing and future development, and natural features. Bridge types considered offered different aesthetics and each had to meet architectural and urban context criteria.

Design and construction cost

The cost for any bridge type must remain within the budget parameters established to date. Cost estimates must account for inflation that occurs over the life of the project, and this inflation is included in a year of expenditure (YOE) budget. The YOE budget for the bridge portion of the project is $134.6 million for design and construction.

Operating cost

The life cycle and operational costs of the bridges were considered. The materials used and the ways they are connected have implications for the on-going cost for the life of the bridge. As the bridge is expected to last for generations, annual increases in maintenance and operations costs, even if small, are of significant concern.

Selection criteria

With the key issues in mind, the Willamette River Bridge Advisory Committee and technical staff agreed upon detailed selection criteria to evaluate and narrow the bridge type options. These criteria included the following:

- **Cost:** The cost of the bridge was a fundamental consideration. The committee considered both the construction and life cycle (maintenance and operation) cost of each bridge type.
- **Risk:** Evaluating the risk factors associated with bridge types was a significant factor in the selection process. The committee evaluated the risk associated with construction cost inflation, bidding, schedule, design uncertainties and permitting risk (both environmental and navigational).
- **Navigation:** The group also considered impacts the bridge would have to river users, such as horizontal and vertical clearance and maneuvering.
- **Fundamental performance:** The bridges were evaluated based on the number, location and size of the piers required for each type in addition to seismic performance and comfort for the user.
- **Architectural:** The aesthetics of each bridge type were carefully examined. Renderings were created to place examples of each one across the river, so the committee could assess the bridge type as it related to its location. The renderings included views from a distance, from the water, from the greenway, as well as from, on and near the bridge.
- **Urban context:** Each type was examined as part of Portland's urban context. The group considered each bridge type's compatibility with the Ross Island and Marquam bridges, its relationship to all other Portland bridges, fit with current and proposed development on either bank of the river, and how it fit into Portland's core values and traditions.
- **Greenway:** How each bridge type accommodates the existing and planned greenways was an important evaluation criterion. The committee considered the depth of span over the greenways, the width of each bridge, the length of the span over the greenways, proximity of possible bridge piers to the greenways, and how these variables might affect the greenway users' experience.

Selection criteria

- **Environmental-sustainability:** The committee considered the environmental impacts of the bridge types, including how construction of each type would impact the environment. The resources required to build each bridge type and the availability of materials locally also was considered. Bridge type effects on fish habitat and issues with contaminated soils were also considered.
- **Bridge operations:** The committee considered which bridge types would function best with light rail, buses, bikes, pedestrians and potential future streetcar operations. The group considered such factors as sightlines, the complexity of installing the overhead catenary system, the ability for emergency response teams to serve bridge users, and the extent and degree of difficulty of bridge inspections.
- **Miscellaneous:** Other technical considerations included how easily utilities could be integrated into the bridge, proximity to underground utilities, how well the types accommodate asymmetric loading and curved greenway spans.
- **Opportunities:** Additionally, the committee discussed which bridge types are best at treating storm water, supporting wildlife and fish habitat, and incorporating alternative energy.

Bridge type evaluation documents presented during this process are posted on *trimet.org/pm*.

Willamette River bridge type study selection process

The WRBAC studied bridge type options from July 2008 to February 2009. A working group of technical staff representing project partners and project consultants met to evaluate selection criteria and developed reports and recommendations, which were made to the WRBAC. The committee also sought input from nationally recognized experts regarding river navigation, bridge engineering and construction, steel supply and steel fabrication.

WRBAC Meetings

July 15, 2008: Bridge familiarization

The technical staff assigned to the bridge process was introduced, and the committee learned of the “universe” of possible bridge types.

August 8, 2008: The universe of bridges

The committee reviewed the Bridge Study goals, process and core values. Details were provided regarding each example of known built bridge types. The committee agreed upon selection criteria for moving from the “universe” of bridge types to a group of many.

Committee discussion at the the August 8, 2008 WRBAC meeting.

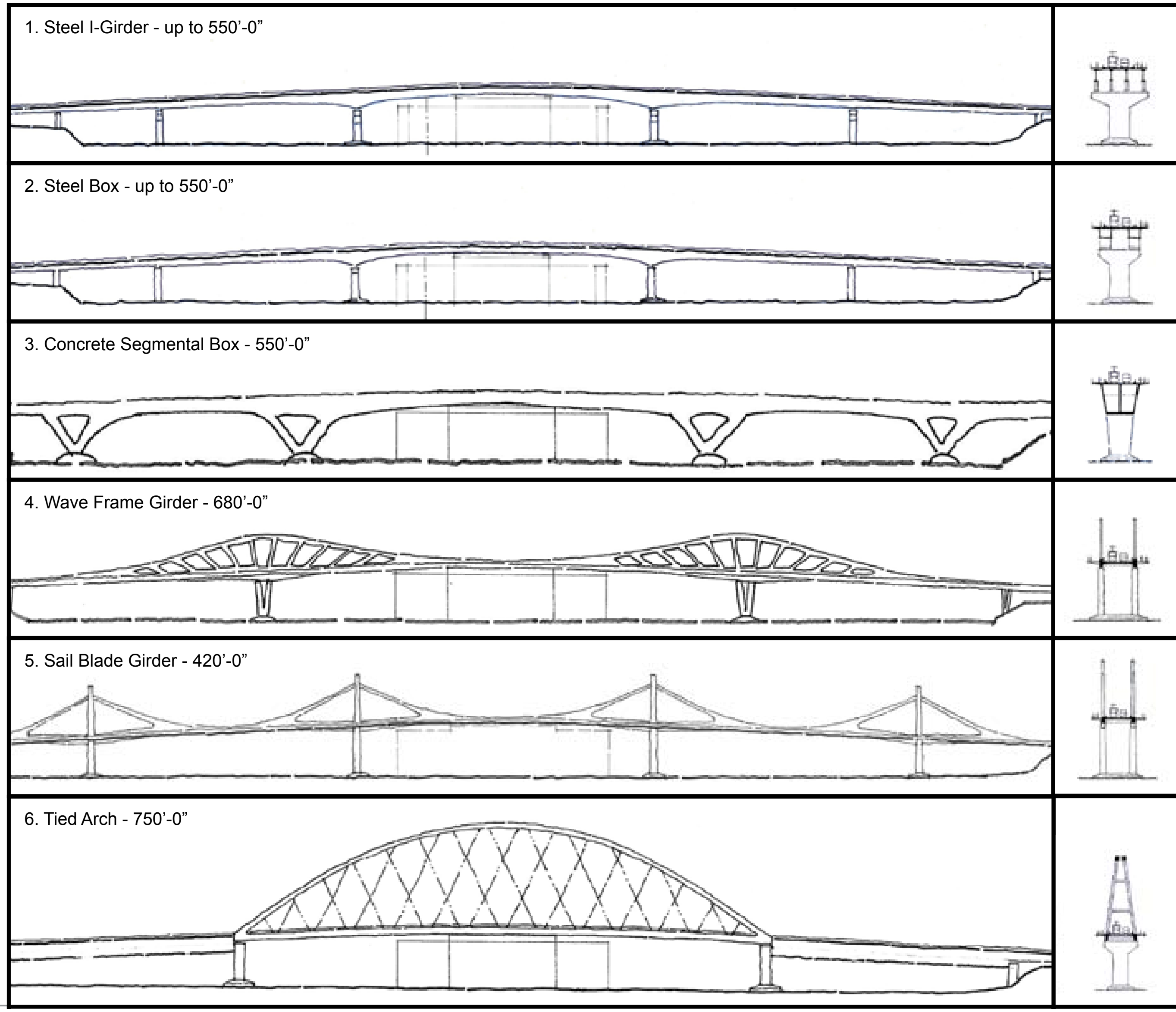
September 16, 2008: Narrowing from the universe to the many

River navigation issues in relation to the bridge alignment were explained, and the committee began exploration of what these issues meant for viable bridge types on the alignment.

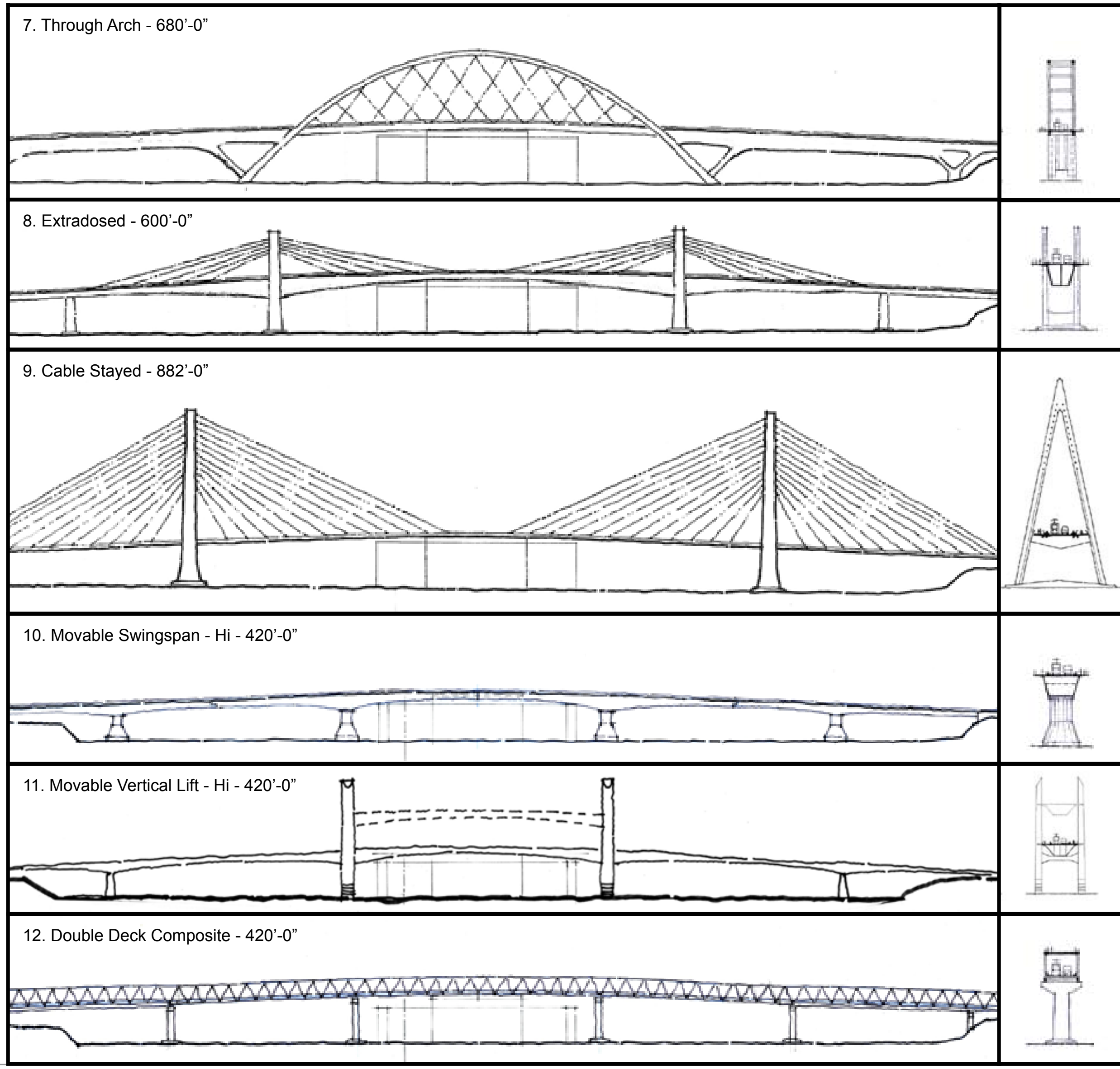
Bridge types that allowed the needed horizontal navigational clearance and met other selection criteria were presented and accepted by the committee, pending findings from independent experts regarding horizontal navigational clearance. Bridge types eliminated were the steel girder; steel box; sail blade girder; moveable swing span; moveable vertical lift; and double deck composite.

Willamette River bridge type study selection process

Right: Diagram showing the "many" bridge types narrowed down from the "universe" of bridge types. The figure on each title shows the maximum achievable span of the piers in feet.



Willamette River bridge type study selection process



Left: Diagram showing the "many" bridge types narrowed down from the "universe" of bridge types. The figure on each title shows the maximum achievable span of the piers in feet.

Willamette River bridge type study selection process

October 8, 2008: Narrowing from the many to some

Independent experts presented their findings on horizontal navigational clearance needs in relation to the bridge alignment, confirming the findings of technical staff. The committee agreed that a minimum span of 600 feet between the two center piers is required to serve existing river users at this location. The concrete segmental bridge type was eliminated. As a result, bridge types that met the selection criteria and remained under consideration included tied arch, through arch, two-pier cable-stayed, four-pier cable-stayed and wave frame.

November 13, 2008: Narrowing list from some to a few

Technical staff further evaluated the remaining five bridge types and presented the committee with detailed reports on the risks associated with building each one. Examples of such risks include cost escalation, geotechnical issues, navigational permitting, construction schedule delay and in-water construction. The committee reached consensus on moving forward with consideration of the wave frame and two variations of the cable-stayed bridge types, eliminating the tied arch and through arch types. Both arches relied on four in-water piers making them perform poorly against key criteria such as environmental impacts. The wave frame and four-pier cable-stayed types both assumed two in-water piers and two piers on land. For the two-pier cable-stayed bridge type, both piers would be located in the water.

December 11, 2008: Reviewing design, cost and risk of few

Specific risk, constructability and cost estimates for the wave frame and cable-stayed bridge types were presented. Independent estimates were prepared by the project's bridge architect consultant and by a national construction consulting firm. Differences in the estimates led the committee to ask for more detail on the costs of the wave frame and cable-stayed options. Additionally, the committee requested staff to present more concepts on the best features of the two remaining cable-stayed options.

February 5, 2009: Bridge type recommendation

Staff provided the WRBAC with a detailed presentation on various design options and possibilities for a cable-stayed type. Staff also provided refined estimates on the cost to build the two- and four-pier cable-stayed bridges as well as the wave frame bridge. The estimates showed that the wave frame bridge type had a substantially higher estimated cost than the cable-stayed bridge type, due primarily to the greater quantity of steel and the difference in type of steel needed. Committee members considered the wave frame cost estimates prohibitive given the project budget. The committee recommended a cable-stayed bridge type for the project and charged project staff with ensuring that the final design of the bridge corresponds to the context in which the bridge will stand.

For agendas, presentations and meeting summaries from all of the WRBAC's meetings visit *trimet.org/pm/library/bridge.htm*

WRBAC bridge type recommendation

The Willamette River Bridge Advisory Committee recommends that a cable-stayed bridge type be implemented for the bridge alignment of the Portland-Milwaukie Light Rail Project. Cable-stayed bridges have been designed and built to fit a variety of settings around the world. A cable-stayed bridge over the Willamette River would be the first of its kind in Oregon and one of the few such bridges on the West Coast.

A cable-stayed bridge is a bridge that consists of one or more towers from which cables are strung to support the bridge deck. The cables are usually attached in one of two ways:

- In a harp design, the cables are attached to the towers so that the height of attachment of each cable on the tower approximates the distance from the towers along the deck to the cable's deck attachment.
- In a fan design, the cables all connect to or pass over the top portion of the towers.

Cable-stayed bridge types are efficient at spanning long distances, which allows a reduction of the number of piers in the water. Fewer in-water piers reduces the long-term environmental impact of the structure. In addition, the cantilevered construction reduces environmental impact during construction.

Less cable is needed for this bridge type, and in comparison with steel girder bridge types, less steel would be required. Cable-stayed bridges also can be designed with thinner decks than other bridge types, making possible a more transparent structure on the city skyline and a greater vertical navigation clearance.

Example of a harp design. Image used under a Creative Commons license.
Source: flickr.com/photos/sunnyuk/3280680745/

Example of a fan design. Image used under a Creative Commons license.
Source: flickr.com/photos/limowreck666/146131114/

WRBAC bridge type recommendation

Conceptual rendering of a cable-stayed-suspension hybrid bridge type as viewed from above.

Conceptual rendering of the deck of a cable-stayed bridge type.

Conceptual rendering of an overlook on a cable-stayed bridge type.

WRBAC bridge type recommendation

Pont de Bourgogne in Chalon, France. Image used under a Creative Commons license. Source: flickr.com/photos/timblair/2763890552/

Second Severn Crossing between England and Wales in the United Kingdom. Image used under a Creative Commons license.
Source: commons.wikimedia.org/wiki/File:Second_Severn_crossing.jpg

Conceptual rendering of a cable-stayed bridge type as viewed from the Ross Island Bridge.

Conceptual rendering of a cable-stayed bridge type as viewed from the Willamette River.

Next steps

During the Preliminary Engineering phase (spring 2009-spring 2010) of the project, staff will work closely with the WRBAC and the community on refining and customizing the cable-stayed design to meet the unique needs of this specific application. Elements focused on during this period include consideration of:

- The final arrangement of the span and piers and their relation to one another
- The vertical clearance
- The height of the bridge deck
- The width and configuration of the cyclist and pedestrian paths and the associated overlooks
- Generation of tower design and engineering options
- Design details for cable connections to deck
- Furnishings, such as benches on the overlooks
- Finishes (paint, no paint, etc.)

Design of the bridge will be evaluated from a variety of viewpoints, such as: from a distance, in close proximity on land and on water, and from on the structure. Design of the bridge will also include consideration of customization, integrated design, and transparency and intimacy.

Customization

The design of the bridge type will be customized to correspond with the context in which the bridge will stand, including:

- The scale of the surrounding planned development and spatial qualities of the area
- The greenways and other features on either bank of the Willamette River
- Environmental considerations and opportunities such as habitat and storm water runoff
- Portland's specific "identity" and history

Integrated design

The above contexts will influence all scales of the design and result in a unified design response, including attention to:

- Tower configuration and shape
- Connection detailing
- Finishes and furnishings (railings, poles, lighting, etc.)

Next steps

Transparency and intimacy

Designers will work to incorporate elements of transparency and intimacy into the bridge by exploring the development of a sequence of experiences when moving over the bridge. This will include consideration of:

- Location of cable attachments to deck
- Design of railings and crash-barriers
- Provision of overlooks and their locations
- Maximizing and optimizing views from the bridge
- Tower detailing to address pedestrian scale and experience

Project timeline

WRBAC bridge type recommendation........................ February 5, 2009

PMLR Citizens Advisory Committee
bridge type recommendation ....February 19

PMLR open houses..............................February 20, March 4, March 10

Project Steering Committee receives
WRBAC recommendations.. March 5

Stakeholder group bridge briefings.............................. February–March

Final bridge type recommendation
reviewed by jurisdictional partners .... March 2009

Project Steering Committee Final
Bridge Type Recommendation ....May 2009

Preliminary Engineering and Final
Environmental Impact Statement.. 2009-10

Final Design 2010–11

Full Funding Grant Agreement 2011

Construction.. 2011-15

Service begins..2015

Appendix A

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WILLAMETTE RIVER CROSSING PARTNERSHIP COMMITTEE

In May 2008, the Willamette River Crossing Partnership recommended a specific alignment for the bridge to cross the Willamette River. This recommended alignment was adopted as part of the Locally Preferred Alternative in July 2008.

Mayor Vera Katz
Willamette River Crossing Partnership

Richard Brandman
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Kurt Bruun
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Additional reference

Reference materials for the Portland-Milwaukie Light Rail Project Bridge Study can be found on *trimet.org/pm*

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