

Washington State's Floating Bridges

Lessons Learned

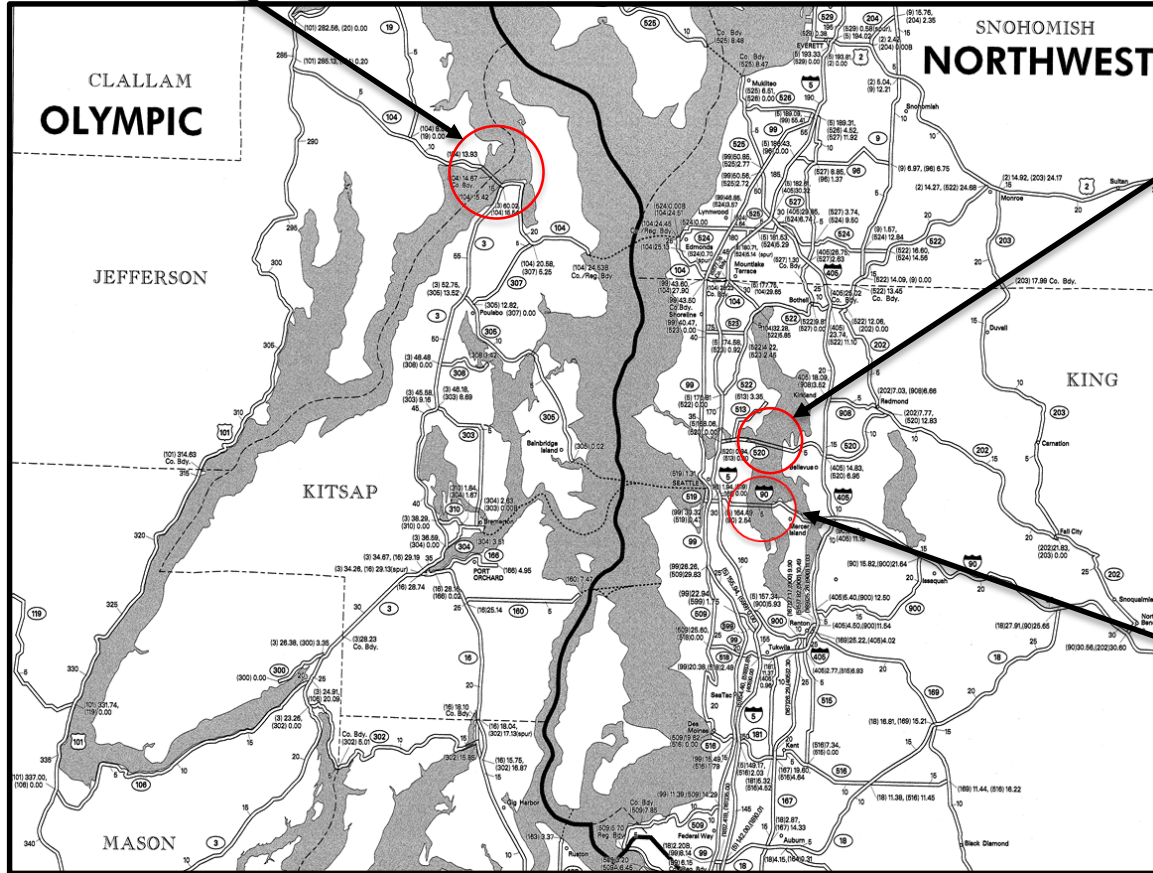
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Washington State



Puget Sound

Hood Canal Bridge



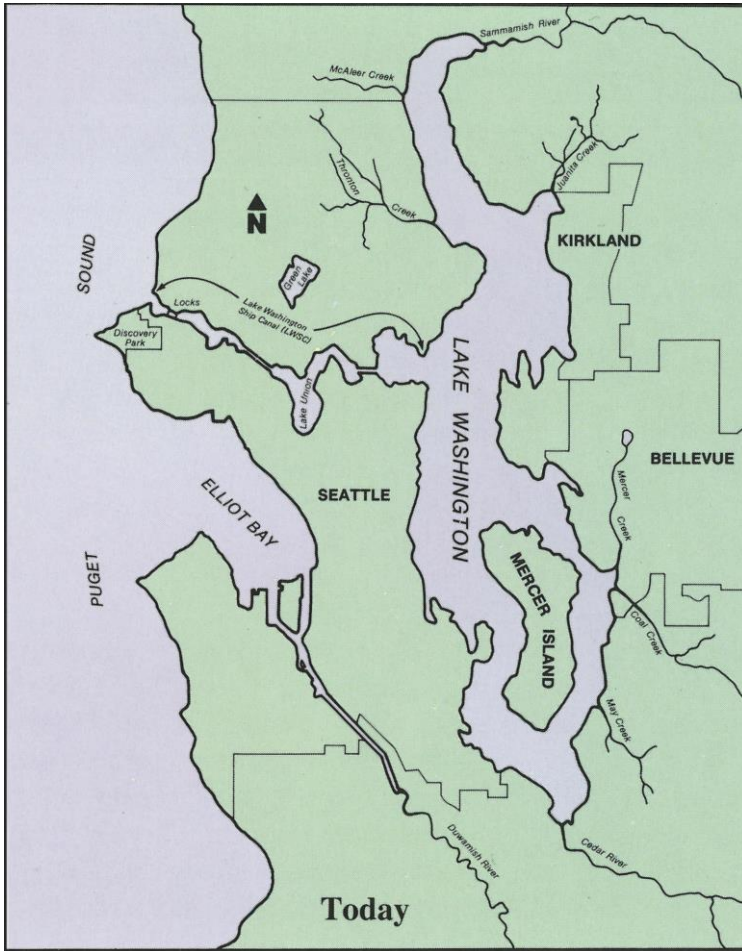
SR 520 Bridge

I-90 Bridges

Floating Bridge Location

- WSDOT has four floating bridges
- Three cross Lake Washington near Seattle
- One crosses Hood Canal, which is NW of Seattle

Lake Washington

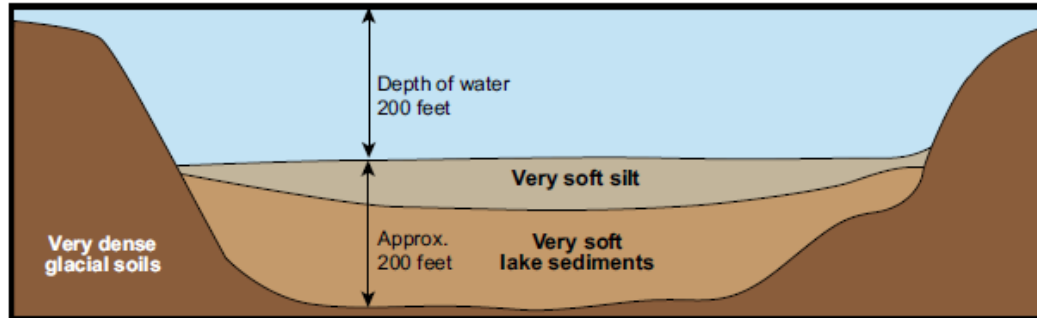


Hood Canal

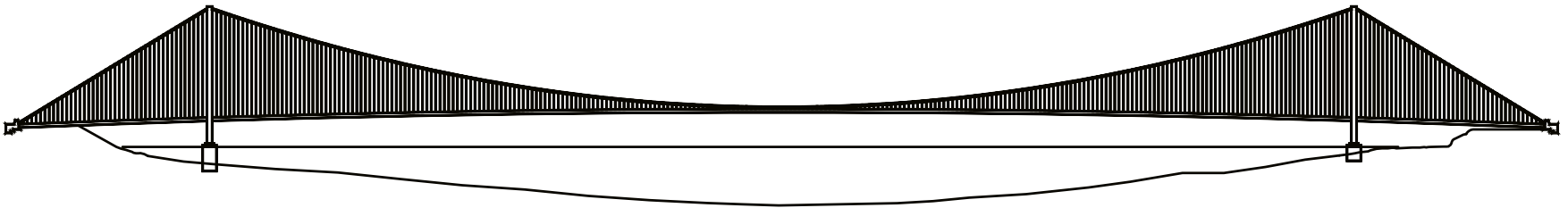


Why a Floating Bridge?

Lake Washington's topography



- Lake Washington is over 60m deep and is underlain by another 60m of very soft material.



- Typical long span bridges in these locations would require tall towers, which is out of character with the local topography.

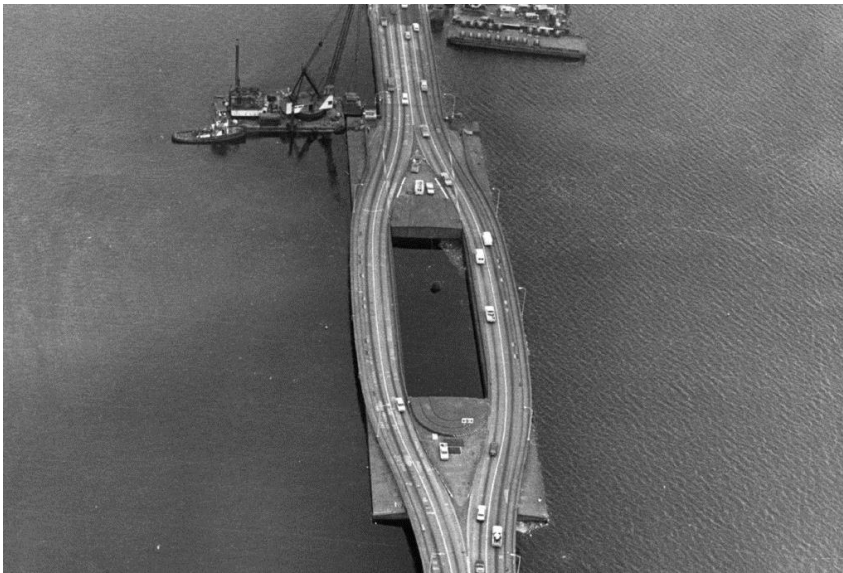
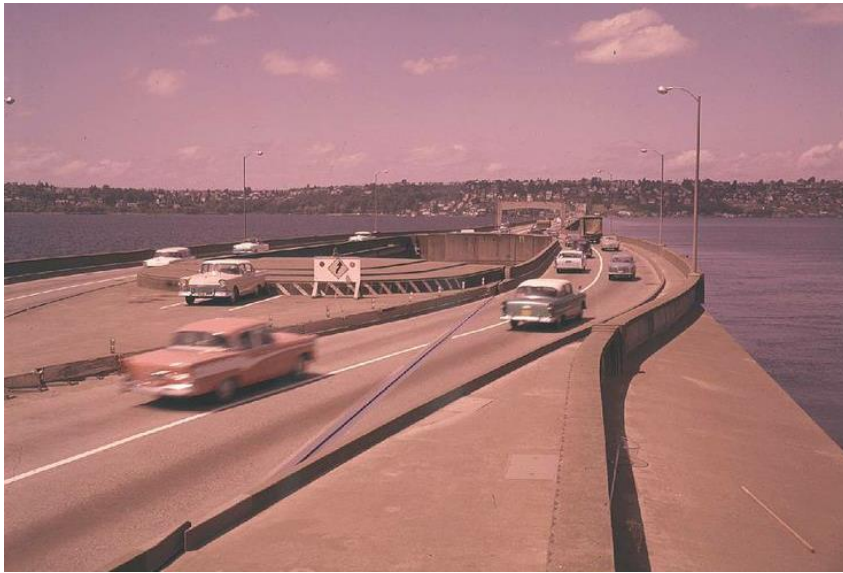


Our First Bridge

- A floating bridge between Seattle and Mercer Island was proposed as early as 1921 by Homer Hadley
- Lobbying for a bridge began in 1930
- Construction began in 1939, and the bridge opened in 1940

- Length – 2,018m
- Width – 14m
- Depth – 7m

- Featured free water ballast
- A 60m long draw span near the east end
- The bridge was formally named for Lacey V. Murrow, former Director of Washington State Highways who championed the bridge, in 1967.



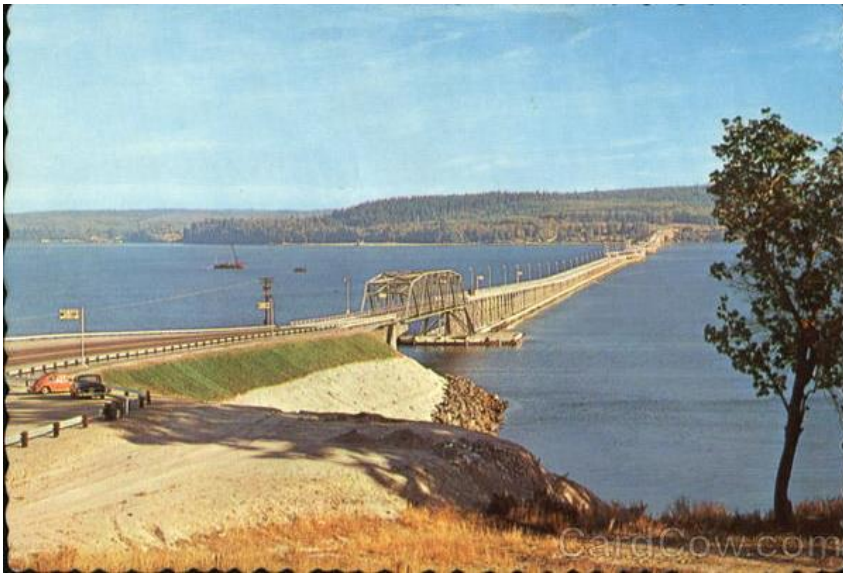
Improvements and Modifications

- LVM has seen many improvements over the years
- Elimination of free water ballast
- Draw span was removed in 1981
- Bridge was originally 4 lanes, with two way traffic
- At certain times of day, one lane would be reversed
- This led to many accidents on the bridge.



Hood Canal

- Connects eastern Jefferson county with the Kitsap peninsula.
 - Design took nearly a decade due to criticism over the bridge type.
 - Construction began in 1958 and opened in 1961.
 - Had a major positive impact on eastern Jefferson county.
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- Length – 1,957m
 - Width – 15m
 - Depth – 6.5m
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- Features a 180m draw span
 - The bridge is formally named for William A. Bugge, former Director of Washington State Highways, in 1977.



Hood Canal Sinking

- On February 13, 1979, a windstorm caused the west half of the Hood Canal bridge to sink.
- Sustained winds of 85 mph with gusts to 120 mph.
- In 1982, a new west half was opened to traffic.
- Built in phases, pontoons R, S & T were built to take the position of the west half draw.
- When the new draw was ready, R, S & T were removed and moored in nearby Port Gamble bay
- West half draw uses flanker pontoons and hydraulic lift spans instead of a “bulge”



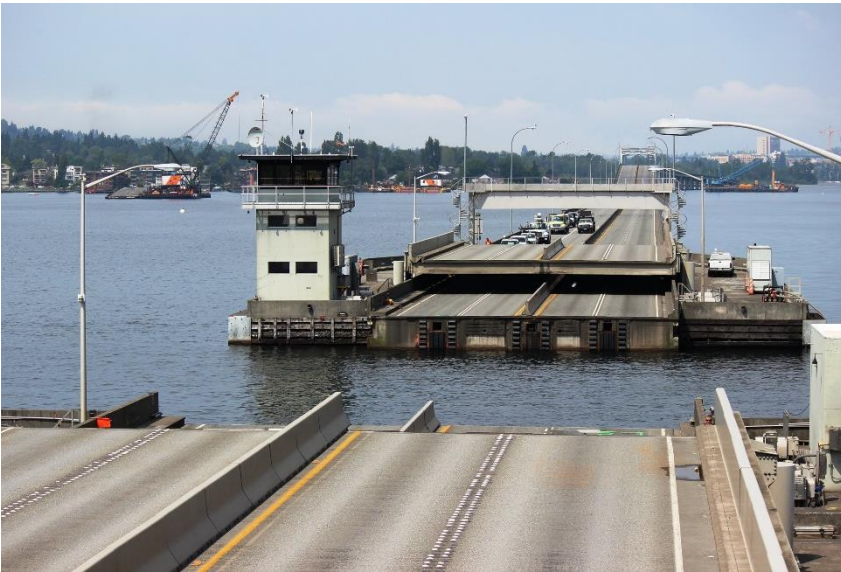


Second Lake Bridge

- Connects Seattle with Eastside communities of Bellevue, Kirkland and Redmond.
- Washington Governor Albert Rosellini advocated for its construction.
- Opened in 1963.
- So popular that a parallel span was considered as early as 1969.

- Length – 2,310m
- Width – 18m
- Depth – 5m

- Featured a 60m draw span.
- Longest floating bridge in the world.
- In 1988, it was renamed in honor of Rosellini.



Enhancements

- Plans for a parallel 520 span were rejected early on
- Bridge routinely closed for winds exceeding 50 mph
- Modernization of the draw span increased reliability and safety
- A center barrier was added
- Each half of the bridge was longitudinally post-tensioned for strengthening
- Weight of these additions reduced freeboard



Third Lake Bridge

- Built to increase capacity on Interstate 90.
- Designed for Bus Rapid Transit vehicles
- Carried two way traffic while LVM was being renovated.
- Until 2017, carried 3 lanes westbound and two reversible lanes.
- Currently being retrofitted to carry light rail trains.

- Length – 1,749m
- Width – 32m
- Depth – 6m

- Features 4.5m cantilevered deck overhangs on each side.

Disaster on Lake Washington

- The Murrow bridge closed in 1989 for renovation
- Among the modifications planned were hatches in the walls to permit maintenance access and hydro-demolition of the corners to remove curbing to widen the bridge
- During construction, the Contractor elected to temporarily store hydro-demolition water in the pontoon cells
- In some places, the side hatch holes only had 125mm of freeboard and were left open
- A windstorm hit during the Thanksgiving holiday weekend in 1990.
- Unattended during the holiday, water was allowed to enter the bridge and compromise the bridge's buoyancy
- The bridge sank on November 25, 1990





Consequences

- When LVM sank, it severed 13 of the nearby Third Lake bridge cables
- Bridge drifted 1m to the North
- Tugs were dispatched to hold the bridge in place
- Bridge was stabilized within 4 months

- Engineers feared at the time that the loss of LVM could lead to the loss of all three Lake bridges

- The Third Lake Washington bridge was formally named for Homer M. Hadley in 1993, considered by many to be the father of the floating bridge in Washington.



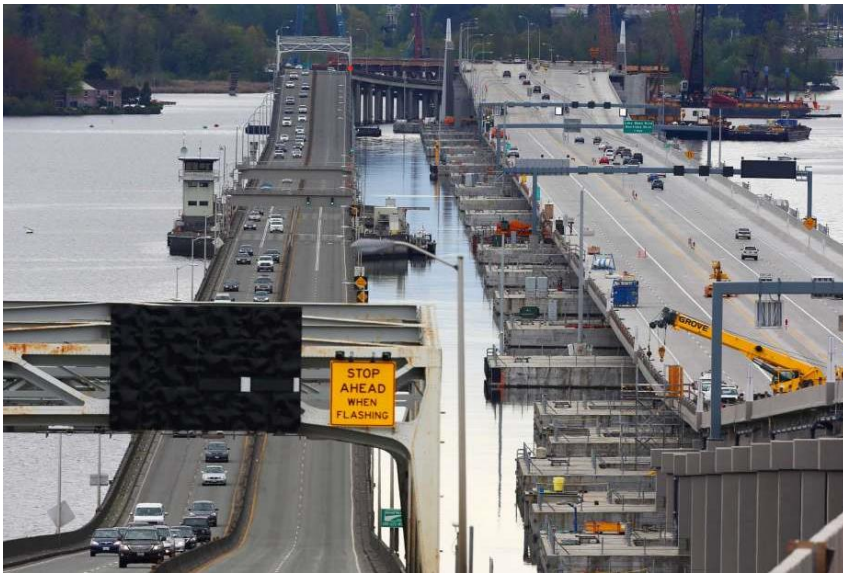
Replacement

- As a result of the sinking, the bridge re-opening was delayed until 1993
- Blue Ribbon Commission was formed by Gov. Booth Gardner to study the causes of the I-90 bridge sinking
- The new bridge was built using the experience of nearly 50 years
- Signature arches were widened
- Maintenance access cells were an addition which allow bridge crews to enter the pontoons away from traffic
- Other improvements included offset anchor galleries, dedicated in cell jacks for adjusting cable tension, full lighting, water level sensors



Replacement

- Plans to replace the ageing East half of Hood Canal began in 2003
- Both approaches were replaced
- Both transition spans replaced
- West half was widened to include a shoulder
- Features epoxy coating on all reinforcement and strand with increased cover
- Bridge re-opened to traffic in 2009



Replacement

- Plans for the replacement started in 2005
- West approach vulnerable to earthquakes due to hollow prestressed columns
- Floating bridge also vulnerable to windstorms
- New bridge features an elevated superstructure
- Modular design can accommodate up to 8 lanes of traffic and light rail
- First bridge to feature Supplemental Stability Pontons (SSP) in addition to main pontoons
- New bridge opened to traffic in 2016

Lessons Learned

As a result of the Blue Ribbon Commission's Investigation into the LVM sinking:

- Work on the floating bridges is usually halted from October 1 until April 30.
- Unannounced water tight inspections are performed periodically
- A Naval Architect or Marine Engineer is consulted during major rehabilitation or replacement contracts

- Graving dock location is an important consideration
- Control of cracking during design more important than Strength of pontoons
- Designing a floating bridge for future loading and widening has been a challenge

- Contracting method, level of responsibility, contractor requirements and service life have been and will continue to be our biggest challenges



The Future for Floating Bridges

- Currently our oldest floating bridge components are the west half of Hood Canal (c. 1982)
- pontoons R, S & T also date back to 1982.
- West half girders are in poor condition and will likely require replacement within the next 5 years
- A preservation contract for Hood Canal is ongoing
- WSDOT has 210 anchor cables in it's inventory
- Anchor cables generally have a life of 25-30 years
- Anchor cable replacements will continue to be a major preservation item.



Light Rail on a Floating Bridge

- In 2017 the express lanes on I-90 were permanently closed to vehicles.
- An HOV lane was added to each direction.
- The center roadway was turned over to Sound Transit for the addition of light rail.
- Light rail will connect Seattle and the eastside by 2023.
- Track bridge assemblies will maintain rail alignment while allowing for pitch, yaw and expansion of the bridge



Maintenance

- Each corridor has a full time dedicated bridge crew
- Maintenance crews periodically adjust cable tension
- Maintain electrical and mechanical systems
- Perform structural repairs
- Maintain the cable cathodic protection systems
- Operate the draw span

Questions?

