OLYMPIC PIPELINE BRIDGE ASSESSMENTS

1.0 INTRODUCTION

The Olympic Pipeline Company plans to construct a 227 mile underground pipeline extension to convey petroleum products from an existing line near Woodinville, Washington to a terminal facility in the Tri-Cities area. The pipeline may utilize several existing bridges along an abandoned railroad line. The purpose of this study is to assess these bridges for their capability of supporting the pipeline and their ability to withstand expected ground motions due to earthquakes.

The assessment included visiting each of the bridges to document the configuration, construction details, site conditions and physical condition. No drawings or documentation were available for review. This assessment represents our engineering opinion based the information that be could readily obtained from a visual survey of the bridges. Dames & Moore's professional services are performed using the degree of care and skill ordinarily exercised under similar circumstances by reputable design professionals practicing in this or similar localities. No warrantee expressed, or implied, is made with regards to the bridges included in this study.

Section 2 describes the construction and configuration of the bridges. The loading characteristics are discussed in Section 3 and the seismic assessment of the bridges is discussed in Section 4. Bridge #2, #3 and #4 plus the approaches to Bridge #1 and #5 are wooden trestles of similar construction and are discussed together as a group.

2.0 BRIDGE DESCRIPTIONS

A total of 10 bridges were to be included in the study. However, limited access prevented Bridges 7, 8 and 9 from being reviewed and limited the review of the Beverly Bridge. All of these bridges are part of an abandoned railroad line which has been partially converted into a bike path/pedestrian trail. The bridges are summarized on Table 2.1 discussed individually below.

Bridge #1

Bridge #1 spans the main stem of the Snoqualmie River east of the City of Snoqualmie. The main span is a 200 foot long, single-span, steel truss (Photo 1). The truss consists of built-up steel sections with riveted connections. The bridge deck consisting of wooden ties was completely removed. The truss is simply supported on abutments consisting of stacked timbers which act as a pile cap for 36 15-inch diameter wooden piles (Figure 1, Photo 2). The timbers are connected by spikes. The piles are diagonally braced and are exposed approximately 8 feet above grade. The bases of the piles were covered with river-borne sediments and debris and were not readily visible to observe for any deterioration. The south approach to the bridge is a 16-span, 218 foot long, wooden trestle of the same construction as discussed in the next section (Photo 3). The north approach had been completely removed but appeared to have been a wooden trestle approximately 125 feet long which spanned across a King County road. The bridge framing would have provided insufficient vertical clearance for the roadway.

Table 2.1 Bridge Summary

Bridge ID	Bridge	Bridge Section	Station	Length (feet)	No. of Spans	Structure
1	Snoqualmie River	North Approach	1734+50	125	0	Removed
		Main Span	1735+75	200	1	Steel Truss
		South Approach	1737+75	218	16	Wood Trestle
2	Meadowbrook Slough	Full Length	1740+00	160	10	Wood Trestle
3	Meadowbrook Slough	Full Length	1757+00	46	3	Wood Trestle
4.1	Small Stream	Full Length	1809+00	42	4	Wood Trestle
4.2	Small Stream	Full Length	1819+00	42	3	Wood Trestle
4.3	Small Stream	Full Length	1836+75	56	4	Wood Trestle
4.4	Stream	Full Length	1842+00	304	17	Wood Trestle
5	South Fork, Snoqualmie River	North Approach	1847+75	95	6	Wood Trestle
		Main Span	1848+75	105	1	Steel Truss
		South Approach	1849+75	63	5	Wood Trestle
6	South Fork, Snoqualmie River	Full Length	2011+00	146	3	Steel Plate Girder
7	Mill Creek		3140+00	?	?	Wood trestle?
8	Roaring Creek		3325+00	?	?	Wood trestle?
9	Meadows Creek		3400+00	?	?	Wood trestle?
Beverly	Columbia River	Main Span	7660+00	2000	16	Steel Truss
		Approaches		180	4	Steel Girder
		East Abutment		80	2	Concrete

Wooden Trestles, Bridges #2, 3 and 4, Bridge #1 and 5 Approaches

A total of 1026 lineal feet of wooden trestle was assessed which included the south approach to Bridge #1, Bridges #2 and #3, four separate segments of Bridge #4 and the approaches to Bridge #5 with lengths ranging from 42 up to 305 feet (Photos 4 to 7). The wooden ties had been removed from all the trestles. The trestles consisted of two sets of three 10x18" timbers bolted together spanning up to 16 feet between 5-pile group bents (Figure 2). The timbers are bolted to the pile cap beam. The piles had a maximum exposed length of 14 feet above the ground surface. The bents were braced diagonally with wooden timbers some of which were deteriorated and/or missing. The abutments consisted of timber retaining walls typically 4 feet high (Figure 2). A series of repairs were underway to these abutments which included replacing deteriorated timbers and encasing posts in concrete. Several deteriorated piles were also identified for replacement. Our investigation found the primary members to be generally in satisfactory condition with significant remaining serviceable life.

Bridge #5

Bridge #5 spans the South Fork of the Snoqualmie River in the City of North Bend. The main span is a 105 foot long, single-span, steel truss (Photo 8). The truss consists of built-up steel sections with riveted connections. The bridge decking consisted of wooden ties and was completely removed. The truss is simply supported on abutments consisting stacked timbers which act as a pile cap for 21 square timber piles and 15 14" diameter wooden piles (Figure 3, Photo 10). The timbers are connected by spikes. The piles are diagonally braced with wood timbers. The north approach is a 6-span, 95 foot long wooden trestle and the south approach is a 4-span, 63 foot long wooden trestle as discussed previously.

Bridge #6

Bridge #6 spans the South Fork of the Snoqualmie River across a fairly steep ravine just east of the City of North Bend. The bridge is 150 feet long and has three spans of 7'-6" deep, steel plate girders (Figure 4, Photo 10). The girders are stiffened by steel angles riveted to the top and bottom edges and vertically at 4'-3" spacing. The three simply-supported spans are on a slight curve and span between two 5' x 13' x 18'-6" tall concrete piers and large concrete abutments at the ends (Photos 11 & 12). The piers are skewed at approximately 45° relative to the bridge. The girders have seat lengths of approximately 4 inches. Clearance between adjacent girder spans and the concrete abutments range from 2-½ up to 6". The girders have diagonal braces between them. The wooden ties remain attached to the tops of the girders and are covered with a plywood decking. The steep river bank has large exposed cobbles and gravel with large boulders in the river.

Bridges 7, 8 & 9

These bridges are all on the railroad grade which runs along the south shore of Keechetus Lake near Snoqualmie Pass. The winter mountain snowpack prevented access to the bridges. No information was available about the bridges except that they were reported to be wooden trestles.

Beverly Bridge

The Beverly Bridge is a 2200 foot long steel bridge. Fencing and a locked gate restricted access to the bridge limiting observations to what could be seen from the river bank. Starting from an earth-filled embankment on the west shore, the bridge has 3 steel plate girder spans totaling approximately 125 feet, 11 steel truss girder spans of 125 feet extending to a central steel truss spanning 125 feet across the navigation channel, 4 more 125 foot steel truss girders spans to the east shore, a single steel plate girder spanning 80 feet over State Highway 243 and terminates with a 2-span, concrete arched, abutment (Figure 5, Photo 13). The railroad grade continues to the east on a large earth fill. Each of the steel truss spans were pinned to a base plate anchored on concrete piers (Photo 14). The seat length at the supports could not be determined from the ground nor could the expansion joint detail although it appeared that each truss was pinned to the same base plate with no provision for longitudinal translation.

The arched concrete abutment at the east end consisted of four large 6 x 8' piers. The concrete had spalled off at the corners exposing heavily corroded #8 vertical steel bars (Photo 15). Two horizontal ties spaced 30" were exposed and had corroded all the way through (Photo 16). Other cracking was evident at the corners of the piers and on the deck beams. The horizontal steel bars on the underside of the concrete deck were also exposed although the degree of deterioration could not be determined from the ground. The concrete piers in the river could not be closely observed and their condition could not be determined.

3.0 BRIDGE LOADING

The structural performance of each of the bridges was assessed in regards to their capability of supporting the pipeline, and whether they can withstand the expected ground motions at each of the sites. The vertical and lateral loads acting on the bridges is discussed below.

3.1 Vertical Loading

The pipeline is planned to be a 14-inch diameter steel pipe from Woodinville to Kittitas reducing to a 12-inch diameter pipe from Kittitas to Pasco. The weight of the pipe running full was taken as 140 pounds per lineal foot (plf) for the 14" pipe and 110 plf for the 12" pipe. These weights are insignificant compared to the design loads of the bridges and less than the weight of the rails and ties which have been removed. As a result, all of the bridges have more than adequate vertical capacity to carry the weight of the pipeline.

3.2 Lateral Loads

Ground motions due to earthquakes induce lateral loads on the bridges. The expected ground motions for each site were taken from the recently published USGS ground motion maps for a seismic event with a 10% chance of occurring every 50 years (475 year return interval). This is the typical design basis earthquake that the building codes are based on. Table 3.2 identifies the expected peak ground acceleration (PGA) as a percentage of gravity on bedrock. These values must be adjusted for the soil conditions at each site. Assumed soil amplification factors and the design level PGA are also shown.

Table 3.2 Expected Ground Motions

Site	Bridges	PGA	Soil	Soil Amplification	Design Level PGA
Snoqualmie/North Bend	1 to 5	.26 g	Silt	1.5	.39 g
North Bend	6	.26 g	Rock	1.0	.26 g
Snoqualmie Pass	7,8,9	.19 g	Unknown	Unknown	Unknown
Beverly	Beverly	.09 g	Gravels	1.25	.11 g

4.0 SEISMIC ASSESSMENT

The seismic performance of the bridges are discussed individually below. A relative seismic performance rating as defined in Table 4.1 is assigned to each bridge. Where deficiencies are identified, possible mitigation measures and their relative ease of implementation are discussed. Also discussed are possible non-structural problems associated with installing the pipeline on the bridges.

Table 4.1 Seismic Performance Rating Definitions

Performance Ranking	Seismic Vulnerability	Structural Performance	Operational Performance (Down time)
1	Low	No damage expected	None
2	Low to Moderate	Minor damage possible	1-2 days
3	Moderate	Local damage possible, collapse not likely	Weeks
4	High	Major damage, failures possible	Months
5	Very High	Severe damage, collapse likely	> 3 months

Bridge #1

The main span truss superstructure is not highly susceptible to being damaged during an earthquake. However, the wooden timber abutments are only lightly tied together and are susceptible to movement primarily in the longitudinal direction. This could potentially unseat the truss support resulting in gross deflection and possible rupture of the pipeline. An additional concern is with relative movement between the approach trestle and the truss span which could stress the pipeline. Adequate expansion and flexible joints should be included in the pipeline to compensate for this movement. The expected performance of this bridge is rated at level 3. The performance could be improved to level 2 by adding steel brackets, holddowns and bolts through the timbers to tie the abutments together and by stiffening the northernmost pier on the wooden trestle to reduce relative deflections between the trestle and truss abutment.

The pipeline would need to be installed on top of the bridge deck in order to provide the necessary vertical clearance over the roadway on the north side. The pipeline could easily be installed between the deck beams on the wooden trestle.

Wooden Trestles, Bridges #1 to 5

The wooden trestles are not highly susceptible to being damaged by severe ground shaking. The wooden piers and deck beams should have adequate stiffness to limit lateral deflections and adequate seat lengths of the beams should prevent the beams from sliding off their supports. The performance of the shorter trestles is rated at level 1. The longer trestles (#2 & 4.4) and the bridge approaches are more flexible and could experience deflections relative to the adjacent abutments which could stress the pipeline. These trestles are rated at performance level 2. The supports could be stiffened by adding diagonal bracing.

All of the piles and diagonal bracing should be closely inspected for deterioration and replaced as required. The pipeline could easily be installed between the deck beams although on the shorter trestles, it may be more appropriate to install the pipeline in a buried trench.

Bridge #5

The main truss superstructure is not highly susceptible to being damaged during an earthquake. The wooden timber abutments are only lightly tied together and are susceptible to movement primarily in the longitudinal direction. This could potentially unseat the truss support resulting in gross deflection and possible rupture of the pipeline. An additional concern is with relative movement between the approach trestles and the truss abutments which could stress the pipeline. Adequate expansion and flexible joints should be included in the pipeline to compensate for this movement. The expected performance of this bridge is rated at level 3. The performance could be improved to level 2 by adding steel brackets, holddowns and bolts through the timbers to tie the abutments together and by stiffening the trestle piers adjacent to the truss abutments to reduce relative deflections.

Bridge #6

The main steel girder superstructure is more than adequate to carry the pipeline and is not highly susceptible to being damaged during an earthquake. The girder spans are adequately braced against each other and will essentially act as a rigid unit. However, the spans are only lightly attached to the abutments and concrete piers. The concern is that the girder could work its way off its support resulting in gross deflection and possible rupture of the pipeline. The 4 inch seat lengths should be adequate to prevent this from occurring in all but the most severe earthquakes. The seismic performance of this bridge is rated at level 3. Strengthening the girder anchorage or installing stops to prevent the girders from becoming unseated would improve the performance to level 1.

This bridge is currently used as an active pedestrian path which could complicate construction. The pipeline could easily be installed beneath or along side the steel girders although the concrete abutments may have to be core-drilled.

Bridges 7, 8 & 9

No information was available regarding these bridges except that they were reported to be wooden trestles. Depending on their length and configuration, the seismic performance could vary but wooden trestles generally are not highly susceptible to damage from ground vibrations. The expected seismic performance of these bridges is anticipated to be at least level 3 and more likely, level 2. This would need to be verified following observation of the bridges.

Beverly Bridge

The information regarding the Beverly Bridge was limited to what could be observed from the ground preventing some important construction details from being documented. Of primary importance is the details at support points of the trusses and the expansion joints. For a bridge of this length and with multiple spans, these details determine whether the entire bridge will respond as a single unit, or the individual spans respond independently. Further investigation is warranted to make a full assessment of the seismic performance of the bridge.

An obvious deficiency in the bridge is the east arched concrete abutment with the severe spalling and corrosion of the reinforcing steel. The cracking was evident up the columns and on the bridge deck indicating that the corrosion may be widespread. It is unusual to see such severe corrosion on a bridge located a semi-arid region suggesting that a chloride additive may have been used in the concrete mix. The horizontal ties were observed to be spaced at 30" which is excessive to adequately confine the concrete. The corrosion to the horizontal ties greatly increases the severity of the problem. The concrete abutment is susceptible to sudden brittle failures during an earthquake. Further investigation would be necessary to fully address this issue. The preliminary seismic performance rating of this bridge is level 4 due to the possibility of brittle failures of the concrete abutment. The bridge in its current condition is probably not suitable for installing the pipeline on. Any upgrade of the bridge would likely be fairly substantial and costly.

5.0 SUMMARY

The findings in the prior sections are summarized on Table 5.1. With the exception of the Beverly Bridge, all the bridges were found to be suitable for carrying the pipeline provided the relatively simple modifications are made. The design and detailing of these modifications and the further investigation of the Beverly Bridge and the three bridges near Snoqualmie Pass was beyond the scope of this study.

Table 5.1 Summary

ID	Bridge	Performance Rating	Seismic Concerns	Recommendations
1	Snoqualmie River	3	Abutments not tied together	Tie timber abutments together
			Relative deflections	Stiffen nearest pier on approach trestle
2	Meadowbrook Slough	2	Relative deflections	Stiffen piles adjacent to abutments
3	Meadowbrook Slough	1	None	
4.1	Small Stream	1	None	
4.2	Small Stream	1	None	
4.3	Small Stream	1	None	
4.4	Stream	2	Relative deflections	Stiffen piles adjacent to abutments
5	South Fork, Snoqualmie River	3	Abutment not tied together	Tie timber abutments together
			Relative deflections	Stiffen nearest piers on approach trestles
6	South Fork, Snoqualmie River	3	Girder anchorage	Anchor girders or provide stops
7	Mill Creek	2	Unknown	Site visit
8	Roaring Creek	2	Unknown	Site visit
9	Meadows Creek	2	Unknown	Site visit
Beverly	Columbia River	4	No ductility, deteriorated abutment	Perform detailed evaluation

TECHNICAL REPORT

BRIDGE ASSESSMENTS
CROSS CASCADES PIPLINE

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