NPS Form 10-900
(7-81)

OMB NO. 1024-0018
EXP. 12/31/84

United States Department of the Interior
National Park Service

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National Register of Historic Places Inventory—Nomination Form

See instructions in *How to Complete National Register Forms*
Type all entries—complete applicable sections

1. Name

historic Historic Bridges and Tunnels in Washington State Thematic Resources

and/or common

2. Location

street & number (see individual inventory forms) ___ not for publication

city, town ___ vicinity of [redacted]

state **code** **county** **code**

3. Classification

Category	Ownership	Status	Present Use	
___ district	___ public	N/A occupied	___ agriculture	___ museum
___ building(s)	___ private	N/A unoccupied	___ commercial	___ park
XX structure	XX both	N/A work in progress	___ educational	___ private residence
___ site	**Public Acquisition**	**Accessible**	___ entertainment	___ religious
___ object	N/A in process	N/A yes: restricted	___ government	___ scientific
XX thematic group	N/A being considered	N/A yes: unrestricted	___ industrial	XX transportation
		N/A no	___ military	___ other:

4. Owner of Property

name multiple ownership

street & number

city, town ___ vicinity of **state**

5. Location of Legal Description

courthouse, registry of deeds, etc. State Department of Transportation; county courthouses;

street & number city halls

city, town **state**

6. Representation in Existing Surveys

title Historic Bridge Survey **has this property been determined eligible?** N/A yes N/A no

date January 1979 - April 1980 ___ federal XX state ___ county ___ local

depository for survey records Office of Archaeology and Historic Preservation

city, town 111 West 21st Avenue, Olympia **state** Washington 98504

Form No. 10-300a
(Rev. 10-74)

UNITED STATES DEPARTMENT OF THE INTERIOR
NATIONAL PARK SERVICE

NATIONAL REGISTER OF HISTORIC PLACES INVENTORY -- NOMINATION FORM

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Bridges Already Listed in the National Register of Historic Places:

+ Baker River Bridge
+ Cascade Tunnels: Stevens Pass Historic District ? photo ? Chelan Co
+ Devil's Corner
+ Grays River Covered Bridge
— Jack Knife Bridge
+ Lower Custer Way Crossing: Tumwater Historic District
+ Monroe Street Bridge
+ Rock Island Railroad Bridge
+ Waitsburg Bridge: Waitsburg Historic District

Bridges Determined Eligible for Listing in the National Register of Historic Places:

Lacey V. Murrow Bridge
Pasco-Kennewick Bridge
Prosser Steel Bridge
Washington Street Bridge
Orient Bridge
"F" Street Bridge
West Monitor Bridge

7. Description

Condition
___ excellent
___ good
___ fair

___ deteriorated
___ ruins
___ unexposed

Check one
___ unaltered
___ altered

Check one
___ original site
___ moved date ___________________

Describe the present and original (if known) physical appearance

The legacy of existing bridges throughout the State of Washington is one of diverse structural types - as diverse as the vast and varied terrain that they were built to traverse The primary intent of this nomination is to outline the legacy set forward by these extant structures, and to place them within the context of bridge engineering history, or within the context of their role in the social, economic, and industrial development of the locality state, region, or nation.

The nomination is the result of a systematic inventory of historic bridges throughout the state, conducted by the State Office of Archaeology and Historic Preservation (SOAHP) in cooperation with the Washington State Department of Transportation (WSDOT) and the Historic American Engineering Record (HAER) of the Department of the Interior. The inventory, which was authorized by the Surface Transportation Act of 1978 (Public Law 95-599), was funded by the WSDOT. As a result, emphasis was placed on the recording of highway bridges. However, railroad bridges and other privately-owned bridges also were inventoried.

Before the information retrieval process could begin, it was necessary to establish bottom-line criteria for the selection of historic bridges. In consultation with HAER, the SOAHP decided that all existing bridges built during or prior to 1940 would be considered for inclusion in the HAER inventory. Although this cut-off date includes bridges less than the National Register's age guideline of 50 years, it was believed that it was essential to give the WSDOT leeway to facilitate future long-range planning decisions. In addition, Washington State's context of history is much more recent than that of other areas in the United States, and it is important that the boundaries of the historic bridge inventory reflect that context. These same boundaries were used to select the bridges eligible for listing in the National Register. Because it was not possible to photograph every culvert in the state, and there are only a few rare examples of bridges less than 50 feet in length that possess engineering or historical significance, it was decided that in almost all instances only bridges greater than 50 feet in length would be included in the inventory.

In conducting the historic bridge inventory (which provided the information base for the nomination) the SOAHP attempted to evaluate all bridges built during or prior to 1940, and greater than 50 feet in length, and to place each of them in one of the following three categories:

Category I. The first category of bridges includes those bridges eligible for listing in the National Register of Historic Places. It must be emphasized that Category I bridges were not selected until the inventory was completed. The bridges were evaluated according to the general criteria stated in 36 C.F.R. Part 60.6. More specifically, those bridges included in the nomination are bridges that:

1. are significant in the history of bridge engineering, in the history of bridge design principles, and in the development of bridge construction techniques;

2. are significant in the social, economic, and industrial development of the locality, state, region, or nation;

3. are significant examples of bridges designed or built by renowned engineers;

4. are significant examples of structural designs associated with the efforts of historic individuals or groups;

5. are significant examples of an early bridge engineering effort commonly used throughout the State of Washington for a specific purpose or reason;

6. are significant early examples, or significant representative examples, of a specific bridge type;

7. are rare examples of a specific bridge type within the state;

8. possess architectural or artistic significance.

Category II includes those properties which are of historical and engineering interest, are worthy of recording through photographic and written documentation, but are not eligible for inclusion in the National Register of Historic Places. It includes the following bridge types which were constructed during or prior to 1940, and are greater than 50 feet in length: trussed bridges; arches; moveable bridges; suspension bridges; aqueducts; cantilever bridges; tunnels; steel and cast and wrought iron girders; steel viaducts. Concrete and timber slabs, beams, girders, viaducts, or trestles are included in Category II only when they are of unusual length or height; when they are socially and economically significant to the locality, state, or region; when they are particularly early examples of the bridge type; when they possess architectural or artistic significance; or when innovative design principles or building techniques have been used in bridge construction.

Category III consists of all other bridges that were constructed during or before 1940 and are greater than fifty feet in length, but are not of such quality as to be included in either Category I or II. Category III includes all concrete and timber slabs, beams, girders, viaducts, and trestles unless they are particularly early examples of the bridge type, or are of unusual length or height, or are socially and economically significant to the locality, state, region, or nation, or demonstrate the use of innovative design principles or construction techniques, or possess architectural or artistic significance.

An Historic American Engineering Record inventory card was prepared for all properties identified under Category I and II. A brief form outlining basic structural information was used to record Category III bridges. Although the individual Category III bridges are not significant enough to warrant substantial documentation, they have furnished valuable statistics on when and where builders, contractors, and fabricators worked which provided insights into bridge construction history throughout the State, and helped to formulate the context in which Category I and II bridges were built.

The examination of the WSDOT computer print-out list was the first step in the lengthy information gathering process. The list provided basic structural data on all state, county, and city-owned highway bridges that were built during or prior to 1940, and were greater than 20 feet in length. By Federal standards, any structure less than 20 feet long is not considered a bridge. Although it had been decided that the historic bridge inventory would include bridges greater than 50 feet in length, the computer print-out provided enough information to determine which bridges less than 50 feet in length had potential engineering significance, and should be included in the inventory.

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Heritage Conservation and Recreation Service

National Register of Historic Places Inventory—Nomination Form

The inventory and evaluation process was conducted on a county-by-county basis. After the raw structural data was attained, the state, county, and local highway commission files were tapped for information regarding the names of bridge builders, contractors, fabricators, and designers. The files provided recent photographs, occasionally old construction photographs, original contractual agreements, plans and drawings, and more extensive structural and design information on the bridges listed on the computer print-out sheet. This information formed the basis for determining whether the bridge would fall into Category II or III. When the inventory was completed, Category I bridges were selected from those bridges listed in Category II.

In addition to researching the state, county, and local highway commission files, bridge lists were acquired from the Burlington Northern Railroad, Inc., the Chicago, St. Paul, Milwaukee, and Pacific Railroad, and the Union Pacific Railroad. Information also was gathered on Forest Service bridges, as well as privately-owned bridges, including abandoned logging structures. However, the information gathering process for the privately-owned bridges was arbitrary, and by no means comprehensive. Because the majority of the railroad bridge records are lodged in the midwest, and there are no records remaining for many of the other privately-owned bridges, it was often necessary to rely heavily on contemporary articles about the bridges, rather than on original blueprints.

Contemporary newspaper articles, engineering journals, and bridge engineering books provided valuable source material. The national journals, Engineering News-Record and Railway Age Gazette, and the regional magazine, Western Construction News, were systematically examined for articles on the construction of bridges in Washington.

After the inventory cards were completed, and the highway commission files were integrated with the literature source material, statistical information was compiled to define the statewide context for the individual bridges. Approximately 1400 bridges were inventoried, 218 of which are railroad bridges. Ninety-five bridges have been included in the nomination, and about 500 have been listed on the HAER Inventory. Of the 1400 bridges, roughly seven percent were constructed before 1910, and approximately 20 percent were built before 1920. There are only five bridges on the inventory that were constructed before 1900.

When the ~~95~~ 89 bridges included in the nomination are discussed individually, they will be compared to other bridges within the State of a similar type. However, the following tables provide a general overview and a statewide context, by relating the bridge types included in the nomination to all bridges surveyed:

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RAILROAD BRIDGES: BREAKDOWN OF TYPES

	100 CONCRETE		200 CONTINUOUS CONCRETE		300 STEEL		400 CONTINUOUS STEEL		500 PRESTRESSED CONCRETE		600 PRESTRESSED CONTINUOUS CONCRETE		700 TIMBER	
TYPE	@	&	@	&	@	&	@	&	@	&	@	&	@	&
020	13													
-01	1													
-02	2		1		9								6	1
-03			1		35		1							
-04			2											
-05														
-06														
-07					1									
-08														
-09					8	3							2	2
-10					80	4							5	3
-11	3	3			2	2								
-12	1													
-13														
-14														
-15					1	1								
-16					2	1								
-17					10	4								
-18	30	3												
-19														
-20					7	2								

@ Surveyed
& Listed in National Register

Total number of railroad bridges surveyed: 218
Total number of railroad bridges recommended for listing in the National Register: 29
(includes those already listed, and those determined eligible)

HIGHWAY BRIDGES: BREAKDOWN OF TYPES

	100 CONCRETE		200 CONTINUOUS CONCRETE		300 STEEL		400 CONTINUOUS STEEL		500 PRESTRESSED CONCRETE		600 PRESTRESSED CONTINUOUS CONCRETE		700 TIMBER	
TYPE	@	&	@	&	@	&	@	&	@	&	@	&	@	&
020	21	1												
-01	33		24						1				2	
-02	48		8		52		5		3				186	
-03	7		9	1	28		6						2	
-04	83	1	87				1		2		1		1	
-05	8				4						1			
-06	5	1	3	1	2									
-07	1	1							2				18	
-08													1	1
-09	1		2		14	3	3							
-10	1	1	1	1	233	9	1	1					20	4
-11	111	8	14	1	3	3	2	2						
-12	8	5	2		1									
-13					1	1	1	1					10	1
-14														
-15					9	2								
-16					9	7								
-17					4	1	2							
-18	13												1	
-19	5												1	
-20	15		2		10				1				17	

@ Surveyed
& Listed in National Register

Total number of highway bridges surveyed: 1173
Total number of highway bridges recommended for listing in the National Register: 58
(includes those already listed, and those determined eligible)

KEY TO BRIDGE TYPES

FIRST DIGIT		SECOND AND THIRD DIGITS	
1	Concrete	01	Slab
2	Concrete Continuous	02	Stringer/Multi-beam or girder
3	Steel	03	Girder and Floorbeam system
4	Steel continuous	04	Tee beam
5	Prestress concrete	05	Box beam or girders - multiple
6	Prestress concrete continuous	06	Box beam or girders - single or spread
7	Timber	07	Frame
8	Masonry	08	Orthotropic
9	Aluminum, wrought iron or cast iron	09	Truss-deck
0	Other	10	Truss-through
		11	Arch-deck
		12	Arch-through
		13	Suspension
		14	Stayed girder
		15	Movable-lift
		16	Movable-bascule
		17	Movable-swing
		18	Tunnel
		19	Culvert
		20	Other or Combination

8. Significance

Period	Areas of Significance—Check and justify below			
N/A prehistoric	___ archeology-prehistoric	___ community planning	___ landscape architecture	___ religion
___ 1400–1499	___ archeology-historic	___ conservation	___ law	___ science
___ 1500–1599	___ agriculture	___ economics	___ literature	___ sculpture
___ 1600–1699	___ architecture	___ education	___ military	___ social/ humanitarian
___ 1700–1799	___ art	X engineering	___ music	___ theater
___ 1800–1899	___ commerce	___ exploration/settlement	___ philosophy	X transportation
___ 1900–	___ communications	___ industry	___ politics/government	___ other (specify)
		___ invention		

Specific dates N/A **Builder/Architect** N/A

Statement of Significance (in one paragraph)

PREFACE: EXPLANATION OF METHODOLOGY

The existing historic bridges and tunnels throughout Washington transmit a legacy that is multifaceted. The structural systems of the individual bridges poignantly reveal the evolution of bridge design and technology from both a national and regional perspective. In addition, each individual structure cannot be isolated from the transportation system of which it is an integral part. The significance of the bridges and tunnels has been interpreted within this dual context.

Early bridge construction within the state is tightly linked to the development of the railroads within the state. There are seventeen bridges and tunnels in the nomination that have been a significant part of the state's early railroad development, and were discussed within this context. Four structures were treated from the perspective of their association with the early highway bridge construction over the Columbia River, and five structures were discussed in terms of their role in logging and mining transportation systems. Most of the twenty-six bridges and tunnels that were evaluated primarily in terms of the transportation systems of which they were a significant part, also were discussed in terms of their structural significance.

The nomination does include a number of structures that are less than fifty years old. As was stated earlier, the nomination mirrors the criteria set by the initial inventory. There is only one structure that was constructed after 1940, the cut-off date set by the inventory. This is a 250 foot log cable-stayed girder bridge, and is one of the first of its type to be constructed within the United States. Its parts are composed of untreated logs which are extremely susceptible to the ravages of time. Consequently, it is essential that this unusual structure is acknowledged and documented without delay.

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F. Suspension Bridges

I. BRIDGES THAT REFLECT RAILROAD DEVELOPMENT IN WASHINGTON STATE

The construction of the earliest bridges and tunnels of major proportions within the State is associated with the construction of the transcontinental railroads. It was in 1864 that the Northern Pacific Railroad was chartered by Congress to build a mainline from Lake Superior to Puget Sound. However, it was not until 1883 that the Northern Pacific established a route between Duluth and Puget Sound by means of connecting its line to the existing Oregon Railroad and Navigation Company line along the south bank of the Columbia River. The two systems were linked by two car ferries: a car ferry across the Snake River which connected with a short railway spur that ran to Wallula, and a car ferry across the Columbia River between Portland and Kalama which connected with the Northern Pacific line that ran between Kalama and its terminus at Tacoma. This circuitous route to Puget Sound was feasible only because of daring financial manipulations made by the northwest railroad magnate, Henry Villard. Although the railroads retained their individual corporate identities, Henry Villard obtained control of both systems. However, in January of 1884 Villard's empire collapsed, and the two railroads reverted to separate control.[1]

Once again cut off from Puget Sound, the Northern Pacific immediately began work on a route across the mountains. The Pasco-Kennewick Bridge (1), the first bridge to be built across the Columbia River, was constructed as a temporary structure in 1888 as part of the Northern Pacific's effort to redirect its route across the mountains. By 1887, a treacherous, temporary switchback was in service over the mountains through Stampede Pass. The completion of the two mile tunnel (2) in May, 1888 initiated the first adequate and direct through railroad service to Puget Sound.

Five years after the completion of the Northern Pacific route, the Great Northern Railroad, under the direction of James J. Hill, was operating a transcontinental line from Minneapolis to Seattle. In 1893, a complex system of switchbacks across the Cascades at Stevens Pass was opened to service, and a large steel truss (3) was erected across the Columbia. The completion of the

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[1] D.W. Meinig, The Great Columbia Plain, (Seattle, 1968), p. 268.

Cascade Tunnel (4,5) in 1900, confirmed that the historic focus of the whole northern portion of the interior of the State, which had been oriented down the Columbia River to Portland had finally been diverted to Puget Sound.[2] And it was the Great Northern Railroad that provided Seattle with the vital rail connections that were instrumental in turning the new focus on Puget Sound, specifically towards Seattle.

The last transcontinental line to be built across Washington to Puget Sound was the Chicago, Milwaukee, and St. Paul Railroad's route to the coast through the interior of the state (13). The line was completed in 1909, more than 15 years after the beginning of transcontinental railroad construction through Washington.

The Milwaukee Railroad was the first railroad to electrify a substantial portion of its line. The Beverly Bridge carries vestiges of the superstructure used to support the copper cables. The advantages of railroad electrification were particularly apparent in the increased load capacity of the freight trains. Railroad electrification also alleviated the dangerous conditions within the long mountain pass tunnels. The Penstock Bridge (5) played an integral role in the water transportation system that powered the Great Northern trains through one of the early Cascade Tunnels.

Competition and power plays between the major railroad companies plagued and profoundly influenced railroad and bridge construction throughout the state. In 1900, James J. Hill surreptitiously purchased the rights of way for a new trunk line between Spokane and Portland on the north bank of the Columbia River in the hopes of obtaining a direct outlet to Portland for the rapidly growing traffic of Spokane and the southern portion of the interior. It was a venture to be shared by the Great Northern and the Northern Pacific. However, it directly competed with the Oregon Railroad and Navigation Company (OR&N) on the south bank of the river, which had been subsumed by the Union Pacific Railroad under the direction of Edward H. Harriman. Harriman valiantly attempted to thwart the construction of the Spokane, Portland, and Seattle Railway (SP&S) by using a variety ploys. While the court battles raged, "construction crews fought with fists, rocks, pickhandles, and dynamite." The last court encounter ended in victory for

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[2] *Ibid.*, p. 270.

Hill in 1906.[3]

The line from Spokane to Portland was finally completed and in operation by 1909. "As a transportation route it represents the highest result of the railroad builder's art," reported an engineer before a meeting of the Pacific-Northwest Society of Civil Engineers in 1925.[4] Because the Great Northern and Northern Pacific desired a high capacity railroad with low operating costs, they did not make use of the existing Northern Pacific line between Spokane and Pasco. Instead, they constructed a new low grade roadbed with a minimum of curves. Their aim was "to make the roadbed of the most permanent character."[5] The bridges on the line certainly reflect this aim. Permanent steel viaducts or earth fills were built initially, rather than temporary timber structures. From Spokane, the line makes its only west-bound ascent of 375 feet. It follows Cow Creek through Adams County. "At the junction of Cow Creek and the Palouse River, the Portland and Seattle encounters the most expensive stretch of railroad construction, except that in Devil's Canyon, ever known in Washington. The valley is crooked and entered frequently by steep, narrow gulches; the road is built across a succession of 'hog backs' and gulches. Eighty-foot cuts are followed by 90-foot fills in alteration; short tunnels are frequent; high steel trestles are necessary in many places."[6] Of the steel trestles built in this area the Cow Creek Viaduct (9) is the longest and the highest. The line passes through the Washtucna Coulee and follows the east bank of the Snake River through Devil's Canyon. Here the treacherous terrain is traversed by four enormous steel viaducts, the highest of which is the Box Canyon Viaduct at 250 feet (8). The route makes use of the Northern Pacific tracks at only one point: the Columbia River crossing between Pasco-Kennewick (1). It follows the north bank of the Columbia across an early reinforced concrete arch (7) at Lyle, and eventually reaches Vancouver crossing the Columbia River to Portland by means of a large steel pinconnected swing bridge (10).

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[3] Charles and Dorothy Wood, Spokane, Portland, and Seattle Railway, (Seattle, 1974), p. 23.

[4] "Cascade Tunnel Route," extracts from a paper read befor the Pacific-Northwest Society of Civil Engineers, Seattle, Washington, October 1925.

[5] W.P. Hardesty, "The Construction of the Portland and Seattle Railway," Engineering News, Vol. 59, No.7, p. 161.

[6] Railroad Gazette, 27 September 1907.

Because of the success of the Spokane, Portland, and Seattle Railway, the Oregon-Washington Railroad and Navigation Company (O-WRN) moved quickly to upgrade its line between Portland and Spokane. The largest structure on the O-WRN's new low grade line was the 3,920 foot Joso Viaduct (12) over the Snake River at Lyons Ferry. The completion of the new Union Pacific line was yet another example of the continuing competition between the Hill and Harriman interests to dominate and control the major railroad routes of the Northwest.

In 1912, the Oregon Trunk Railway, a subsidiary of the Spokane, Portland, and Seattle Railway, was completed, representing one of the first steps in the entry of the Hill lines into Oregon, a territory which previously had been associated exclusively with the Harriman lines. In his virtual autonomy over the railroads in Oregon and California, Harriman had effectively controlled the major railroad links to tidewater. However, Hill's entrance into Oregon made his dream of stretching the Great Northern empire from Spokane to San Francisco plausible. Although the Great Northern did not reach the Pacific coast of California until 1931, long after Hill's death, the completion of the Oregon Trunk Railway represented a significant step towards the fulfillment of Hill's dream. The Celilo Bridge (13), the largest of ten steel bridges built on the Oregon Trunk Line, was a major link in connecting the SP&S to Union Pacific Territory.

The legacy of extant structures associated with railroad development within the State span a vast, varied, and often treacherous topography, and stand as a fitting testimony to the grand schemes and boundless ingenuity of the early railroad maganates in their efforts to dominate the major routes of the Northwest.

II. BRIDGES THAT REFLECT EARLY HIGHWAY DEVELOPMENT

In 1911, the Washington State Highway Commissioner proclaimed that: "A system of State roads is today the livest [sic] issue before the people of Washington or any other state. We are living in a transition period and changes come rapidly. Evolution in transportation methods affects road construction in no less a degree than a deepening of waterways, and the construction of easier grades and easier curves on the trunk railways."[1] With the proliferation of the automobile, the engineer was confronted with a new and complex range of urgent structural demands. As the Washington State Highway Commissioner observed, the foremost demand was the rapid construction of highways, of which the building of adequate highway bridges was an integral part. The heavy load capacities required by railroad traffic had previously shaped the development of bridge design. Automobile traffic, however, exerted different demands and design requirements on the bridge construction engineer which eventually shifted existing patterns and changed the direction of American bridge building. Although there are examples of concrete structures, the railroad bridge has been almost exclusively built in steel, and is characterized by the heavy riveted steel truss. The lower highway loadings enabled the engineer to use a range of bridge types and materials which resulted in a vast number of concrete structures on the highways. However, the dominance of the steel truss did not diminish on the roadways. And steel remained the most suitable material for extremely long spans over navigable wa(y)terways.[2] It is interesting to note that the design of the earliest highway structures of major proportions in Washington were based on a technology that originated in railroad bridge construction of the 19th century.

The first highway bridge to be constructed across the Columbia River was a pinconnected steel cantilever truss at Wenatchee (14). It was built in 1908 to transport automobiles and water to east Wenatchee in order to develop the land for the expanding apple industry. Like most of these large,

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[1] W.J. Roberts, "System of Roads: Routes, Mileage and Costs," Pacific Builder and Engineer, 18 November 1911, p. 337.

[2] Carl Condit, American Building Art, 2 Vols., (New York, 1961), 2: 5-6.

early highway structures, the Wenatchee Bridge was privately financed, though subsequently purchased by the State Highway Department in 1909.

In 1916, construction began on a bridge between Vancouver and Portland (15). This enormous structure which consists of a series of simple trusses was financed by Clark and Multnomah Counties. In 1929, Washington and Oregon purchased the bridge from the counties.

A highway bridge was built across the Columbia between Pasco and Kennewick (16) in 1922. It was the first of five steel structures, and the first of four cantilever trusses to be constructed across the Columbia River during the 1920's, marking the beginning of a proliferation of major bridge construction in this new transportation era. The State Highway Department purchased the bridge from its private owners in 1931.

Though the construction of the Longview Bridge (17) was entrenched in controversy, its completion represented another effort to bridge the Columbia River with highway structures. It formed an important connecting link in the Pacific Highway extending from Vancouver, B.C. to Tia Juana, Mexico. The Longview Bridge was the last privately-financed bridge to be constructed across the Columbia River, and represented a turning point in the financing of bridge construction in the State. Soon after this time, the State purchased all privately-owned toll bridges. The construction of bridges throughout the State became increasingly dependent upon, and influenced by state and federal aid programs.

III. SPECIALIZED STRUCTURES: LOGGING AND MINING BRIDGES

The State's abundant resources have always been unattainable and useless without a transportation network to retrieve the minerals and vast supplies of timber, and a means of depositing them at a location where they can be processed for public consumption. The structures that are a part of these transportation systems embody an important segment of bridge construction history within the State.

These grand transportation schemes often involved the construction of large structures in remote, inaccessible territory. The earliest bridge associated with the development of logging and mining interests remaining within the State, is a timber deck Howe truss (18) over the Little Sheep Creek in Stevens County. It was constructed in 1896 as part of the Red Mountain Railroad which ran between Northport and Rossland. The railroad was conceived and financed by D.C. Corbin to link the untapped Canadian mineral deposits in the Kootenay district to the smelters in the United States. At Newport, the Red Mountain spur line connected to another one of D.C. Corbin's railroads, the Spokane Falls and Northern mainline. Through D.C. Corbin's initiative, the mining of the Kootenay district brought great, though momentary wealth to Spokane during the late nineteenth century.

The earliest extant bridge associated with the logging industry is the Winslow Railroad Bridge (19). It is a timber deck Howe truss which was constructed in 1916-17 by the Winslow Lumber Manufacturing Company as part of a 25 mile track system used to transport logs to the company's mill in Orin. As the logging industry developed, there became a growing separation between the logging and milling businesses. However, the Winslow Railroad, like most of the earliest logging railroads, was built by operators of the lumber mill who needed a dependable supply of logs.

Two enormous steel arches (20,21) rising almost 400 feet above wooded gorges were constructed by the Simpson Logging Company in 1929. They were built during a time when high costs were bringing an end to the era of logging railroads. By the 1930's, the West's most accessible timber had been logged, and the initial investment of construction and equipment costs for even the shortest railroad lines was becoming prohibitive.[1] It was only the largest corporations, such as the Simpson Logging Company, that would find that the unit cost of hauling logs by rail was cheaper than that by truck. The Vance Creek Bridge remains in use as a railroad bridge, while the High Steel Bridge was converted for use by vehicular traffic approximately 20 years ago. The awesome permanence of the steel structure over Vance Creek belies its seemingly anachronistic function, and reflects a changing era in the use of logging railroads. During the late 19th and early 20th centuries, the logging railroad bridges were usually timber structures. Although the mainline of the logging railroads were in service for a number of years, the structures on the spur lines, which often included extremely long and high timber trestles, were temporary, and were abandoned or reused at different locations as soon as the specific area was logged. However, as construction costs increased, enormous structures like the Vance Creek and High Steel Bridges were only economically feasible if they could be used over a long period of time. As a case in point, after a period of more than fifty years, both the Vance Creek Bridge and the High Steel Bridge remain in use. The alterations which have been made to the High Steel Bridge reflect the inevitable changes in the transportation of timber -- the gradual disappearance of the logging railroads and their replacement by trucks.

The magnificent raw power of the 250 foot log cable-stayed girder bridge (22) spanning the Quinault River is undeniable. It was designed and constructed by the Aloha Logging Company's Superintendent in 1952 to support the weight of a loaded logging truck, as part of the road system built to retrieve the company's timber fron the dense forests of the Olympic Peninsula. The Chow Chow Bridge, which was constructed from a 12 foot scale model, was designed by a man who had unusual constructive ability, but who had no formal engineering background. Although the existing timber structures associated with logging and mining industries within the State span a period of almost sixty years, the bridge builders shared a common trait; they shared an intuitive constructive ability. The logging superintendent's spirit and inventive genius can be compared to the American bridge builders of the 18th and early 19th centuries who were

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[1] Kramer Adams, Logging Railroads of the West, (Seattle, 1961), p. 54.

"practical men...who depended upon their own resources and natural instinct, experimenting with models and profiting by previous failures, but who had no accurate knowledge of the strains produced on the various members of a structure by the exterior forces."[2] Practice always preceded the science; consequently structural systems were invented long before the theory was developed. The Chow Chow Bridge is indeed an example of a structural system that was used to solve a problem before the formal theory was developed. It is one of the first examples of a cable-stayed girder bridge within the United States. Although there are numerous European applications of the cable-stayed design, the bridge type has not been used in the United States until very recently, because it is a statically indeterminate system, and has been difficult to analyze with any reasonable degree of accuracy.

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[2] C. Schneider, "Evolution of Bridge Building," Engineering News-Record, 22 June 1905, p. 649.

IV. REPRESENTATION OF BRIDGE TYPES: TRESTLES

There still remains within Washington a sparse sampling of structures that are representative of bridge types which once predominated the landscape. The timber trestle which has evolved as a distinctly American structure, characterized railroad construction in Washington during the late 19th and early 20th centuries. The 984 foot Wilburton Trestle (23) which rises to a height of 98 feet above Mercer Slough, demonstrates the magnitude of the length and height of the early timber trestles that once traversed the varied and seemingly formidable topography of Washington. It is a rare surviving example within the State of a bridge type that once dominated transcontinental railroad construction. During this period, when the railroad's primary objective was to cross the continent rapidly, steel construction became a luxury, both in time of construction, and in initial expense. Timber, however, was abundant throughout western Washington, and was free for the taking.

After the transcontinental route was completed, the looming timber structures were often replaced by solid earth fills or permanent steel viaducts. The steel viaduct which was also a distinctly American structure associated with railroad construction, is best represented in the two long steel Spokane, Portland and Seattle Railraod viaducts over Cow Creek (9) and Box Canyon (8), and in the Union Pacific Joso Viaduct. (12).

IV. REPRESENTATION OF BRIDGE TYPES: TRUSSES

As exemplified in the table of bridge types, the truss is clearly the most common bridge form constructed in Washington between 1880 and 1940 for both railroad and highway structures. Because Washington was settled long after the major experimentation with truss types had occurred, there is not a vast representation of truss forms.

The earliest truss form represented is the timber Howe truss which was patented in 1840. The Little Sheep Creek Railroad Bridge (18) constructed in 1896 and the Winslow Railroad Bridge (19) constructed in 1916-17 are the oldest extant examples within the State of this once common truss type. Timber continued to be used for the construction of railroad bridges throughout Washington during the first quarter of the century due to the abundance of the resource, and its initial economic advantages. The use of treated timber also extended the life of these structures. There is one Milwaukee Railroad standard timber Howe through truss remaining within the State (24). Although it was constructed in 1930, it replaced an identical structure built in the teens.

There are two examples of timber trusses within the State that are of the Pratt configuration (25,26). In the Howe truss, the vertical members resist the load in tension, while the diagonal members resist the load in compression. The tensile strength of steel or iron coincides with the function of the vertical members, and the compressive qualities of wood coincide with the function of the diagonal members. However, in the Pratt truss, the function of the vertical and diagonal members is reversed; consequently the vertical components are timber, and the diagonal components are steel. Although the Pratt truss was patented in 1844, the Howe truss design continued to be the most common form in timber construction. It was not until the introduction of all steel and iron trusses that the Pratt truss design prevailed.

These untreated timber structures had a life span of approximately 10 to 15 years. In an effort to extend the life of the bridges, the timber components were protected by constructing housing around them. There are four covered bridges remaining within the State. The oldest is a highway structure, a two span Howe truss constructed across Grays River (27) in 1905. In 1918 a covered timber Howe truss (28) was constructed across the Palouse River outside of Colfax as part of the Spokane and Inland Empire Railroad, an expansive interurban electric railroad line scheme that extended from the Palouse to Spokane. Because it was necessary to provide for the connection between the locomotive and the overhead electric lines, the top of the bridge was left uncovered. Over the Chehalis River at Doty stands the last standard Milwaukee Road covered bridge (29). At one time several of these stark, utilitarian structures, constructed by company forces, spanned the waterways of Washington. A short-spanned timber Howe pony truss covered with corrugated metal (30) was constructed across the Chehalis River in 1934.

The seemingly endless source of timber throughout much of Washington, providing a cheap building material, may account for the fact that a number of timber highway trusses continued to be built throughout the 1930's. Because most of the early bridge construction in Washington occurred long after the technology of iron or steel truss construction had been developed, the timber and steel truss existed within the State simultaneously. The predominance of timber construction over that of steel or iron was not a matter of technology, but rather one of economy and accessibility. However, the iron or steel truss provided a strength, durability, and resistance to fire that the timber truss would never be able to attain.

There is a limited representation within Washington of the early steel truss forms which consisted of complex systems of triangulation. These early truss forms are demonstrated in the lattice or triple-intersection Warren truss over the Spokane River (31) and the double-intersection Warren truss over the Wishkah River (38). The double-intersection Pratt truss (1) over the Columbia River is similar to the lattice truss, and was a common truss form in railroad construction in the late nineteenth century. These three bridges share this multiple system of triangulation which was claimed to create an "unavoidable ambiguity in stress distribution."[1] These complex truss forms have been replaced almost exclusively by two other nineteenth century designs: the simple system of verticals and diagonals of the Pratt truss and the straightforward single system of triangles of the Warren truss. It is interesting to note that in contrast to the east coast, there are very few examples within

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[1] J.A.L. Waddell, Bridge Engineering, 2 Vols., (New York, 1916), 1: 476.

Washington of trusses with a multiple system of triangulation which in itself may shed light on the evolution of the truss form. Even during the early years of bridge construction within the State, the superiority of the Warren and Pratt configuration had been confirmed.

During the early twentieth century, the Pratt truss was claimed to be the most commonly used bridge type in America for spans under 250 feet. The two earliest and least altered examples of this truss type remaining within Washington are the F Street Bridge in Palouse (33) and the West Monitor Bridge (34). Both of these are pinconnected structures which preceded the more rigid riveted truss. With the improvement of riveting techniques, and the development of the pneumatic riveter during the early twentieth century, the pinconnected truss soon became a rarity.

During the mid-ninteenth century, the Parker truss was developed. In contrast to the uniform depth of the parallel chords of the basic Pratt truss, the polygonal top chord of the Parker truss which reaches its greatest height at the center panels, reflects the increase in bending moment that occurs from the ends of the truss to the center. The use of the arched top chord increased the rigidity of the structure, and enabled the construction of longer spans. The earliest, least altered examples of the Parker truss within the State are the Curlew Bridge (35), the Orient Bridge (36), and the Prosser Steel Bridge (37).

In an effort to construct longer spans, the Pratt truss configuration was adapted and modified by sub-dividing the panels with additional substruts and subties. The development of the Petit truss during the 1870's represented a major advance in strengthening the standard Pratt truss form. The Middle Fork Nooksack River Bridge (38) is the longest pinconnected modified Petit highway truss within the State, while the White River Bridge (39) constructed in 1908, is the oldest pinconnected modified Baltimore Petit structure.

In 1913, Clallam County constructed a two-span deck truss over the Elwha River (41). Its Warren truss configuration was patented in 1848, and is composed of diagonals which are placed alternately in tension and compression. The Elwha River Bridge is the oldest Warren truss in the State constructed for highway use. Like the Pratt truss, this single system of triangles continues to be used by engineers in modern steel trusses.

The largest truss bridges are cantilever structures which consist of a combination of anchor spans, cantilevers, and suspended spans. The oldest cantilever truss within the State is a pinconnected structure constructed across the Columbia River in 1908 (13). The Pasco-Kennewick Bridge (16), the Lyons Ferry Bridge (42), and the Longview Bridge (17) all represent cantilever construction that occurred during the 1920's. The George Washington Memorial Bridge (43), the Grand Coulee Bridge (44), and the Deception Pass Bridge (45) were built during the 30's and reflect a departure in form from the cantilever structures built in Washington during the previous decade. They reflect the refinement and progressive simplification of the cantilever truss form in the twentieth century.[2] The George Washington Memorial Bridge and the Deception Pass Bridge demonstrate the final merging of a functional and aesthetic form in the cantilever truss.

[2]Carl Condit, American Building Art, 2 Vols., (New York, 1961), 2: 104.

IV. REPRESENTATION OF BRIDGE TYPES: MOVEABLE BRIDGES

A very specific bridge technology evolved from the necessity of spanning navigable waterways. The earliest moveable bridges within the State are swing bridges, and are essentially steel trusses which rotate around a center pier. The Spokane, Portland, and Seattle Railway Bridge (10) which spans the Columbia River is the oldest swing bridge remaining within the State. Its 462 foot pinconnected draw span was long for its day, and was even acknowledged by the bridge engineer, Henry G. Tyrrell, in his book, History of Bridge Engineering. The Puyallup Waterway Crossing (47) is an example of a pinconnected swing span which was once frequently visible on the navigable waterways of the late nineteenth and early twentieth centuries.

In his authoritative volume on Bridge Engineering, J.A.L. Waddell remarks that in 1916, the swing bridge remained the most common type of moveable bridge. However, it was during this period that many of the early swing bridges spanning the waterways were being replaced by bascule structures. The bascule bridge, whose prototype is the medieval drawbridge, derives its name from the French word meaning balance. The bascule span is opened and closed much more rapidly than the swing bridge by means of a counterweight system. The absence of a central pivot pier in the bascule bridge was a great asset. The timber structure extending from the pier which served to protect the draw span was a dangerous obstruction in narrow channels, and often usurped valuable dock space. The advantages of the bascule structure over that of its predecessor were numerous, and particularly apparent in the populated, congested cities where both roadway and waterway traffic were heavy.[3]

Methods of refining and improving the counterweight system in the bascule spans absorbed the energies of many bridge engineers during the late nineteenth and early twentieth ceturies. The earliest examples of bascule bridge design within Washington are of the trunnion type. The Salmon Bay Great Northern Railroad Bridge (48) constructed in 1913 is an early example of the Strauss heel trunnion single leaf bascule bridge. The single leaf bascule was preferred for railroad traffic due to its greater rigidity. The heel trunnion, single leaf bascule bridge was patented by

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[3] J.A.L. Waddell, Bridge Engineering, 2 Vols., (New York, 1916) 1: 664, 700-702.

J.B. Strauss of the Strauss Bascule Bridge Company of Chicage in 1911, and consists of an overhead counterweight which is pivoted on a fixed trunnion by a parallelogram of linkages. The structure's center of gravity does not move either vertically or horizontally as the bridge opens and closes. Consequently, this design enabled the construction of simple economical foundations. The heel trunnion design was a modification of, and eventually superceded earlier Strauss designs. In 1914, a single leaf Strauss heel trunnion bascule bridge (49) was constructed across the Ebey Slough in Everett. It was the first of its type to be used within the State as a highway structure.

The construction of several moveable spans was incorporated into the design of Seattle's Lake Washington Ship Canal. Between 1915 and 1919 three double-leaf trunnion bascule bridges of the transverse cross-girder type were constructed to span the new waterway (50-52). These bridges, which are the earliest examples within the State of a double-leaf bascule bridge, were designed by the City of Seattle, and followed a general design developed by the Chicago Department of Public Works in 1898. In 1924-25 a fourth double-leaf trunnion bascule bridge (53) was constructed across the canal on foundations that had been constructed when the ship canal was first built. A unique feature of the Montlake Avenue Bridge was that the trunnions were supported on a cantilever projection extending from the pier which eliminated the need for the transverse cross-girder used in the earlier canal bridges. In contrast to the three earlier bascule bridges constructed over the canal, ornate towers loom over the piers of the Montlake Avenue Bridge, evoking an aura of monumental dignity.

The Hoquiam River Bridge (54) was designed by the Strauss Bascule Bridge Company of Chicago, and was constructed in 1928. It is a patented Strauss trunnion double-leaf bascule bridge.

The 14th Avenue South Bridge (55) which was constructed across the Duwamish River in Seattle in 1931 is the only Scherzer rolling lift bascule bridge within the State. The bridge type was developed by William Scherzer in 1895. In this type, the leaf rotates on a quadrant which rolls along horizontal track girders. In contrast to the fixed position of axis rotation of the trunnion bascule, the axis of rotation of the Scherzer Bridge has a "motion of translation longitudinally with the structure."

Consequently, the Scherzer Bridge generally provides a greater clear opening for any total length of span than that provided by the fixed trunnion type. However, because the rolling action constantly changed the location of the center of pressure of the load on the abutment, solid rock foundations were necessary.

J.A.L. Waddell's synthesis of the significance of the bascule bridge is apt. He states that all bascule bridges are "inherently ugly, and for all but comparatively short spans are uneconomic in comparison to the vertical lift; but they are scientific and they represent, probably, the best and most profound thought that has ever been devoted to bridge engineering."[4]

The vertical lift bridge developed simultaneously with the bascule bridge. The earliest vertical lift highway structure remaining within the State is the City Waterway Bridge (56) which was constructed by the renowned early twentieth century bridge engineering frim of Waddell and Harrington. The Vancouver-Portland Interstate Bridge (15), designed in 1916 by the newly formed firm of Harrington, Howard, and Ash is another early example of a vertical lift bridge.

In 1914, the Northern Pacific constructed a Strauss direct vertical lift bridge over Steilacoom Creek (57). The design,which replaced the usual counterweight cables, chains, sheaves, and winding drums of the vertical lift bridge with a system of counterbalanced levers and rack and pinion gearing, was patented by J.B. Strauss of Chicago, and was put on the market by the Strauss Bascule Bridge Company in 1912. The Steilacoom Creek Bridge was one of the first of this design to be constructed. The Strauss direct lift bridge possesses many of the design elements of the Strauss heel trunnion bridge. Like the Strauss bascule, the lifting mechanism of the direct lift bridge consists of a parallel link counter-weight which moved on fixed trunnions, or pivot points. The stark steel form is blatant in its bold adherence to its functional purpose. Although the design of the Steilacoom Creek Bridge was limited to short spanned structures, it is significant in its demonstration of the evolution and experimentation of bridge design during the early twentieth century, in its demonstration of the way in which the concepts of bascule bridge design were merged with the design concepts of the vertical lift bridge.

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[4] J.A.L. Waddell, Bridge Engineering, 2 Vols., (New York, 1916), 1: 713-14.

In 1916, J.A.L. Waddell accurately interpreted the importance of the vertical lift brdige in relation to other moveable sturctures. He wrote that the type had come to stay, and that it would continue to be used more and more as time went on, "for not only is it inexpensive in first cost comparatively speaking, but it is also simple, rigid, easy to operate, and economical of power. It has met with considerable opposition up to the present time, mainly from the owners of bascule patents; but it has overcome that opposition most satisfactorily and unequivocally, consequently the future of the type may be counted upon as assured."[5]

The design of the Lake Washington Floating Bridge (58) which includes an unusual moveable span was unprecedented within the United States. Because piers could not be constructed in the 150 to 200 foot depths of Lake Washington, under which lies almost 100 feet of soft mud, it was not possible to bridge the 7800 foot crossing with a more conventional long span structure. A bridge of pontoon construction eliminated the problem of pier construction. The 6561 foot deck is anchored to a series of floating reinforced concrete boxes which lie only a few feet beneath the surface of the lake. A total of 64 cables secure the floating structure transversely and horizontally to anchors on the lake bottom. The required 200 foot channel is provided by the horizontal movement of a portion of the floating deck into a recess in an adjacent fixed pontoon.

removed in 1981. See Inventory Card for #58.

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[5]Ibid., p. 746.

IV. REPRESENTATION OF BRIDGE TYPES: ARCHES

During the early twentieth century the steel arch was not extensively used in the United States in comparison to other bridge forms. In his book, Bridge Engineering, J.A.L. Waddell explains the reason for the paucity of arches in the United States. "Arches are employed very generally in Europe on account of their superior appearance as compared with simple truss bridges, and because of the powerful influence of the old masonry arch upon the minds of European bridge designers, regardless of the consideration of economy. American engineers, on the other hand, have been indifferent to the question of aesthetics, and have preferred simple spans to arches mainly for reasons of simplicity and economy, but sometimes on account of their rigidity."[6]

The Twelfth Avenue West Bridge on Dearborn Avenue (60) was constructed by the City of Seattle in 1911 and is the oldest extant steel arch within the State. Of the earliest steel arches within the State, it is the only example of a spandrel-braced arch. There are two examples within the State of a three-hinged lattice arch, one built over Ravenna Park (61) in 1912-13 by the City of Seattle, and one built over the Carbon River (62) in 1921 by the State and Pierce County. The three-hinged arch, with a hinge at the crown and at the two abutments, was widely used by American engineers. Although it is the least rigid of all arch structures, there is no ambiguity of stress distribution, and the method of stress calculation is relatively simple. A solid-rib two-hinged parabolic steel arch dramatically spans a steep wooded ravine on North Queen Anne Hill (63). This attenuated striking steel form was designed by the Seattle Engineering Department in 1935. It is the only one of its type within the State that was constructed before 1940. The Canoe Pass Bridge (46) constructed in 1935, and the two high steel arches erected by the Simpson Logging Company (20, 21) in 1929 are more recent examples of the spandrel-braced arch.

There has been little change in the form of the steel arch since the last decade of the nineteenth century. The essential components of ribs, stiffening trusses, and spandrel posts must always be present, and

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[6] J.A.L. Waddell, Bridge Engineering, 2 Vols., (New York, 1916), 1: 617.

have left little scope for variations. The design innovations in the arch bridge were linked to the developments of reinforced concrete.[7]

The earliest extant reinforced concrete arches within the State are the Washington Street Brdige (65) constructed over the Spokane River in 1908, and the Klickitat River Bridge (7) constructed by the Spokane, Portland, and Seattle Railway during the same year. The Arboretum Sewer Trestle (66) which was built in 1910 by the City of Seattle demonstrates how many of the earliest reinforced concrete bridges were park bridges, which were "notable more for their artistic design than for their large proportions."[8] The solid-barrel arch rings which were used in the Klickitat River Bridge and in the Arboretum Sewer Trestle were predominant in the earliest reinforced concrete arch designs. Often these early structures were constructed as monoliths, and the metal reinforcing acted more as a binding element than as reinforcing. The Washington Street Bridge is an early example of a ribbed arch. The flattened form of the ribs of the Washington Street Bridge reflected future developments in concrete arch design.

When the Monroe Street Bridge (67) was completed in 1911, its monolithic arch was hailed as the largest concrete arch in the United States. The Monroe Street Bridge was similar to the Walnut Lane Bridge of Philadelphia, constructed in 1906-8, which was an important forerunner in the design of long-span fixed arches. The great size of the massive arched ribs of these two structures reveals the limits of unreinforced concrete in long span structures. However, the open spandrels and flattened ribs of the Monroe Street's central arch pointed toward the future in concrete arch design. The Latah Creek Bridge (68) was the second of Spokane's grand monumental concrete arches, and is an early example within the State of a long-span fixed-end reinforced concrete arch.

The commanding monumental form of the Rosalia Bridge (69) constructed by the Milwaukee Railroad in 1915 rivals that of the two Spokane arches. The Rosalia Bridge is the only multiple span concrete arch railroad bridge within the State. Because of the high impact of railroad loads, concrete arches were never widely used in the construction of railroad bridges,

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[7] Carl Condit, American Building Art, 2 Vols., (New York, 1961), 2: 128.

[8] Henry Grattan Tyrell, History of Bridge Engineering, (Chicago, 1911), p. 427.

particularly in long span structures.

The Lower Custer Way Crossing (70) is an early example within the State of a Luten arch. The Luten arch was introduced to the United States from Germany in 1900, and was one of the early scientific solutions to bar reinforcing in concrete. Unlike many of the earliest solutions to arch reinforcing which indiscriminately placed steel shapes throughout the concrete, the Luten system pointed to later techniques which distributed the steel primarily in the tension zones. In the Luten system, several bars forming a complete loop were laid transversely through the vault and invert of the arch. These series of loops were also laid throughout the length of the structure at regular intervals. The bars were bent to conform to the semicircular section of the vault, and were placed near the surfaces of maximum tension under live load.[9]

As the reinforcing of concrete became better understood, the rigid concrete and the elastic steel were scientifically designed to function together organically, and it became possible to build lighter, more attenuated forms. The minimal, graceful form of the 34th Street Bridges (74, 73) in Tacoma and the Cowen Park Bridge (72) in Seattle reveal the capabilities of reinforced concrete, and reflect the progressive reduction in the quantity of structural material used in concrete arch design. However, the bold, dynamic innovative concrete forms of the European designers, Maillart and Freyssinet have never been equalled in the United States. "The scarcity of advanced designs in concrete bridges has arisen in part from the necessities of American practice: lower working stresses than are the rule in Europe; much higher traffic loads, both rail and highway; the higher cost of formwork, chiefly because of high labor costs; and in many places, higher wind and snow loads."[10]

During the 1920's and 30's five reinforced concrete tied arches were constructed within the State (76-80). In these arches, the deck slab is hung by suspenders from a pair of arch ribs above the roadway. In most arches, massive abutments and foundations are necessary to resist the horizontal thrust exerted by the arch on the skewbacks. However, in the tied arch, the horizontal thrust is resisted by longitudinal ties

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[9]Ibid., 2: 197.

[10]Ibid., 2: 195-196.

which extend between the hinged springing points. In most of the five tied arches in Washington, the deck slab itself acts as a tie. The double function of the deck slab was an economical solution, and it eliminated the need of massive abutments. Although there are examples of tied arches that were built throughout the 20's and 30's, the tied arch has remained a rare concrete arch form.[11]

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[11] Ibid., 2; 206.

IV. REPRESENTATION OF BRIDGE TYPES: CONCRETE BEAMS, GIRDERS, AND TRUSSES

The concrete girder has become a predominant feature in the landscape of the American highway. The two earliest examples within the State of concrete girder highway bridges are the North 23rd (81) and the North 21st (82) Street Bridges in Tacoma. Both bridges were designed by Waddell and Harrington. The North 23rd Street Bridge was built in 1909, and is an early example of a concrete rigid frame girder bridge. The concrete beams are massive and overdesigned. The rigid frame was not adopted on any extensive scale, until after World War I. The 21st Street Bridge constructed in 1910 is a continuous concrete rigid frame girder bridge. It was built almost simultaneously with the 950 foot Asylum Avenue Viaduct in Knoxville, which Carl Condit documented in American Building Art, as the first continuous concrete girder bridge to be constructed.[12]

There are three concrete structures within the nomination which are early American applications of the European innovation of concrete hollow-box construction. In cellular construction, the concrete is poured around hollow box forms thus reducing to a minimum the amount of material used. The steel and concrete is placed only at those points where it functions actively under live load. This economical hollow-box form was used extensively throughout Europe, but was not widely used in the United States. The Purdy Bridge, constructed over Henderson Bay in 1936, is one of the few box-girder bridges within the United States, and has the longest single span among concrete-girder forms.[13] The design features and layout of the bridge were suggested by Homer M. Hadley, and was one of several unique concrete bridge designs of cellular constructions conceived and carried out by Mr. Hadley throughout Washington during his lifetime.

Homer Hadley also designed the McMillin Bridge (87), a reinforced concrete truss of hollow-box construction. At the time that it was built, its 170 foot main span was the longest beam span within the United States. The

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[12] Carl W. Condit, American Building Art, (New York, 1961), 2:207.

[13] Ibid., p. 209.

organic strength of concrete that is so frequently revealed through the arch form, is shrouded by the massive breadth and scale of this truss at McMillin. The McMillin Bridge demonstrates the use of concrete for a design that traditionally evolved and conformed to the structural properties of timber and steel.

The Seattle Engineering Department introduced hollow box construction in the design of concrete rigid frame bridges when it built a concrete structure in Schmitz Park (86) in 1935.

There are two concrete beams within the nomination that are included for their architectural merits. The Johnson Bridge (83), is a three-span concrete T-beam. The engineers have used a straightforward, commonplace bridge type, and through the addition and integration of simple, subtle geometric shapes have transformed the structure into one which has an aesthetically compelling visual impact. As the most impressive of several short spanned structures with similar ornamental motifs throughout Walla Walla County, the Johnson Bridge reflects the impact of a single creative engineer on regional bridge design. The Capitol Boulevard Crossing (84) is one of the best examples within the State of the influence of Art Deco and Modernistic Architecture on bridge design. The concrete viaduct exemplifies the way in which decoration was used to transform an ordinary structure into an entranceway into the Capital City.

IV. REPRESENTATION OF BRIDGE TYPES: SUSPENSION BRIDGES

The thin parabolic cables of the suspension bridge stretching between two towers has an unyielding visual force. "The principle of the suspension bridge is simple,' stated the bridge engineer, David B. Steinman. 'It consists of three essential parts: the towers, the anchorages, and the cables. The roadway and the stiffening construction have local importance, but both may be wholly or partially destroyed without causing the collapse of the bridge. In all other types of bridge construction, the failure or buckling of a single member will precipitate the collapse of the entire structure. A suspension bridge is the safest type of construction in that any local overloading or structural deficiency will not jeopardize the safety of the whole."[1] However at the beginning of the 20th century the bridge engineering profession did not have this same confidence in the suspension bridge. In 1911, the bridge engineer, Henry Tyrrell wrote that although the suspension bridge is one of the oldest bridge forms, it has not been adopted as rapidly as other bridge types, because of its lack of rigidity and the absence of correct theory for proportioning stiffening trusses.[2] Mr. Tyrrell's cautiousness is perhaps explained by the fact that he was writing during the era of the railroad. Because of the flexibility of the suspension bridge design, it was not widely used for the heavier railroad loadings. It was the advent of the automobile that initiated the proliferation of the suspension bridge, particularly for long-spanned structures.

The oldest extant suspension bridges within the State are a series of timber suspension bridges crossing deep lateral gorges in the North Cascades at Devil's Corner (87). They were built by miners in the 1890's to provide access to their claims, and stand as a testimony to man's ingenuity and to the dogged persistence of the early miner's in breaching the formidable mountain barrier.

Although there are numerous examples of timber suspension bridges throughout the State, the Yale Bridge (88) is the only example of a short-spanned steel suspension bridge. Steel suspension bridges of moderate length

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[1]David B. Steinman and Sara Ruth Watson, Bridges and their Builders, (New York, 1941) p. 326.

[2]Henry Grattan Tyrrell, History of Bridge Engineering (Chicago, 1911), p. 254.

have remained rare because cost factors have prevented them from competing with simple steel trusses, cantilevers, or arches for ordinary highway structures.

The suspension bridge was primarily used for the very longest spans. When the graceful, ribbonlike Tacoma Narrows Bridge (89) was opened to traffic on July 1, 1940, it was the third longest suspension bridge in the world. The design of the Tacoma Narrows Bridge followed the mainline of development in the evolution of the suspension bridge. It represented a culmination of the trend to increase the span length, to reduce the width of the deck and to minimize the depth of the stiffening components, which simplified and distilled the bridge form; it represented the epitome of a move towards a suspension bridge of slender proportions that placed a premium of economy on flexible design.

However, on November 7, 1940 only four months after the opening of the bridge, the design ended in disaster. Gale force winds created torsional oscillations in the bridge that eventually reached catastrophic proportions causing the sinuous main span to break away from the undulating mass and plunge into the water below. The collapse of the bridge initiated a deluge of scientific investigation. Studies revealed that the bridge was destroyed by a combination of factors, factors that were more pronounced in the Tacoma span than in any other modern suspension bridge.

One critical factor was the vertical slenderness and resulting vertical flexibility of the structure which was caused by the construction of high flexible towers and a thin suspended span. Another flaw in the design of the bridge was the use of slender, solid web plate girders to stiffen the deck rather than the use of the complex and conventional truss. The steel truss acts like a sieve to the forces of the wind. However, the wind could not penetrate the solid wall of the girder. Because the span was highly flexible, the cross-section of the solid plate girders in combination with a solid floor was particularly sensitive to aerodynamic forces. The characteristics of this cross-section caused small undulations of the bridge to amplify. There was a tendency for these undulations to change into a twisting motion which would generate harmonic movements of dangerous magnitude. It was these harmonic motions that eventually proved fatal to the bridge.[3]

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[3]Steinman, op. cit, pp. 353-357.

Other bridge designs did benefit from the mistakes made in the construction of the Tacoma Narrows Bridge. The noted engineer, Ottmar H. Amman, who had designed the recently completed Bronx-Whitestone Bridge in New York with stiffening girders, quickly replaced them with trusses. The knowledge gained from the research following the disaster was valuable to the entire engineering profession in terms of understanding the importance of aerodynamics in suspension bridge design.

V. THE ROLE OF THE BRIDGE ENGINEER

The singular role of the bridge engineer in the development of Washington is undeniable. This role was probably most pronounced in the construction of the grand transportation schemes of the transcontinental railroads. The awesome scale of the land demanded structures of equal proportion. The bridge and tunnel engineers of this era were men who had more than unusual constructive abilities; they were men with vision; they were dreamers, planners, managers, and builders who built on an enormous scale.

These qualities were exemplified in men like Mr. Nelson Bennett who completed the two mile long Stampede tunnel through the "backbone of the Cascade range" under unyielding odds. The immensity of the projects in which these engineers were involved is reflected in the career of John Frank Stevens. Stevens surveyed the Great Northern route over the Cascades which resulted in the construction of the Cascade Tunnel, and then went on to play a major role in the construction of the Panama Canal.

There were a handful of prominent, prolific bridge engineers who devoted their early careers to railroad bridge construction. For example, there was Ralph Modjeski who contributed to the design and construction of several major spans during the 20's and 30's including the San Francisco Bay Bridge. His early years were spent as chief bridge engineer of the Oregon Trunk Railway, and it was he who was responsible for the construction of the Celilo Bridge across the Columbia River in 1911-12.

The impact of the bridge engineer is visible throughout Washington. There are numerous examples of the influence of a single creative engineering talent on a particular region. For example, E.R. Smith's tenure as county engineer during the 20's and 30's has left its impact throughout rural Walla Walla County. Through the addition of simple, softly colored geometric shapes, several short-spanned concrete T-beams were transformed into visually compelling structures.

During the period between 1909 and 1914, two enormous multiple spanned concrete arches were constructed in the city of Spokane. There are few bridges within the State that are monuments of such a grand scale. It was the foresight and perserverance of a few individuals within the city engineering department who were responsible for the construction of these forceful, concrete forms. An abundant number of concrete arches were built throughout the city of Spokane during this era by the engineering department directly impacting the visual countenance of the city. However, it is the magnitude of the Monroe Street Bridge and the Latah Street Bridge that make them particularly unique. Their rhythmic arch forms are commanding architectural focal points within the city. Morton McCartney, who was a key individual in the construction of the Monroe Street Bridge, supervised the design and construction of the Latah Creek Bridge as City Engineer.

The engineer, Homer Hadley, designed several unique concrete bridges throughout the state of Washington during his lifetime. The Purdy Bridge and the McMillin Bridge were both designed by Mr. Hadley. They are early American applications of the European innovation of concrete hollow-box construction. This economical method of construction was used extensively throughout Europe, but was not widely used in the United States. It was Homer Hadley who originally conceived the design of a floating bridge across Lake Washington. He visualized a floating roadway made up of a series of hollow concrete barges. Mr. Hadley's unusual work reveals the effects of a single innovative engineer on bridge design within the State.

There are other examples of bridge builders within Washington who forged outside of the mainstream of American bridge design practices. The 250 foot log cable-stayed girder bridge that was constructed across the Quinault River by the Logging Superintendent, Frank Milward, in 1952 is a prime example of a bold design that did not conform to American design patterns. It was the tenacious pioneering spirit of Mr. Milward, who constructed one of the first examples of a cable-stayed girder bridge within the United States. A segment of the history of bridge construction within Washington is revealed by the fact that structures were built in the mid-20th century by an individual whose background and methods of building closely paralleled those of 19th century engineers. Pioneering mavericks with little formal education were building innovative structures within the State simultaneously with engineers who used the most contemporary scientific analyses to determine appropriate bridge designs.

The history of bridge construction, and the role of the bridge engineer in the development of Washington is indeed multifaceted. Throughout the State's bridge construction history, there are repeated demonstrations of the resourcefulness and persistence of talented individuals who sought to direct "the great sources of power in nature for the use and convenience of man."[1] Without question, the bridge engineer's role is a significant one. In some respects, the bridge engineer played an indispensable role in the development of the state. Several of the earliest bridge engineers built structures that were integral parts of vast transportation systems which made Puget Sound and an inscrutable wilderness accessible to large numbers of people, directly impacting the course of settlement patterns within the State. The influence of the bridge engineer is pervasive; the construction of even the shortest spans affect people's lives, easing their ability to move from one location to another. This pervasive influence of the bridge engineer is reflected in the extant historic bridges and tunnels remaining within Washington.

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[1]Julius Adams, "The Dinner," Proceedings of the American Society of Civil Engineers, I (1874), 175; as quoted from Raymond H. Merritt, Engineering in American Society, Lexington, 1969, p. 3.

UTM NOT VERIFIED

9. Major Bibliographical References

ACREAGE NOT VERIFIED

Condit, Carl W., American Building Art, 2 Vols., New York: Oxford University Press, 1961.
Tyrrell, Henry Grattan, History of Bridge Engineering, Chicago: H.J. Tyrrell, 1911.
Waddell, J.A.L., Bridge Engineering, 2 Vols., New York: John Wiley and Sons, 1916.
(Refer to individual inventory forms for additional references.)

10. Geographical Data

Acreage of nominated property (refer to individual inventory forms)

Quadrangle name

Quadrangle scale

UMT References

	Zone	Easting	Northing		Zone	Easting	Northing
A				B			
C				D			
E				F			
G				H			

Verbal boundary description and justification

List all states and counties for properties overlapping state or county boundaries

state N/A code county code

state N/A code county code

11. Form Prepared By

name/title Lisa Soderberg, Historian

organization Office of Archaeology and Hist. Pres. date August 1980

street & number 111 West 21st Avenue telephone (206) 754-1625

city or town Olympia state Washington 98504

12. State Historic Preservation Officer Certification

The evaluated significance of this property within the state is: See Continuation Sheet

___ national ___ state ___ local

As the designated State Historic Preservation Officer for the National Historic Preservation Act of 1966 (Public Law 89–665), I hereby nominate this property for inclusion in the National Register and certify that it has been evaluated according to the criteria and procedures set forth by the National Park Service.

State Historic Preservation Officer signature

title date 5/3/82

For NPS use only

I hereby certify that this property is included in the National Register

See continuation sheet for listing date

Keeper of the National Register

Attest: date

Chief of Registration

United States Department of the Interior
National Park Service

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date entered

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Multiple Resource Area
Thematic Group

dnr-11

Name Historic Bridges and Tunnels in Washington State Thematic Resources
State Washington

Nomination/Type of Review				Date/Signature
1.	Penstock Bridge	Entered in the National Register	Keeper	Delores Byers 7/16/82
			Attest	
2.	Joso Viaduct	DOE/OWNER OBJECTION	Keeper	Determined eligible Bruce MacDougal 7-16-82
			Attest	Emma Jane Saxe 7-6-82
3.	Beverly Railroad Bridge	Entered in the National Register	Keeper	Delores Byers 7/16/82
			Attest	
4.	Columbia River Bridge	Substantive Review	Keeper	Bruce MacDougal 7-16-82
			Attest	Emma Jane Saxe 7-6-82
5.	Vancouver-Portland Bridge	Entered in the National Register	Keeper	Delores Byers 7/16/82
			Attest	
6.	Pasco-Kennewick Bridge	Entered in the National Register	Keeper	Delores Byers 7/16/82
			Attest	
7.	Longview Bridge	Entered in the National Register	Keeper	Delores Byers 7/16/82
			Attest	
8.	Red Mountain Railroad Bridge	Entered in the National Register	Keeper	Delores Byers 7/16/82
			Attest	
9.	Winslow Railroad Bridge	Substantive Review	Keeper	Bruce MacDougal 7-16-82
			Attest	Emma Jane Saxe 7-6-82
10.	Vance Creek Bridge	Entered in the National Register	Keeper	Delores Byers 7/16/82
			Attest	

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(3-82)

OMB No. 1024-0018
Exp. 10-31-84

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Thematic Group

Name: Historic Bridges and Tunnels in Washington State Thematic Resources
State: Washington

Nomination/Type of Review				Date/Signature
11.	High Steel Bridge	Entered in the National Register	Keeper	Delores Byers 7/16/82
			Attest	
12.	Chow Chow Bridge	Substantive Review	Keeper	Bruce MacDougal 7-16-82
			Attest	Emma Jane Saxe 7-6-82
13.	Dungeness River Bridge	Entered in the National Register	Keeper	Delores Byers 7/16/82
			Attest	
14.	McClure Bridge	Substantive Review	Keeper	Bruce MacDougal 7/16/82
			Attest	
15.	North 4th and Dock Street Bridge	Entered in the National Register	Keeper	Delores Byers 7/16/82
			Attest	
16.	Manning-Rye Covered Bridge	Entered in the National Register	Keeper	Delores Byers 7/16/82
			Attest	
17.	Doty Bridge	Entered in the National Register	Keeper	Delores Byers 7/16/82
			Attest	
18.	Weyerhaeuser/Pe Ell Bridge	Substantive Review	Keeper	Bruce MacDougal 7/16/82
			Attest	Emma Jane Saxe 7-6-82
19.	Spokane River Bridge	DOE/OWNER OBJECTION Substantive Review	Keeper	determined eligible Bruce MacDougal 7/16/82
			Attest	Emma Jane Saxe 7-6-82
20.	Wishkah River Bridge	Entered in the National Register	Keeper	Delores Byers 7/16/82
			Attest	

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State Washington

Nomination/Type of Review			Date/Signature
21. F Street Bridge	Entered in the National Register	Keeper	Delores Byers 7/16/82
		Attest	
22. West Monitor Bridge	Entered in the National Register	Keeper	Delores Byers 7/16/82
		Attest	
23. Curlew Bridge	Entered in the National Register	Keeper	Delores Byers 7/16/82
		Attest	
24. Orient Bridge	Substantive Review	Keeper	Bruce MacDougal 7-16-82
		Attest	Emma Jane Saxe 7-6-82
25. Prosser Steel Bridge	Entered in the National Register	Keeper	Delores Byers
		Attest	
26. Middle Fork Nooksack River Bridge	Entered in the National Register	Keeper	Delores Byers 7/16/82
		Attest	
27. Idaho and Washington Northern Railroad Bridge	Entered in the National Register	Keeper	Delores Byers 7/16/82
		Attest	
28. Elwha River Bridge	Entered in the National Register	Keeper	Delores Byers 7/16/82
		Attest	
29. Snake River Bridge (Lyons Ferry)	Substantive Review	Keeper	Bruce MacDougal 7-16-82
		Attest	Emma Jane Saxe 7-6-82
30. Aurora Avenue (George Washington Memorial)	Entered in the National Register	Keeper	Delores Byers 7/16/82
		Attest	

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Nomination/Type of Review			Date/Signature
31. Grand Coulee Bridge	Substantive Review	Keeper	Bruce MacDougal 7-16-82
		Attest	Emma Jane Saxe 7-7-82
32. Deception Pass Bridge	Substantive Review	Keeper	Bruce MacDougal 7-16-82
		Attest	Emma Jane Saxe 7-12-82
33. Canoe Pass Bridge	Substantive Review	Keeper	
		Attest	
34. University Bridge	Substantive Review	Keeper	Bruce MacDougal 7-16-82
		Attest	Emma Jane Saxe 7-7-82
35. Ballard Bridge	Entered in the National Register	Keeper	Delores Byers 7/16/82
		Attest	
36. Fremont Bridge	Entered in the National Register	Keeper	Delores Byers 7/16/82
		Attest	
37. Montlake Bridge	Entered in the National Register	Keeper	Delores Byers 7/16/82
		Attest	
38. Hoquiam River Bridge	Entered in the National Register	Keeper	Delores Byers 7/16/82
		Attest	
39. 14th Avenue South Bridge	Substantive Review	Keeper	Bruce MacDougal
		Attest	Emma Jane Saxe 7-7-82
40. City Waterway Bridge	Entered in the National Register	Keeper	Delores Byers 7/16/82
		Attest	

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Nomination/Type of Review			Date/Signature
41. Lacey V. Murrow Floating Bridge	Substantive Review	Keeper	4/29/83
		Attest	
42. Mount Baker Ridge Tunnel	Substantive Review	Keeper	7-16-82
		Attest	Emma Jane Saye 7-7-82
43. 12th Avenue South Bridge	Entered in the National Register	Keeper	Delores Byers 7/16/82
		Attest	
44. Ravenna Park Bridge	Substantive Review	Keeper	7-16-82
		Attest	Emma Jane Saye 7-7-82
45. Fairfax Bridge	Entered in the National Register	Keeper	Delores Byers 7/16/82
		Attest	
46. North Queen Anne Drive Bridge	Substantive Review	Keeper	
		Attest	
47. Washington Street Bridge	Entered in the National Register	Keeper	Delores Byers 7/16/82
		Attest	
48. Arboretum Sewer Trestle	Entered in the National Register	Keeper	Delores Byers 7/16/82
		Attest	
49. Sunset Boulevard Bridge	Substantive Review	Keeper	7-16-82
		Attest	Emma Jane Saye 7-8-82
50. Rosalia Railroad Bridge	Entered in the National Register	Keeper	Delores Byers 7/16/82
		Attest	

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Nomination/Type of Review			Date/Signature
51. Cowen Park Bridge	Substantive Review	Keeper	[signature] 7-16-82
		Attest	Emma Jane Saxe 7-12-82
52. NR East 34th Street Bridge (Pacific to A Street) – 50 yrs	Substantive Review	Keeper	[signature] 7-16-82
		Attest	
53. East 34th Street Bridge (East B to East D Street) – 50 yrs	Substantive Review	Keeper	Ret
		Attest	
54. Indian Timothy Memorial Bridge	Substantive Review	Keeper	[signature] 7-16-82
		Attest	Emma Jane Saxe 7-8-82
55. Goldsborough Creek Bridge	Entered in the National Register	Keeper	
		Attest	
56. North Hamma Hamma River Bridge	Entered in the National Register	Keeper	Delores Byers 7/16/82
		Attest	
57. South Hamma Hamma River Bridge	Entered in the National Register	Keeper	Delores Byers 7/16/82
		Attest	
58. Duckabush River Bridge Less than 50 yrs	Substantive Review	Keeper	[signature] 7-16-82
		Attest	Emma Jane Saxe 7-8-82
59. North 23rd Street Bridge	Substantive Review	Keeper	[signature] 7-16-82
		Attest	Emma Jane Saxe 7-8-82
60. North 21st Street Bridge	Entered in the National Register	Keeper	Delores Byers 7/16/82
		Attest	

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Nomination/Type of Review			Date/Signature
61. Johnson Bridge	Entered in the National Register	Keeper	Delores Byers 7/16/82
		Attest	
62. Capitol Boulevard Crossing	Substantive Review	Keeper	Bruce MacDougal 7-16-82
		Attest	Emma Jane Saxe 7-8-82
63. Purdy Bridge	Substantive Review	Keeper	Bruce MacDougal 7-16-82
		Attest	Emma Jane Saxe 7-8-82
64. Schmitz Park Bridge	Substantive Review	Keeper	Bruce MacDougal 7-16-82
		Attest	Emma Jane Saxe 7-8-82
65. McMillin Bridge	Substantive Review	Keeper	Bruce MacDougal 7-16-82
		Attest	Emma Jane Saxe 7-8-82
66. Yale Bridge	Entered in the National Register	Keeper	Delores Byers 7/16/82
		Attest	
67. Tacoma Narrows Bridge		Keeper	
		Attest	
		Keeper	
		Attest	
		Keeper	
		Attest	
		Keeper	
		Attest	