Date: May 30, 2023

To: John Vicente
Public Works Engineering Director
City of Kenmore

From: Aaron Olson, PE
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Subject: Swamp Creek Bridge No. 5015 - Alternatives Evaluation

INTRODUCTION AND DESCRIPTION

Swamp Creek is the largest watershed in Kenmore, with its main creek channel running North-South from Everett and eventually crossing under Highway 522 in Kenmore to drain into the Sammamish River. A series of three adjacent but separate bridges carry Highway 522, the Burke-Gilman trail, and NE 175th Street over the creek.

The original Swamp Creek Bridge No. 5015 was constructed in 1951 and carries NE 175th Street over the creek. It is comprised of three spans of pre-cast concrete girders supported on timber piled bents and abutments, for a total length of 47-feet. With an overall sufficiency rating of 40.52, the bridge is nearing the end of its service life and has been progressively downgraded in condition during routine inspections. Load ratings completed in 2015 and 2023 indicate that the bridge is continuing to deteriorate but is currently safe for use and does not yet need to be posted. It is recommended that the bridge be replaced within the next 5 years.

NE 175th Street is discontinuous approximately 0.5 miles East of Swamp Creek and the bridge provides the only means of access to multiple privately owned properties along that section of road. The City of Kenmore is exploring replacement options to ensure that a new structure can be built before the existing one becomes structurally or functionally obsolete. The purpose of this memo is to evaluate structural alternatives to aid the City in selecting a preferred alternative to progress forward into full design.

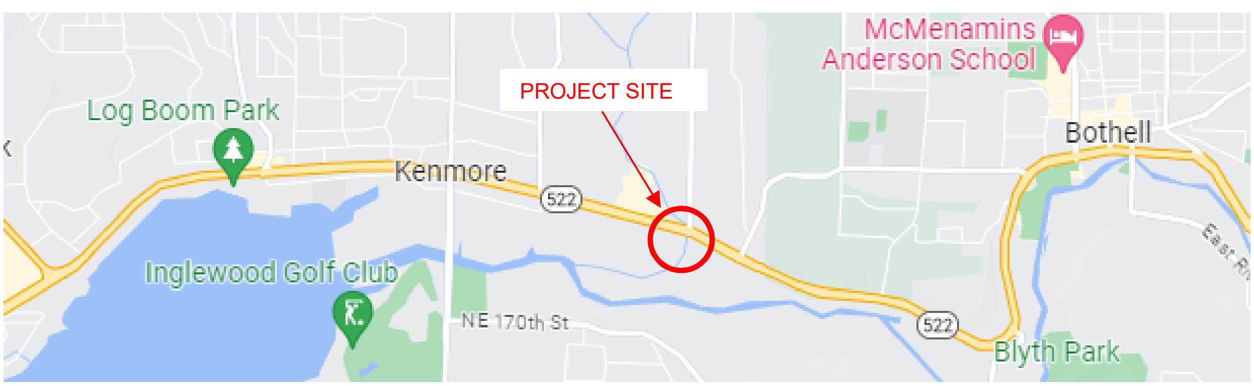

Figure 1 – Project Vicinity Map

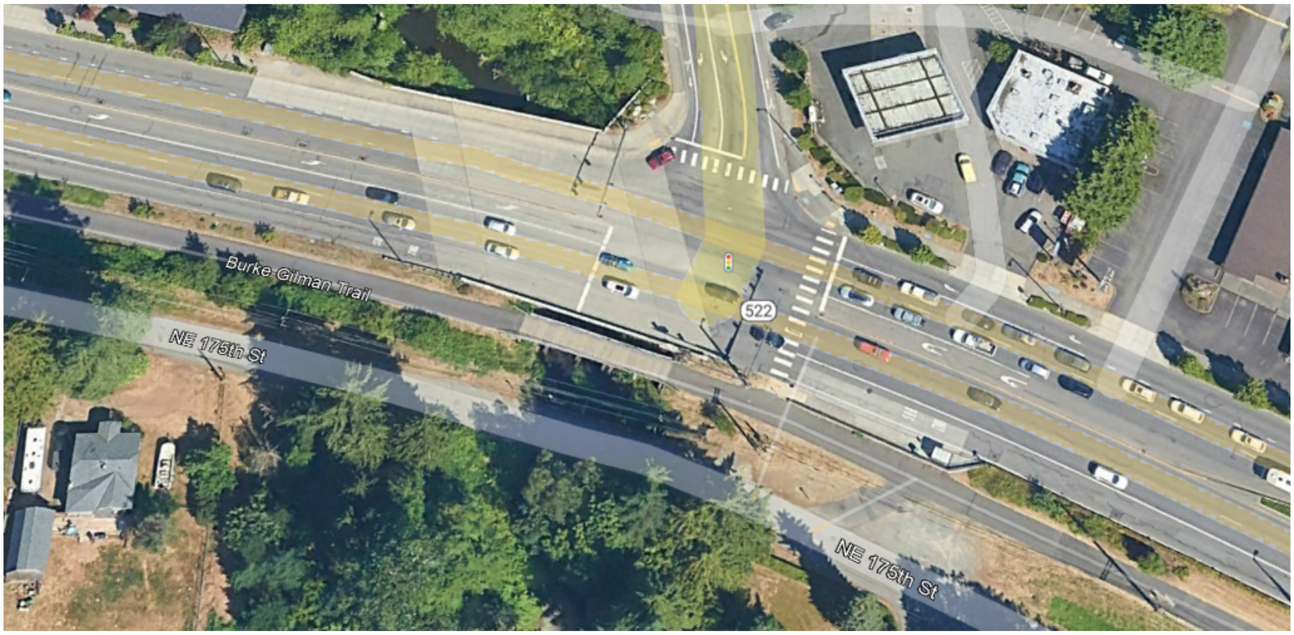

Figure 2 – Aerial View of Project Site

ASSUMPTIONS

The following design assumptions were made during the development of this report:

- NE 175th Street must remain open to local and emergency vehicle traffic during construction activities.
- The new roadway will match or vary only slightly from the existing roadway elevations and alignment.
- Hydraulic and geotechnical conditions will warrant a span length and substructure design which is similar to the existing adjacent SR 522 bridge.
- The 12-inch diameter ductile iron pipe on the South side of the existing bridge is a water line and can be temporarily closed or relocated during construction.
- Overhead power and communication lines can be temporarily relocated during construction.

DESIGN CHALLENGES AND CONSIDERATIONS

The project poses the following construction challenges:

- Close proximity to existing Burke-Gilman trail and bridge No. 2109-4 (approximately 25-feet between structures) results in limited horizontal space for installation of a temporary access bridge or roadway realignment options.
- Existing private structure(s) may make a temporary easement to connect the gap in NE 175th Street infeasible, preventing the creation of short-term local access to properties located on the East side of the bridge.
- Public safety concerns, public disapproval, or King County Parks refusal to grant temporary easement may prevent the re-routing of local vehicle traffic along the Burke-Gilman and over the 2109-4 bridge during construction.

BRIDGE ALTERNATIVES

Based on recommendations provided in the 2016 report completed by Jacobs Engineering, only full bridge replacement options utilizing pre-stressed, pre-cast concrete girders were evaluated. Two different bridge and roadway configurations were considered. Details for the alternatives are provided in the following section.

GENERAL BRIDGE COMPONENTS

Superstructure
Precast concrete wide flange deck girders and voided slab girders are commonly used throughout Washington State. This solution provides a single span girder and bridge deck combined in a single element. Neither girder type requires the additional step of constructing a cast-in-place deck after the girders have been erected. These structures are typically topped with an asphalt overlay that provides an additional wearing surface that extends the life of the girders. These elements would be fabricated at a precast plant and shipped to the site where they would be placed in their final location with large cranes.

Erection of both girder types in this location may be a challenge due to their weight and the limited space in which to set up a crane. This will likely require work access wide enough for a crane on each side of the creek, with the girder delivery truck staged along the Burke-Gilman trail.

All options presented assume 42-inch tall single-slope concrete barriers with 12-inch tall BP rail on the bridge, transitioning to guardrail off the bridge, as required.

Substructure
No geotechnical investigation was completed as part of this evaluation. 4-foot diameter drilled shafts with cast-in-place shaft caps were assumed based on the use of that same foundation type at the adjacent SR 522 bridge site.

Geometry
No hydraulic information was available at the time of this assessment. It was assumed that the creek channel width at this site should match the width provided by the more recently constructed SR 522 bridge just upstream of NE 175th Street. For this reason, an approximately 85-foot bridge length and maximum 30-degree skew was selected for all options.

Access and Staged Construction
The new foundation elements are located more than 15-feet away from the existing bridge bents. It may be possible to stage construction of the foundation elements in a way that allows a single-lane of traffic to remain on the existing bridge during shaft and shaft cap placement. The additional cost and complexity of staging construction is expected to be significant and as such the possibility of staged construction has not been considered. As noted in the previous evaluation report, there is adequate room on the North side of the existing bridge to install a temporary single-lane pre-fabricated bridge to maintain access and avoid staged construction.

ALTERNATIVE 1: REPLACE WITH SINGLE-LANE BRIDGE

Geometry
A single-lane bridge option with stop signs to facilitate one-way traffic was considered as only residential access is required East of the bridge site. The bridge would carry a single 10-foot lane with 4-foot wide shoulders on each side, for a total curb-curb width of approximately 18-feet and a center-center pier distance of 80-feet. Both alternatives assumed two 4-foot diameter shafts with cast-in-place shaft caps at each abutment as the substructure.

Alternative 1.A - Wide Flange Deck Girder
This option utilizes three lines of 39-inch deep wide flange deck girders for a total out-out bridge width of 20-feet 3-inches.

Alternative 1.B - Voided Slab Superstructure
Five lines of 3-foot deep by 4-foot 4-inch wide voided slabs can be installed for a total out-out bridge width of 21-feet 8-inches.

ALTERNATIVE 2: REPLACE WITH TWO-LANE BRIDGE

Geometry
A two-lane bridge option which matches the existing roadway width was also considered. The bridge would carry a (2) 10-foot lanes with 4-foot wide shoulders on each side, for a total curb-curb width of approximately 28-feet and a center-center pier distance of 80-feet.

Alternative 2.A - Wide Flange Deck Girder
This option utilizes five lines of 39-inch deep wide flange deck girders for a total out-out bridge width of 30-feet 2-inches.

Alternative 2.B - Voided Slab Superstructure
Seven lines of 3-foot deep by 4-foot 4-inch wide voided slabs can be installed for a total out-out bridge width of 30-feet 5-inches.

ADDITIONAL CONCEPTS CONSIDERED

Several additional structural solutions were identified during the alternatives analysis and were not developed further.

Wide Flange Precast Concrete Girders with a Cast-in-Place Deck
Precast concrete girders with a cast-in-place deck are the most commonly used bridge types in Washington State. This concept was not developed further because it would require forming and placing cast-in-place concrete over the creek. This would increase the construction duration and the cost compared to a wide flange deck or voided slab girder bridge.

Wide Flange Thin Deck Girders
Precast thin deck girders could be used in a similar manner to the wide flange deck system, but would require a concrete topping slab. This concept was not developed further because the concrete topping slab would increase the construction cost and increase the construction duration compared to the wide flange deck girder bridge.

Steel Girder Bridge
Steel girder bridges are commonly used for long-span structures, in situations where girder erection is only feasible through launching, or in cases where a lighter-weight superstructure is advantageous. Steel bridges typically need to be repainted every 25-years and are known to have a higher overall maintenance cost during the structure lifespan when compared to concrete girders.

COST AND CONSTRUCTABILITY CONSIDERATIONS

Constructability for both girder superstructure types will be very similar and straightforward. In general, the wide flange deck girder will be lighter and may be possible to set using a single crane. The two-lane option provides more opportunity for staged construction and potential to eliminate the need for a temporary access bridge, but it would add complexity to construction and could increase the cost and duration of the project.

Cost breakdowns for the alternatives considered are included in the table below. The breakdowns provided show the rough distribution of costs for each part of the project. Costs associated with construction of the creek channel are not included.

	Alternative 1.A Deck Bulb Tee	**Alternative 1.B Voided Slab**	**Alternative 2.A Deck Bulb Tee**	**Alternative 2.B Voided Slab**
Bridge Length (ft)	82.8	82.8	82.8	82.8
Curb-curb Deck Width (ft)	18.1	19.5	28.0	28.2
No. Girder Lines	3	5	5	7
Total Deck Area (SF)	1500.0	1620.0	2320.0	2340.0
Unit Cost per SF of Deck ($/SF)	$ 650	$ 670	$ 615	$ 645
Bridge Construction Cost	$ 975,000	$ 1,085,400	$ 1,426,800	$ 1,509,300
Removal of Existing Bridge	$ 20,000	$ 20,000	$ 20,000	$ 20,000
Allowance for Staged Construction	$ -	$ -	$ -	$ -
Temporary Detour Bridge	$ 120,000	$ 120,000	$ 120,000	$ 120,000
Roadway Approaches (15%)	$ 147,000	$ 163,000	$ 215,000	$ 227,000
Mobilization (10%)	$ 195,000	$ 218,000	$ 286,000	$ 302,000
Construction Contingency (15%)	$ 146,300	$ 162,900	$ 214,100	$ 226,400
Total Construction	$ 1,604,000	$ 1,770,000	$ 2,282,000	$ 2,405,000
Preliminary Engineering (30%)	$ 481,200	$ 531,000	$ 684,600	$ 721,500
Construction Engineering (25%)	$ 240,600	$ 265,500	$ 342,300	$ 360,750
Subtotal - Project Cost	$ 2,326,000	$ 2,567,000	$ 3,309,000	$ 3,488,000
Planning Level Contingency (30%)	$ 697,800	$ 770,100	$ 992,700	$ 1,046,400
TOTAL PROJECT COST ESTIMATE	**$ 3,024,000**	**$ 3,338,000**	**$ 4,302,000**	**$ 4,535,000**

PREFFERED ALTERNATIVE

The single-lane WF39DG superstructure option is the preferred alternative due to its low cost. Use of a single-lane, temporary access bridge on the North side of the existing structure is also recommended as it is expected to be the lowest cost and the least complex solution to maintaining residential access on the East side.

APPENDIX A: TYPICAL SECTIONS

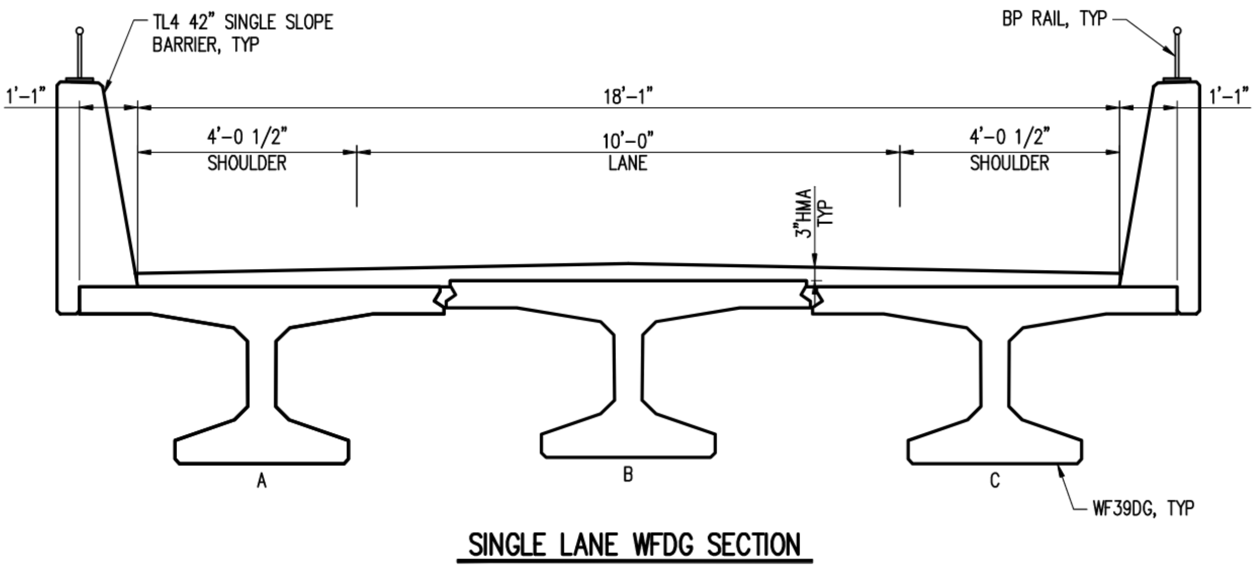

Figure A1 – Alternative 1.A Wide flange deck

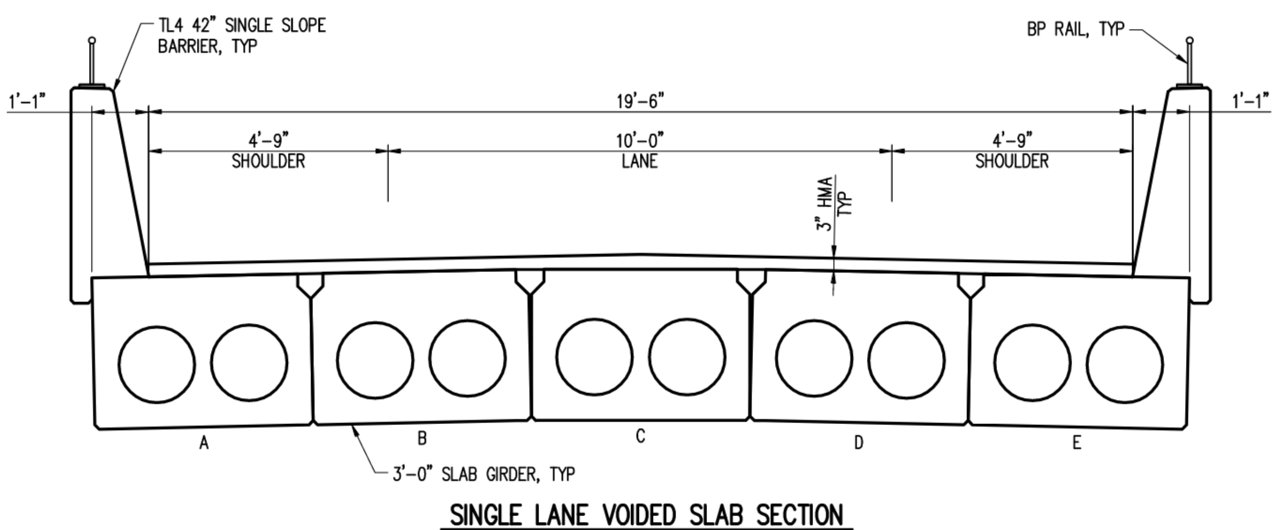

Figure A2 – Alternative 1.B Voided Slab

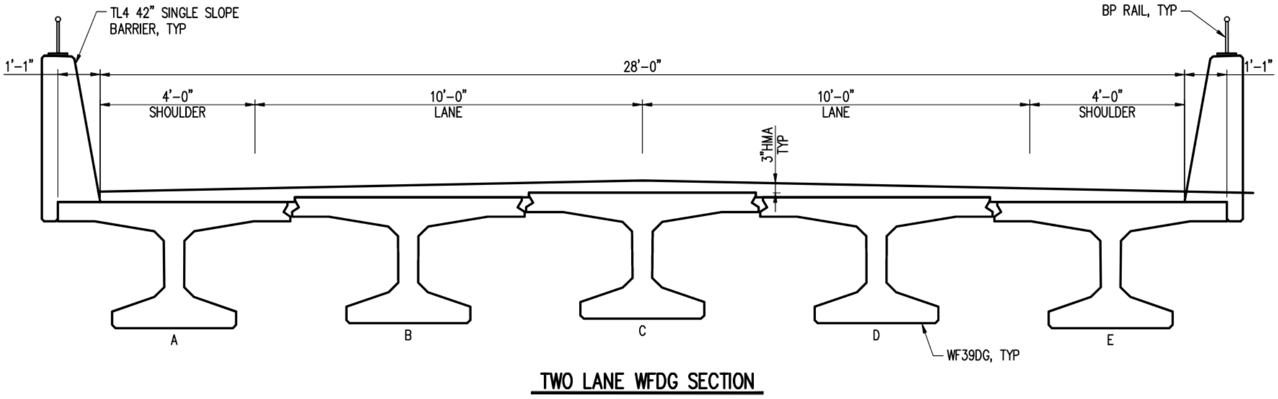

Figure A3 – Alternative 2.A Wide flange deck

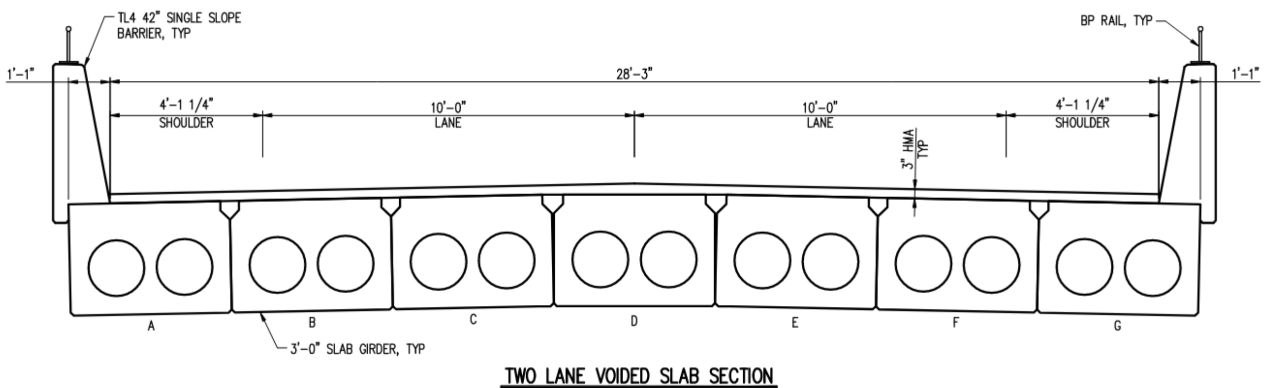

Figure A4 – Alternative 2.B Voided Slab