# Executive Summary
# Evaluation of Seismic Retrofit Options for the Alaskan Way Viaduct

Stakeholders Advisory Committee Briefing
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## Scope of Investigation

In May 2008, the Tri-Agency Partnership contracted with KPFF Consulting Engineers (KPFF), as part of the Independent Project Management Team, to provide an independent review of seismic retrofit options for the double-deck portion of the existing Alaskan Way Viaduct (AWV) structure along the central waterfront. While many options are under consideration for addressing the aging Alaskan Way Viaduct, including replacement with a new viaduct or tunnel, or demolition without replacement, our study focused exclusively on evaluating the advisability of pursuing a seismic retrofit of the existing structure.

In performing this review of retrofit options, we examined key retrofit evaluation and design documents covering the period June 2001 to April 2008. These documents are summarized in Table 1. The documents in Table 1 represent the opinions and findings of various advisory panels, consultants, and the Viaduct Preservation Group (VPG). While these documents represent varying, and sometimes conflicting, opinions on the advisability of retrofitting the existing Alaskan Way Viaduct, we evaluated each document separately, and on its own merits. Following these evaluations, we formulated overall findings, based on a collective review and comparison of all the documents. A summary of our significant findings based on the reports reviewed is presented below.

The Tri-Agency Partnership has determined certain Guiding Principles that shall be applied to evaluation of any proposed plan for retrofitting or replacing the Alaskan Way Viaduct:

1. The plan shall improve public safety
2. The plan shall provide efficient movements of people and goods now and in the future
3. The plan shall maintain or improve downtown Seattle, regional, the port and state economic vitality
4. The plan shall enhance Seattle's waterfront, downtown and adjacent neighborhoods as a place for people
5. The plan shall create solutions that are fiscally responsible
6. The plan shall improve the health of the environment

Because this evaluation report is primarily technical in nature, and focuses on seismic behavior, it does not address all of the Guiding Principles listed above. However, in the discussion below, where applicable, the relevant Guiding Principles are cited. For example, Guiding Principle 5, Fiscal Responsibility, results in the Tri-Agency Partnership's commitment to providing a long-term, rather than short-term solution. Thus, the Tri-Agency Partnership has resolved that a fiscally responsible solution shall have the same life expectancy of a new structure designed according to current AASHTO and WSDOT standards: 75 to 100 years.

**Summary of Findings**

The existing Alaskan Way Viaduct (including foundations), is in an advanced state of deterioration, and is approaching the end of its functional life. Deterioration of the viaduct is an ongoing process, primarily brought about by long-term intrusion of salts (chlorides) into the concrete, which results in continuing corrosion of steel reinforcing bars (Ref. 1, pages 13 to15). A second cause of continued deterioration of the viaduct is the compromised condition of some foundation piles following the Nisqually Earthquake. In areas with liquefiable soils, the earthquake caused loss of adhesion between the piles and the surrounding soils. This loss of adhesion increased the load carried by the tips of the piles, which reduced the overall capacity of the piles. This reduction in pile capacity (while at the same time the loads acting on the piles remain unchanged) will likely lead to long-term settlement of those piles. (Ref. 7, page 4)

For these reasons, if the existing viaduct structure is retrofitted, deterioration of the original, underlying, structure will continue. Thus, the maximum remaining life of the viaduct structure, regardless of the retrofit scheme, is approximately 25 years (Ref. 1, page 14). This life-span does not meet the fiscally responsible, long-term solution criterion, Guiding Principle 5.

There exists a significant probability of soil liquefaction over much of the double-deck portion of the viaduct in the event of a significant earthquake. A recent study (Ref. 15, page 13) stated that widespread soil liquefaction is likely to occur during an earthquake with a 1-in-20 chance of occurrence in the next 10 years. In areas where liquefaction occurs, the soil pressures acting on the seawall will triple (Ref. 15, page 13), resulting in failure of the seawall. Collapse of the seawall will lead to significant lateral ground movement around the viaduct foundations. According to a geotechnical evaluation of foundation capacities (Ref. 4), liquefaction would lead to failure of approximately 50 percent of the foundation piles supporting the central portion of the viaduct (the segment from approximately Pike Street to Dearborn Street). Thus, soil liquefaction is a critically important factor in the seismic performance of the seawall and the viaduct foundations. Improvements to viaduct foundations and the seawall must be an integral part of any plan to retrofit or replace the viaduct. This is in accordance Guiding Principle 1, because improving the viaduct superstructure, without improving the viaduct foundations and the seawall, would not significantly improve public safety.

An earthquake that would cause partial or complete structural collapse of the existing double-deck portion of the viaduct has an even higher probability of occurrence than the earthquake that would cause soil liquefaction, seawall collapse and foundation failure (discussed above). Whereas the probability of an earthquake that would cause soil liquefaction is approximately a 1-in-20 over the next 10 years, the probability of an earthquake that would cause partial or complete structural collapse of the existing viaduct is twice as high: approximately a 1-in-10 chance over the next 10 years (Ref. 15, page 1).

Thus, the seismic risks associated with catastrophic damage to the existing viaduct structure, foundation, and seawall are very high: a 1-in-20 chance in the next 10 years of extensive seawall failure and viaduct foundation failure, and a 1-in-10 chance in the next ten years of partial or complete structural collapse of the double-deck portion of the viaduct. These levels of risk far exceeds acceptable levels for public transportation structures, and highlight the urgency of replacing the existing viaduct structure. Current design standards for new bridge structures generally adopt an acceptable risk of a 1-in-100 chance in 10 years of severe damage, and the new bridge structure must be designed so that this level of damage will not initiate collapse. This is in sharp contrast to the expected collapse performance of the existing viaduct in a much smaller, more frequent, seismic event. Therefore, because current seismic risks are high, there

is an urgent need to improve the viaduct superstructure, foundations, and seawall, in keeping with Guiding Principle 1, “Improve public safety.”

The costs of all retrofit schemes proposed to date are high, compared to the cost of completely replacing the viaduct with a new elevated structure. According to WSDOT estimates, the damping retrofit scheme proposed by the Viaduct Preservation Group would cost approximately 80 percent of the cost of replacing the viaduct ( Ref. 12 and 14). A retrofitted structure would still have inadequate lane widths, no emergency shoulders, and sub-standard acceleration and deceleration lanes. A new elevated structure would have a somewhat higher initial cost than a retrofit, but would address the existing functional problems, would provide a structure designed to current AASHTO and WSDOT seismic standards, and would have an expected life of 75 to 100 years. Therefore, retrofit of the existing viaduct structure would not fulfill Guiding Principle 2, “Provide efficient movement of people and goods” or Guiding Principle 5, “Create solutions that are fiscally responsible.”

Advocates of seismic retrofit options for the viaduct have often stated that a seismic retrofit could be constructed with minimal disruption to the flow of traffic on the existing viaduct. In fact, this is not the case. Construction of any of the retrofit schemes proposed to date would result in significant and long-term disruptions to traffic both on and around the viaduct. This is because the existing condition and structural configuration (steel reinforcement layout) of the existing viaduct is so poor that the majority of structural elements (columns, beams, decks) would have to be replaced or strengthened as part of the retrofit plan (Ref. 11). For example, the “knee” and “tee” joints between columns and cross beams are weak, due to deterioration and due to design practices in the 1950s that do not come close to meeting today’s standards. This would necessitate complete replacement of many of these joints. Replacement of a “knee” or “tee” joint requires temporary support of the cross beams and roadway deck associated with that joint. This temporary support could not be accomplished without blocking traffic both on and around the viaduct, resulting in closure of the viaduct for a total of many months or years during the retrofit construction process.

When considered together, the above findings lead us to conclude that a retrofit approach to improving the Alaskan Way Viaduct is neither technically or fiscally prudent.

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| No. | Date | Title | Author(s) | Pages | Notes |
|---|---|---|---|---|---|
| 1 | 28-Jun-01 | Alaskan Way Viaduct, Report of the Structural Sufficiency Review Committee | Clark, Gerwick, Goodyear, Grant, Mast, Stanton | 37 | |
| 2 | 24-Apr-02 | Alaskan Way Viaduct, Phase 1 - Retrofit Option, April 24, 2002; and cover letter from committee chair Theodore Bell, July 12, 2002 | ASCE Expert Team: Arnold, Baska, Bell, Locke, Mageau, Myhre, Sand, Scott, Symonds, Tuttle, Upsahl | 11 | |
| 3 | Aug-02 | Rebuild/Retrofit Alternative Report | PB, Inc. | 47 | Superseded by "Rebuild/Retrofit 500 report" April 2003 |
| 4 | 17-Jan-03 | Preliminary Deep Foundation Engineering Analyses, Existing Piles, Alaskan Way Viaduct Project | Shannon & Wilson | 12 | Memorandum from S&W to PBQD and Jacobs Civil |
| 5 | Apr-03 | Rebuild/Retrofit 500 Executive Summary, 500-year Design Earthquake | PB, Inc. | 8 | |
| 6 | Apr-03 | Rebuild/Retrofit 500, 500-Year Design Earthquake | PB, Inc. | 76 | |
| 7 | 2005 | Alaskan Way Viaduct Summary: Safety and Service Limitations of the Alaskan Way Viaduct | T.Y. Lin International | 5 | |
| 8 | 6-Jun-06 | Letter from Victor O. Gray to WA State Secretary of Transportation Douglas B. MacDonald (Re: Gray's cost estimate for retrofit) | Victor O. Gray | 8 | |
| 9 | 5-Jul-06 | Proposed Retrofit of Alaskan Way Viaduct Using Fluid Viscous Dampers: Preliminary Phase | Miyamoto International, Inc. | 23 | |
| 10 | 27-Jul-06 | Letter from Ronald J. Paananen, WSDOT Project Director, Alaskan Way Viaduct and Seawall Replacement Project to Victor O. Gray | Ronald J. Paananen | 8 | |
| 11 | 31-Jul-06 | Alaskan Way Viaduct, Evaluation of Gray's Retrofit Proposal | T.Y. Lin International | 168 | Technical evaluation of Gray's original proposal |
| 12 | 11-Nov-06 | Cost Report: AWV - TY Lin Retro | Ken Fiorentino, Jacobs Civil | 16 | Detailed cost estimate for TY Lin/Gray retrofit |
| 13 | 4-Dec-06 | Report of the ASCE Viaduct Review Committee | ASCE Viaduct Review Committee | 24 | Review of Gray's revised proposal |
| 14 | 20-Dec-06 | Summary of Cost estimate revisions by Victor O. Gray for Gray's retrofit concept | PB, Inc. | 6 | Compares WSDOT ERP Review, E-C1, 9/06, WSDOT estimate for Gray's proposal, and Gray's comments on estimates |
| 15 | Nov-07 | Seismic Vulnerability Analysis Report | PB, Inc. | 82 | |
| 16 | 24-Apr-08 | “The Viaduct: A Stakeholders Marathon” letter to Stakeholders Advisory Committee, with attachments | Victor O. Gray | 8 | |

Table 1. Documents reviewed during evaluation of retrofit options.

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