United States Department of the Interior
National Park Service

National Register of Historic Places
Registration Form

This form is for use in nominating or requesting determinations for individual properties and districts. Complete the National Register of Historic Places Registration Form (National Register Bulletin 16A). Complete each item by marking "x" in the appropriate box or by entering the information requested. If an item does not apply to the property being documented, enter "N/A" for "not applicable." For functions, architectural classification, materials, and areas of significance, enter only categories and subcategories from the instructions. Place additional entries and narrative items on continuation sheets (NPS Form 10-900a). Use a typewriter, word processor, or computer, to complete all items.

1. Name of Property

historic name: Tacoma Narrows Bridge

other names/site number

2. Location

street & number: Spanning the Tacoma Narrows

city or town: Tacoma

state: Washington code: WA county: Pierce code: 053 zip code

3. State/Federal Agency Certification

As the designated authority under the National Historic Preservation Act, as amended, I hereby certify that this nomination request for determination of eligibility meets the documentation standards for registering properties in the National Register of Historic Places and meets the procedural and professional requirements set forth in 36 CFR Part 60. In my opinion, the property

☒ meets ☐ does not meet the National Register criteria. I recommend that this property be considered significant

☒ nationally ☐ statewide ☐ locally. ☐ See continuation sheet for additional comments.

Signature of certifying official/Title Date

State of Federal agency and bureau

In my opinion, the property ☒ meets ☐ does not meet the National Register criteria. ☐ See continuation sheet for additional comments.

Signature of certifying official/Title Date

State or Federal agency and bureau

4. National Park Service Certification

I hereby certify that the property is:

☒ entered in the National Register. See continuation sheet.

☒ determined eligible for the National Register. See continuation sheet.

☒ determined not eligible for the National Register.

☒ removed from the National Register.

☒ other, (explain:)

Signature of the Keeper Date of Action
**Tacoma Narrows Bridge**

**Name of Property**

**Pierce Co., WA**

**County and State**

### 5. Classification

#### Ownership of Property

- [ ] private
- [ ] public-local
- [x] public-State
- [ ] public-Federal

#### Category of Property

- [ ] building(s)
- [ ] district
- [ ] site
- [x] structure
- [ ] object

#### Number of Resources within Property

(Do not include previously listed resources in the count.)

<table>
<thead>
<tr>
<th>Category</th>
<th>Contributing</th>
<th>Noncontributing</th>
</tr>
</thead>
<tbody>
<tr>
<td>buildings</td>
<td></td>
<td></td>
</tr>
<tr>
<td>sites</td>
<td></td>
<td></td>
</tr>
<tr>
<td>structures</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>objects</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Name of related multiple property listing

(Enter "N/A" if property is not part of a multiple property listing.)

**Bridges and Tunnels of Washington State**

### 6. Function or Use

#### Historic Functions

(Enter categories from instructions)

**TRANSPORTATION: road-related (vehicular)**

#### Current Functions

(Enter categories from instructions)

**TRANSPORTATION: road-related (vehicular)**

### 7. Description

#### Architectural Classification

(Enter categories from instructions)

**Suspension bridge**

#### Materials

(Enter categories from instructions)

- foundation: **concrete**
- walls:                        
- roof:                        
- other: **metal cables**

#### Narrative Description

(Describe the historic and current condition of the property on one or more continuation sheets.)
Tacoma Narrows Bridge

Name of Property: Tacoma Narrows Bridge

County and State: Pierce, WA

8. Statement of Significance

Applicable National Register Criteria
(Mark "x" in one or more boxes for the criteria qualifying the property for National Register listing.)

- A Property is associated with events that have made a significant contribution to the broad patterns of our history.
- B Property is associated with the lives of persons significant in our past.
- C Property embodies the distinctive characteristics of a type, period, or method of construction or represents the work of a master, or possesses high artistic values, or represents a significant and distinguishable entity whose components lack individual distinction.
- D Property has yielded, or is likely to yield, information important in prehistory or history.

Criteria Considerations
(Mark "x" in all the boxes that apply.)

Property is:
- A owned by a religious institution or used for religious purposes.
- B removed from its original location.
- C a birthplace or grave.
- D a cemetery.
- E a reconstructed building, object, or structure.
- F a commemorative property.
- G less than 50 years of age or achieved significance within the past 50 years.

Areas of Significance
(Enter categories from instructions)

- Bridge engineering
- Transportation

Period of Significance
1950-1960

Significant Dates
1950

Significant Person
Charles E. Andrew; W.A. Bugge; F.B. Farquhars

Cultural Affiliation

Architect/Builder
Bethlehem Pacific Coast Steel Corp.
John A. Roebings Sons Co.

9. Major Bibliographical References

Bibliography
(Cite the books, articles, and other sources used in preparing this form on one or more continuation sheets.)

Previous documentation on file (NPS):
- preliminary determination of individual listing (36 CFR 67) has been requested
- previously listed in the National Register
- previously determined eligible by the National Register
- designated a National Historic Landmark
- recorded by Historic American Buildings Survey
- recorded by Historic American Engineering Record

Primary location of additional data:
- State Historic Preservation Office
- Other State agency
- Federal agency
- Local government
- University
- Other

Name of repository:
WA State Dept. of Transportation
Tacoma Narrows Bridge

10. Geographical Data

Acreage of Property  ca. 15 acres

UTM References
(Place additional UTM references on a continuation sheet.)

<table>
<thead>
<tr>
<th>Zone</th>
<th>Easting</th>
<th>Northing</th>
</tr>
</thead>
</table>
| 1    | 110     | 5347344160 | south end
| 2    | 112     | 5344336900 | north end

Verbal Boundary Description
(Describe the boundaries of the property on a continuation sheet.)

Boundary Justification
(Explain why the boundaries were selected on a continuation sheet.)

11. Form Prepared By

name/title Robert H. Krier, retired WSDOT Bridge Engineer; edited by Craig Holstine, historian

organization Archaeological & Historical Services  date May 1993

Eastern Washington University

street & number Monroe Hall, Room 313, M.S. 168  telephone (509) 359-2239

city or town Cheney  state WA  zip code 99004

Additional Documentation
Submit the following items with the completed form:

Continuation Sheets

Maps

A USGS map (7.5 or 15 minute series) indicating the property's location.

A Sketch map for historic districts and properties having large acreage or numerous resources.

Photographs

Representative black and white photographs of the property.

Additional Items
(checked with the SHPO or FPO for any additional items)

Property Owner
(Complete this item at the request of SHPO or FPO.)

name Washington State Department of Transportation

street & number Highway Transportation Building  telephone 206-705-7480

city or town Olympia  state WA  zip code 98504

Paperwork Reduction Act Statement: This information is being collected for applications to the National Register of Historic Places to nominate properties for listing or determine eligibility for listing, to list properties, and to amend existing listings. Response to this request is required to obtain a benefit in accordance with the National Historic Preservation Act, as amended (16 U.S.C. 470 et seq.).

Estimated Burden Statement: Public reporting burden for this form is estimated to average 18.1 hours per response including time for reviewing instructions, gathering and maintaining data, and completing and reviewing the form. Direct comments regarding this burden estimate or any aspect of this form to the Chief, Administrative Services Division, National Park Service, P.O. Box 37127, Washington, DC 20013-7127; and the Office of Management and Budget, Paperwork Reductions Projects (1024-0018), Washington, DC 20503.
United States Department of the Interior  
National Park Service  

National Register of Historic Places  
Continuation Sheet  

Section number  7  Page  1  

Tacoma Narrows Bridge  
Pierce County, WA  

Description  

As one of the longest suspension bridges of its type in the United States, the Tacoma Narrows Bridge spans a swift-moving body of tidal water located in southern Puget Sound. Its length of over one mile gracefully connects the City of Tacoma and surrounding areas with the Kitsap Peninsula and, via highways and a floating bridge to the north, with the more distant Olympic Peninsula.  

The nominated property includes the entire bridge assembly, as well as all accessory features that were part of the 1950 design: the bridge structure, the two-story concrete North and South buildings, the concrete stairways and railings, the sidewalk at the upper level, and the roadway, paths and plantings areas at the lower level. The original toll booths and toll plaza were later removed, although the toll houses remain at the south end of the bridge.  

Starting from the west end, the bridge consists of a 164-foot-long concrete anchor block and gallery; three 150-foot-long steel plate girder approach spans; a 1,100-foot-long steel suspended side span; the 2,800 foot center suspension span; a 1,100 foot suspended side span; four east approach spans consisting of concrete tee-beams with spans 47 feet 7 inches, 42 feet 5 inches, 45 feet, and 45 feet; and an anchor block and gallery 185 feet long. The suspension cables are 60 feet center to center. The sides or stiffening trusses are 33 feet in depth and, at the time of construction, were deeper than those on any other known suspension bridge. The principal geometries of the bridge consist of the following:  

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total structure length</td>
<td>5,979 feet</td>
</tr>
<tr>
<td>Suspension bridge</td>
<td>5,000 feet</td>
</tr>
<tr>
<td>Center suspension span</td>
<td>2,800 feet</td>
</tr>
<tr>
<td>Shore suspension spans (2), each</td>
<td>1,100 feet</td>
</tr>
<tr>
<td>East approach and anchorage</td>
<td>365 feet</td>
</tr>
<tr>
<td>West approach and anchorage</td>
<td>614 feet</td>
</tr>
<tr>
<td>Center span height above water</td>
<td>187.5 feet</td>
</tr>
<tr>
<td>Width of roadway</td>
<td>49 feet 10 inches</td>
</tr>
<tr>
<td>Width of sidewalks (2), each</td>
<td>3 feet 10 inches</td>
</tr>
<tr>
<td>Diameter of suspension cables</td>
<td>20 1/4 inches</td>
</tr>
<tr>
<td>Weight of suspension cables</td>
<td>5,441 tons</td>
</tr>
<tr>
<td>Total length of single wire</td>
<td>20,000 miles</td>
</tr>
<tr>
<td>Suspended weight sustained by cables</td>
<td>18,160 tons</td>
</tr>
<tr>
<td>Number of No. 6 wires, each cable</td>
<td>8,705</td>
</tr>
<tr>
<td>Shore anchors for cables, weight</td>
<td>66,000 tons</td>
</tr>
</tbody>
</table>
Towers

Height above piers ........................................... 467 feet
Weight of each tower ....................................... 2,675 tons

Piers on Which Towers Rest

Area ............................................................. 118 feet 11 inches by 65 feet 11 inches
Total height of east pier .................................... 265 feet
Depth of water, east pier ..................................... 135 feet
East pier penetration at bottom ............................. 90 feet
Total height of west pier .................................... 215 feet
Depth of water, west pier .................................... 120 feet
West pier penetration at bottom ............................ 55 feet

Every reasonable precaution was taken to stabilize the structure and insure against any possibility of noticeable motion. One of those precautions, and a feature unique to this bridge, is in the design of the roadway deck. Open steel grid slots were installed between each of the four traffic lanes and at both curbs. These open steel gratings function as vents to relieve the alternating up and down impulses which are a principal factor in causing oscillation created by the passing wind. The gratings are bonded to the concrete so as to preserve slab continuity across the full roadway. The use of these slots was found in tests to be a most effective method of reducing the forces which cause oscillation and, consequently, constitute a large factor in stabilizing the structure.

Another precaution against torsional motion is that the ratio of the depth of stiffening truss to span length is greater than normally used in suspension bridges. Also, the trusses are provided with a double lateral system. In nearly all suspension bridges of that era, only one lateral system of horizontal bracing was used to connect the bottom chords of the trusses. In this bridge horizontal bracing is installed between both the top and bottom chords of the stiffening
Tacoma Narrows Bridge  
Pierce County, WA

Description (continued)

trusses. These features greatly increase the resistance of the suspended structure to the torsional or twisting motion that occurred in the original structure.

A third precautionary and unique design feature was the installation of double acting hydraulic jacks that function in much the same manner as shock absorbers in an automobile. These members act as energy absorbing devices and provide a damping effect in the event the bridge should begin to oscillate and cause differential horizontal movement between the cables and the truss. These devices are located in a longitudinal, diagonal position at the center of the main span on each side and connect the main cables to the top chords of the stiffening trusses. Additional jacks are installed in the tower legs connecting the top chords of the main span to the top chords of the side spans, which are then rigidly connected to the anchorages. Beneath the bottom chords adjacent to the main towers (Nos. 4 & 5) are diagonal jacks connecting the bottom chords to the towers to complete the couple with the top chord jacks. This system of energy absorption provides added protection against the possibility of oscillation from excessive wind forces.

The two main channel piers (Nos. 4 & 5) were undamaged during the failure of the original bridge and were used to support the second bridge with only minor modifications to the concrete pedestals under the new steel tower legs. The original construction of Pier 5 was one of the most difficult ever attempted, establishing a world record for depth of water in which a caisson had ever been landed. Water depth, along with tidal currents of nine miles per hour at the site, required extreme caution and ingenuity on the part of the engineers and contractors. Thirty concrete anchors, each weighing approximately 600 tons and connected to the caisson with 90 one-inch diameter wire cables, were required to hold the caisson against the current. At times the level of water at one end of the caisson would be seven to eight feet higher than at the other. Holding construction barges alongside the caisson was extremely difficult. Steel cutting edges were attached to the bottom of the caisson. After the caisson was lowered to the bottom of the channel in 135 feet of water, the cutting edges assisted in penetrating through 90 feet of sand, gravel, and boulders where the bottom of the caisson was finally positioned at a depth of 225 feet below mean low tide.
Tacoma Narrows Bridge
Pierce County, WA

Description (continued)

Light weight concrete was used in the roadway deck of the second (present) bridge to lessen the load on the piers. However, the total superstructure weight of the second bridge exceeded the first bridge by approximately 1.6 times per lineal foot. The designers determined that this additional weight would not cause excessive overloading of the foundations. The original anchor blocks were also used in the second bridge, but had to be modified substantially due to the greater weight of the superstructure. This weight increased the horizontal force in the main cables from the original 28 million pounds to 36 million pounds. In addition, the new cables were spaced 60 feet apart compared to the original 39 feet. The concrete anchorage was modified by removing the sides of the anchor by blasting down to the top of the footing blocks, installing new anchor bars to attach the main cables, adding eight feet of concrete on each side, and extending the back of the anchor 20 feet to its full height. The additional width and length, in effect, provided a yolk or "U" configuration around the old concrete core that remained.

Several features were incorporated into the bridge for maintenance purposes. One leg of each of the main towers contains an elevator that travels the full height of the towers to carry personnel and supplies. Maintenance travelers powered by gasoline motor generators were attached to the underside of the steel portions of the superstructure for traveling the length of the bridge.

Statement of Significance

Summary of Significance

When completed in 1950, the Tacoma Narrows Bridge was the third longest suspension bridge in the world. Its innovative design features contributed to the body of knowledge of suspension bridge engineering. Although many longer suspension spans have been constructed since its completion, the Tacoma Narrows Bridge still remains one of the grandest structures of its type in the United States. As of 1991, it was the fifth longest suspension span in North America. Thus the bridge is significant under Criterion C as an important representative of a bridge type
Tacoma Narrows Bridge
Pierce County, WA

Statement of Significance (continued)

(suspension bridges) identified in the Multiple Property Documentation (MPD) listing "Bridges and Tunnels in Washington State" (1980) and the "Amendment to Bridges and Tunnels in Washington State" (1991). The structure is significant under Criterion A for its vital role in serving transportation needs in the Puget Sound area. The bridge is also significant under Criterion B for its association with several engineers whose reputations extended beyond the State of Washington. Although the bridge is less than fifty years old, it is of exceptional importance and thus meets the eligibility requirement of Criteria Consideration G.

Historical Background and Significance

The Tacoma Narrows Bridge is one of the world’s longest suspension bridges. Spanning a deep, swift body of water called "The Narrows," where tidal flows of Puget Sound reach nine miles per hour through this nearly mile-wide passage, the bridge serves as a major transportation corridor between the City of Tacoma on the Puget Sound mainland and the Kitsap Peninsula. Prior to the construction of the bridge, the mode of transportation between these two destinations was either by ferry or by a circuitous highway route around the lower end of Puget Sound through the City of Olympia, a distance of more than 100 miles. Spanning the gap between the two land masses, the structure connects the Bremerton metropolitan area, which includes the Puget Sound Naval Shipyard, with Tacoma, and thereby plays an important role in supporting the economy of Puget Sound.

Bridging Puget Sound across the Narrows had long been a dream of both the City of Tacoma and the western region of Washington, which includes the Olympic and Kitsap peninsulas. In ca. 1923 a corporation attempted to build a bridge as a private venture at a location south of the present structure. For various reasons, principally financing, the project did not materialize. Their dream was finally, if briefly, realized with the construction by the Washington State Department of Highways of a suspension bridge, which opened to traffic on July 1, 1940. High winds in the Narrows caused excessive motion and undulations that induced violent torsional oscillations of the new structure, leading local observers to christen the bridge "Galloping Gertie." These movements created stresses in the members far in excess of what the bridge...
Tacoma Narrows Bridge
Pierce County, WA

Statement of Significance (continued)

could withstand, resulting in a catastrophic collapse of the superstructure on November 7, 1940. Although such forces had not been considered at that time as critical in suspension bridge design, it was reported later that the aerodynamic effect of wind on similar structures had been demonstrated by similar failures in England 100 years before, and in truth, forgotten by all suspension bridge engineers engaged in modern design.

The high volume of traffic that used the first bridge during its short period of existence clearly demonstrated the necessity for a bridge. Undaunted by the failure, the Washington Toll Bridge Authority (no longer in existence), then headed by Governor Arthur Langlie, authorized an engineering study to determine the possibility of safely bridging the Narrows. A Board of Consulting Engineers was appointed to perform the study and provide recommendations. The Board consisted of Charles E. Andrew, Chairman; Glenn B. Woodruff; John I. Parcel of Sverdrup & Parcel; and Dr. Theodore von Karman, noted aerodynamicist of Pasadena, California.

The efforts that went into the design of the second Narrows Bridge were unique and had an important effect on the design of suspension and similar structures that were to follow. Approximately four years were spent in original research to study aerodynamics and design features to achieve stability of a new structure. The Consulting Board at the beginning of the study recognized that the question of aerodynamic stability of suspension bridges would have to be resolved to achieve a safe design. Although the development of aerodynamics in the 1940s was not unique as applied to aircraft, there had been no previous scientific effort devoted to the dynamic effect of winds passing over a bridge structure, whose geometries are entirely different from those of an airplane wing. The studies consisted of construction of a special wind tunnel at the University of Washington and testing three-dimensional bridge models - the first time such models had ever been built. A 1:50 three-dimensional model of the original bridge was built to prove that wind velocities acting on models scaled to match the bridge’s form and elastic properties would create the same motions as those actually measured and recorded in the field on the prototype. If similitude could be proven by testing the first model, then a scaled model...
Tacoma Narrows Bridge
Pierce County, WA

Statement of Significance (continued)

of a proposed form of a new bridge structure would be built to predict the behavior of its prototype.

The first test proved the theory of similitude between model and prototype with almost perfect accuracy, establishing confidence in tests on other and different designs. In conducting the research, all available knowledge of aerodynamics was used as a guide. Many modifications were necessary and the tests were spread over nearly four years during the shortages of World War II, with its attendant handicaps, before the desired degree of stability was found. Methods and devices necessary to obtain the required stability were also determined. Tests were performed under the general direction of Charles E. Andrew with the approval of the Board of Consulting Engineers. Professor F.B. Farquharson of the University of Washington directed building of the wind tunnel and bridge models. Dr. Theodore von Karman supervised testing of the models in the wind tunnel. Test results formed the basis for a continuing study by a national committee comprised of many engineers in the country interested in suspension bridges.

Because of the extreme shortage of steel and wire during World War II, it was decided to salvage all remaining material from the first bridge to every extent possible. Ironically, it would have been more economical for the state to have dropped the remaining portions of the structure into the deep waters of the Puget Sound.

Designs for the new bridge were completed in 1947 and checked aerodynamically by the use of models. Contracts were let for construction on March 31 and April 1, 1948. The primary contractors for construction of the bridge were the Bethlehem Pacific Coast Steel Corporation and John A. Roeblings Sons Company. Both of these firms were notable for their innovative construction skills in the fabrication and erection of steel bridges.

The Tacoma Narrows Bridge opened to traffic on October 14, 1950; all components of the structure were finally in place by November 1951. Construction was financed through a $14,000,000 bond issue. The bridge operated as a toll facility until the bonds were retired, at which time the tolls were removed along with the toll plaza and booths (although the toll houses
Tacoma Narrows Bridge
Pierce County, WA

Statement of Significance (continued)

remain off the south end of the bridge). The toll for an automobile and driver was 50 cents. Each additional passenger paid 10 cents.

The successful building of this bridge was a combined effort of the many engineers who had a part in its design and construction; the members of the Washington Toll Bridge Authority in their support of the judgment of the engineers; members of the Washington Legislature, who passed the necessary legislation and appropriations; the residents of Tacoma, Kitsap and Pierce counties for their loyal support and financial guarantees; the contractors who risked their capital and resources to guarantee its final construction; and to organized labor, who actually put together the steel and concrete which forms the final structure.

At the time of completion, the Tacoma Narrows Bridge included the third longest suspension span in the world. As of 1991 it ranked as the fifth longest span in North America. This bridge is of major significance because of its numerous unique design features. It was the first time a research program was implemented to investigate the aerodynamic effects of wind acting upon a bridge. In designing this structure, bridge engineers first used wind tunnel tests to determine the behavior and stability of a physical model of a proposed bridge. The research and design provided significant information to suspension bridge engineers nationwide and had an important effect on all suspension bridge designs that followed. The design incorporated unique features into the structure, such as the open steel grid slots, the greater ratio of the depth of stiffening truss to span length, the double lateral system, the hydraulic energy absorbing and damping devices, and the record depth below water at which pier construction occurred with the aid of submerged caissons. Few bridges have received as much engineering significance in technical publications or as much nation-wide attention and publicity, due in part to the failure of the first Tacoma Narrows Bridge. The present structure represents an extraordinary achievement in bridge design and construction engineering, an effort that produced a structure of unprecedented function and stability, and virtually unequaled esthetic attraction spanning one of the country’s most challenging crossings. In addition, the bridge established one of the most significant transportation corridors in Washington state by connecting the mainland with the Kitsap and Olympic peninsulas.
Tacoma Narrows Bridge
Pierce County, WA

Statement of Significance (continued)

Significant Persons Associated with the Tacoma Narrows Bridge

The Tacoma Narrows Bridge meets the eligibility requirements under Criterion B due to its association with bridge engineers renowned in their profession. Charles E. Andrew, Principal Engineer in charge of the design and construction of the bridge, was a renowned engineer for his unique and creative bridge designs. He was highly regarded in the engineering profession for his ability to undertake projects that were unique, or of major size and construction difficulty. Other projects that were designed and constructed under his direction included the San Francisco-Oakland Bay Bridge, the Lacey V. Murrow, Evergreen Point, and the Hood Canal floating concrete bridges. Another engineer who achieved outstanding recognition for his contributions to the field of transportation was W.A. Bugge, Director of the Department of Highways during the construction of the second Tacoma Narrows Bridge. Demonstrating outstanding abilities as both engineer and administrator, Bugge went on to play a major role in developing the Bay Area Rapid Transit (BART) tunnel under San Francisco Bay. As a result of his work on the bridge, University of Washington Professor of Engineering F.B. Farquharson received recognition for his outstanding research of the aerodynamic behavior of suspended structures.

Major Bibliographical References


Bridge Condition Unit Files. Washington State Department of Transportation, Olympia.
Tacoma Narrows Bridge
Pierce County, WA

Major Bibliographical References (continued)


Verbal Boundary Description

The boundary encompasses all elements of the bridge structure, and includes the approaches, North and South buildings, concrete stairways and railings, sidewalks, roadway, paths and associated plantings.

Boundary Justification

The boundary is based on the bridge and all associated elements that were part of the original 1950 design.
TACOMA NARROWS BRIDGE
PIERCE COUNTY, WASHINGTON
NRIS Reference Number: 94001438

NATIONAL REGISTER NOMINATION - RETURN

The nomination materials are being returned at this time for the technical and substantive reasons outlined below:

Significance

- The case for "exceptional" significance required for properties less than fifty years old has not been adequately substantiated. With significance proposed at the national level, the nomination should be based upon a well-documented scholarly analysis of the historic context. As noted in the attached memo from Eric DeLony of HAER, the current nomination--while well-written--contains very little discussion of the national context for bridge construction after the collapse of the original Tacoma Bridge. The revised nomination should make use of the large body of scholarly documentation already available (engineering periodicals, general reference works, local sources) to fully substantiate the "exceptional" engineering significance of the Tacoma Bridge under Criteria A and C. Please review Mr. DeLony's letter for other comments concerning the nomination as well.

The significance of the bridge under Criterion B, in association with the engineers who worked on the project, is also questionable. It is unclear from the current documentation whether or not there are other elements of their individual careers that might be better representative of their significant contributions to the field, particularly in light of the limited context provided and the less than 50-year period of their accomplishments. It is more likely that their significance could be acknowledged under Criterion C, similar to the works of noted architects (i.e. "works of a master").

- Period of Significance. Please provide a explanation for the period of significance, particularly the end date of 1960. This is important with respect to the use of Criteria Consideration G.

Geographic Data

- U.T.M. Coordinates. The northing value for UTM point Number 2 is incorrect and should be revised on both the map and the form.

Reviewer: Paul R. Lusignan
Historian, NPS
(202) 343-1628
Date: 12/22/94

A:\Tacoma.rtn
Tacoma Narrows Bridge
Pierce County, WA
H.S. Rice, photographer
March 1993
AHS, EWU, Cheney, WA
view to SW
#1
Tacoma Narrows Bridge
Pierce County, WA
H. S. Rice, photographer
March 1993
AHS, EWU, Cheney, WA
View to west
#2
Tacoma Narrows Bridge
Pierce County, WA
H.S. Rice, photographer
March 1993
AHS, EWU, Cheney, WA
view to east
#4
Tacoma Narrows Bridge
Pierce County, WA
H. S. Rice, photographer
March 1993
AHS, Ewu, cheney, WA
view to west
#5
Tacoma Narrows Bridge
Pierce County, WA
H. S. Rice, photographer
March 1993
AHS, Ewu, Cheney, WA
View to SE
#6
In 1939, it was reported that false-bottom caissons used for a record water depth of 120 feet provide the outstanding construction feature on the 2800 foot suspension bridge being built over the Tacoma Narrows. Although the piers were of standard design and construction, they were adopted in a location where the water depth was more than double the previous record for this type of pier construction.

However, ultimately it was not the unusual pier construction that brought fame to the Tacoma Narrows Bridge. At the time that the graceful, ribbonlike bridge was opened to traffic on July 1, 1940, it was the third longest suspension bridge in the world. It was designed by Leon S. Moisseiff, a renowned bridge engineer, who helped design the Manhattan suspension bridge between New York and Brooklyn in 1909, and was a consulting engineer for the construction of the Golden Gate Bridge, as well as for other major bridge projects of the first half of the 20th century.

REFERENCES—HISTORICAL REFERENCES, PERSONAL CONTACTS, AND/OR OTHER
State Department of Transportation bridge files.
David B. Steinman and Sara Ruth Watson, Bridges and their Builders, (New York, 1941), pp. 353-360.
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. The engineer, David B. Steinman wrote that a generation earlier, authorities had recommended that the minimum depth of the stiffening trusses should be one fortieth of the total span length. This recommendation was reduced to a range from one ninetieth to one fiftieth for spans between 2,000 and 3,000 feet in length. In contrast to these recommendations, the eight foot depth of the stiffening girder in the Tacoma Narrows bridge was one three-hundred-and-fiftieth of the 2800 foot span. The natural oscillation periods of the high flexible towers in combination with those of the main span made the structure susceptible to the generation of harmonic motions of dangerous amplitude.

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. In addition, a solid bridge floor was framed into the plate girders. 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 is then a tendency for the undulations to change into a twisting motion, with further progressive increase of amplitude until these torsional oscillations reach dangerous or destructive proportions." It was exactly these harmonic motions that eventually proved fatal to the bridge. These motions were evident even before the structure was completed. During construction, the motions of the bridge were so violent that the workers became seasick.

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-Whitestome 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.

On October 15, 1950 a second Tacoma Narrows Bridge was opened to traffic. The dimensions of the present bridge are identical to those of the first. There is a 2800 foot suspended span, and two 1100 foot spans. The main piers, part of the west approach spans, and the anchor blocks of the first structure were utilized in the existing structure.
Tacoma Narrows Bridge

25. Photos and Sketch Map of Location

Looking northwest.
Tacoma Narrows Bridge

looking southeast

Tacoma Narrows Bridge

cable connection

Tacoma Narrows Bridge

south tower

55496 ft

Tacoma Narrows Bridge

south approach
Tacoma Narrows Bridge
looking southeast

Tacoma Narrows Bridge
south pier
Tacoma Narrows Bridge
Tacoma Narrows Bridge

25. Photos and Sketch Map of Location
The first white explorers of these waters made acquaintance on the night of May 20, 1792 near this site. The explorers were from the British expedition under Captain George Vancouver. Lieutenant Peter Furgus was in charge of this part. His mission was to chart the sea in the Strait to its southern limits. Vancouver named the banks of waterways "Paper Sound" - in honor, greatly later, to the naval officer...

The suspension bridge can be seen Tacoma and Mount Rainier.
Location

Field Site No. DAHP No. PI00259
Historic Name: Tacoma Narrows Bridge
Common Name:
Property Address: Route 16, 7.3 N Jct SR 5, Tacoma, WA
Comments:
Tax No./Parcel No.
Plat/Block/Lot
Acreage
Supplemental Map(s)

<table>
<thead>
<tr>
<th>Township/Range/EW</th>
<th>Section</th>
<th>1/4 Sec</th>
<th>1/4 Sec</th>
<th>County</th>
<th>Quadrangle</th>
</tr>
</thead>
<tbody>
<tr>
<td>T21R02E</td>
<td>28</td>
<td></td>
<td></td>
<td>Pierce</td>
<td></td>
</tr>
<tr>
<td>T21R02E</td>
<td>33</td>
<td></td>
<td></td>
<td>Pierce</td>
<td></td>
</tr>
<tr>
<td>T21R02E</td>
<td>34</td>
<td></td>
<td></td>
<td>Pierce</td>
<td></td>
</tr>
</tbody>
</table>

Coordinate Reference

Easting: #Error
Northing: #Error
Projection: Washington State Plane South
Datum: HARN (feet)
Identification

Survey Name:   Legacy for City of Tacoma
Field Recorder: 
Owner’s Name:  WA State DOT
Owner Address: Hihgway Transportation Bldg.
City: Olympia State: WA Zip: 98504
Classification: Structure
Resource Status:  Comments:
State Register
Within a District?  Contributing?
National Register:  Tacoma Narrows Bridge
Local District: 
National Register District/Thematic Nomination Name: 
Eligibility Status: Not Determined - SHPO
Determination Date:  1/1/0001
Determination Comments:

Description

<table>
<thead>
<tr>
<th>Historic Use:</th>
<th>Current Use:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plan:</td>
<td>Stories:</td>
</tr>
<tr>
<td>Changes to Plan:</td>
<td>Changes to Interior:</td>
</tr>
<tr>
<td>Changes to Original Cladding:</td>
<td>Changes to Windows:</td>
</tr>
<tr>
<td>Changes to Other:</td>
<td>Other (specify):</td>
</tr>
<tr>
<td>Style:</td>
<td>Cladding:</td>
</tr>
<tr>
<td>Foundation:</td>
<td>Form/Type:</td>
</tr>
<tr>
<td>Roof Type:</td>
<td>Roof Material:</td>
</tr>
</tbody>
</table>

Narrative

Study Unit Other
Date of Construction: Builder: 
Engineer: 
Architect: 

Property appears to meet criteria for the National Register of Historic Places:
Property is located in a potential historic district (National and/or local):
Property potentially contributes to a historic district (National and/or local):
Statement of Significance:

Description of Physical Appearance:

Major Bibliographic References:
### Identification

<table>
<thead>
<tr>
<th>Survey Name:</th>
<th>Legacy for City of Tacoma</th>
<th>Date Recorded:</th>
<th>01/01/1900</th>
</tr>
</thead>
<tbody>
<tr>
<td>Field Recorder:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Owner’s Name:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Owner Address:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>City:</td>
<td>State:</td>
<td>Zip:</td>
<td></td>
</tr>
<tr>
<td>Classification:</td>
<td>Resource Status:</td>
<td>Comments:</td>
<td></td>
</tr>
<tr>
<td>Within a District?</td>
<td>Contributing?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>National Register:</td>
<td>Local District:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>National Register District/Thematic Nomination Name:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eligibility Status:</td>
<td>Not Determined - SHPO</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Determination Date:</td>
<td>1/1/0001</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Determination Comments:</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Description

<table>
<thead>
<tr>
<th>Historic Use:</th>
<th>Current Use:</th>
<th>Plan:</th>
<th>Stories:</th>
<th>Structural System:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Changes to Plan:</td>
<td></td>
<td>Changes to Interior:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Changes to Original Cladding:</td>
<td></td>
<td>Changes to Windows:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Changes to Other:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other (specify):</td>
<td>Style:</td>
<td>Cladding:</td>
<td>Roof Type:</td>
<td>Roof Material:</td>
</tr>
<tr>
<td></td>
<td>Foundation:</td>
<td>Form/Type:</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Narrative

<table>
<thead>
<tr>
<th>Study Unit</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date of Construction:</td>
<td>Builder:</td>
</tr>
<tr>
<td></td>
<td>Engineer:</td>
</tr>
<tr>
<td></td>
<td>Architect:</td>
</tr>
</tbody>
</table>

Property appears to meet criteria for the National Register of Historic Places:

Property is located in a potential historic district (National and/or local):

Property potentially contributes to a historic district (National and/or local):

Statement of Significance:
Description of Physical Appearance:

Major Bibliographic References:
Historic Name: Tacoma Narrows Bridge

Address: Spanning the Tacoma Narrows
City: Tacoma
County: Pierce

Download nomination form

Historic Use: Transportation
Style: None
Built: 1950

Architect:
Builder: Bethlehem P.C. Steeel; John A. Roeblings Sons and Co

Smithsonian Number: 45PI00259
Date Listed: 9/15/1994
Listing Status: WHR
Classification: STR
Resource Count: 1
Area of Significance: Engineering
Level of Significance: Local
Listing Criteria:

Statement of Significance

Designs for the new bridge were completed in 1947 to replace the ill fated "galloping Gurtie" bridge were checked aerodynamically with the use of models. Contracts were let for construction on March 31 and April 1, 1948. The primary contractors for construction of the bridge were the Bethlehem Pacific Coast Steel Corporation and John A. Roeblings Sons Company. Both of these firms were notable for their innovative construction skills in the fabrication and erection of steel bridges.

The Tacoma Narrows Bridge opened to traffic on October 14, 1950; all components of the structure were finally in place by November 1951. Construction was financed through a $14,000,000 bond issue. The bridge operated as a toll facility until the bonds were retired, at which time the tolls were removed along with the toll plaza and booths (although the toll houses remain off the south end of the bridge). The toll for an automobile and driver was 50 cents. Each additional passenger paid 10 cents.

At the time of completion, the Tacoma Narrows Bridge included the third longest suspension span in the world. As of 1991 it ranked as the fifth longest span in North America. This bridge is of major significance because of its numerous unique design features. It was the first time a research program was implemented to investigate the aerodynamic effects of wind acting upon a bridge. In designing this structure, bridge engineers first used wind tunnel tests to determine the behavior and stability of a physical model of a proposed bridge. The research and design provided significant information to suspension bridge engineers nationwide and had an important effect on all suspension bridge designs that followed. The design incorporated unique features into the structure, such as the open steel grid slots, the greater ratio of the depth of stiffening truss to span length, the double lateral system, the hydraulic energy absorbing and damping devices, and the record depth below water at which pier construction occurred with the aid of submerged caissons. Few bridges have received as much engineering significance in technical publications or as much nation-wide attention and publicity, due largely to the failure of the first Tacoma Narrows Bridge. The present structure represents an extraordinary achievement in bridge design and construction engineering. This effort produced a structure of unprecedented function, stability, and virtually unequaled esthetic attraction spanning one of the country's most challenging crossings. In addition, the bridge established one of the most significant transportation corridors in Washington State by connecting the mainland with the Kitsap and Olympic peninsulas.

Photos
United States Department of the Interior
National Park Service

National Register of Historic Places
Registration Form

This form is for use in nominating or requesting determinations of eligibility for individual properties or districts. See Instructions in Guidelines for Completing National Register Forms (National Register Bulletin 16). Complete each item by marking "x" in the appropriate box or by entering the requested information. If an item does not apply to the property being documented, enter "N/A" for "not applicable." For functions, styles, materials, and areas of significance, enter only the categories and subcategories listed in the instructions. For additional space use continuation sheets (Form 10-900-a). Type all entries.

1. **Name of Property**
   - historic name: Tacoma Narrows Bridge Ruins
   - other names/site number: Galloping Gertie

2. **Location**
   - street & number: Highway 16 over the Tacoma Narrows
   - city, town: Tacoma
   - state: Washington
   - county: Pierce
   - code: WA 053
   - zip code: 

3. **Classification**
   - Ownership of Property: public-Federal
   - Category of Property: building(s)
   - Number of Resources within Property: Contributing: I, Noncontributing: 0

Name of related multiple property listing: N/A

4. **State/Federal Agency Certification**
   - As the designated authority under the National Historic Preservation Act of 1966, as amended, I hereby certify that this nomination request for determination of eligibility meets the documentation standards for registering properties in the National Register of Historic Places and meets the procedural and professional requirements set forth in 36 CFR Part 60. In my opinion, the property meets the National Register criteria. See continuation sheet.

   Signature of certifying official: [Signature]
   Date: [Date]

   Washington State Office of Archaeology and Historic Preservation
   State or Federal agency and bureau:

In my opinion, the property meets or does not meet the National Register criteria. See continuation sheet.

Signature of commenting or other official: [Signature]
Date: [Date]

State or Federal agency and bureau:

5. **National Park Service Certification**
   - I hereby certify that this property is:
     - entered in the National Register.
     - determined eligible for the National Register.
     - determined not eligible for the National Register.
     - removed from the National Register.
     - other, (explain): 

   Signature of the Keeper: [Signature]
   Date of Action: [Date]
The first Tacoma Narrows Bridge was revolutionary in its design and historic in its collapse. Its failure on November 7, 1940 marked the end of a trend in bridge engineering towards a maximum of lightness, grace and flexibility. Since the turn of the century, suspension bridge construction valued structural grace and slenderness to achieve an artistic appearance. With its shallow stiffening trusses and slender towers, the bridge across the Narrows was the epitome of artistry in bridge construction.

Prior to the Narrows Bridge, conventional engineering wisdom recommended that stiffening trusses on a suspension bridge be a minimum of 1:40 in depth and that the minimum roadway width compared to the length of the span be 1:30. The eight foot stiffening girders supporting the 2,800 foot span on the Narrows bridge was 1:350 and the roadway to length of span ratio was 1:72. This lightweight design and long center span gave the bridge unparalleled flexibility and beauty.

The original plan for the first bridge was designed by Clark Eldridge, an engineer with the Washington State Department of Highways. His design called for a 5,000-foot, two-lane suspension bridge. The two approach (side) spans were 1,100 feet long, the center span 2,800. Two 425-foot towers rested on deep piers of the cellular caisson design. When completed, the structure was the third longest suspension bridge in the world (The George Washington Bridge in New York City and the Golden Gate Bridge in San Francisco being longer).

Eldridge's plans were reviewed by a State-appointed engineering consultant, Moran and Proctor, who suggested major revisions to the design. These revisions were ultimately scrapped during the bidding process when a group of contractors informed the State that the revised substructure specifications could not be built. Eldridge's plan for the substructure was reintroduced into the design. In addition, the State retained Leon S. Moisseiff, a world-renowned bridge designer (Golden Gate Bridge) to examine the design of the superstructure. Moisseiff substituted Eldridge's 25-foot deep, open stiffening truss with an eight foot, shallow plate grid.

The contract was awarded to the Pacific Bridge Company for their bid of $5,594,730.40 and the associate contractor was Bethlehem Steel Company for the steel and wire. The bridge was opened July 1, 1940. The specifications are listed on the next page.
Today the center span and other debris lie on the floor of Puget Sound, where they fell. A site plan of these remains, developed from sonar soundings of the Narrows, is attached. The remains of the center span are readily identifiable on the plan. The videotape "Gertie Gallops Again," prepared by Tacoma Municipal Television for the show "CityScape," is also submitted with the nomination for the historic footage of the collapse and the underwater filming of the present remains.

The side spans were removed and salvaged for their high resale value during the war effort. The original piers were used for the second bridge (1952), and new towers were constructed.

**SPECIFICATIONS OF THE FIRST TACOMA NARROWS BRIDGE:**

<table>
<thead>
<tr>
<th>Specification</th>
<th>Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total length</td>
<td>5,939 feet</td>
</tr>
<tr>
<td>Suspension bridge section</td>
<td>5,000 feet</td>
</tr>
<tr>
<td>Center span</td>
<td>2,800 feet</td>
</tr>
<tr>
<td>Shore suspension spans, each</td>
<td>1,100 feet</td>
</tr>
<tr>
<td>East approach and anchorage</td>
<td>345 feet</td>
</tr>
<tr>
<td>West approach and anchorage</td>
<td>594 feet</td>
</tr>
<tr>
<td>Center span height above water</td>
<td>195 feet</td>
</tr>
<tr>
<td>Width of roadway</td>
<td>26 feet</td>
</tr>
<tr>
<td>Width of sidewalks, each</td>
<td>5 feet</td>
</tr>
<tr>
<td>Diameter of main suspension cable</td>
<td>17-1/2 inches</td>
</tr>
<tr>
<td>Weight of main suspension cable</td>
<td>3,817 tons</td>
</tr>
<tr>
<td>Weight sustained by cables</td>
<td>11,250 tons</td>
</tr>
<tr>
<td>Number of No. 6 wires each cable</td>
<td>6,308</td>
</tr>
<tr>
<td>Weight shore anchors</td>
<td>52,500 tons</td>
</tr>
<tr>
<td>Towers:</td>
<td></td>
</tr>
<tr>
<td>Height above piers</td>
<td>425 feet</td>
</tr>
<tr>
<td>Weight of each tower</td>
<td>1,927 tons</td>
</tr>
<tr>
<td>Piers:</td>
<td></td>
</tr>
<tr>
<td>Area</td>
<td>118 feet, 11 inches x 65 feet, 11 inches</td>
</tr>
<tr>
<td>East pier, total height</td>
<td>247 feet</td>
</tr>
<tr>
<td>Depth of water</td>
<td>140 feet</td>
</tr>
<tr>
<td>West pier, total height</td>
<td>198 feet</td>
</tr>
<tr>
<td>Depth of water</td>
<td>120 feet</td>
</tr>
</tbody>
</table>
The significance of the first Tacoma Narrows Bridge is derived directly from its startling collapse on November 7, 1940, which brought engineers world-wide to the realization that aerodynamic phenomena in suspension bridges were not adequately understood in the profession nor had they been addressed in this design. New research was necessary to understand and predict these forces. The official investigation into the collapse (Farquharson et al., 1949-54) recommended the use of wind-tunnel tests to aid in the design of the second Tacoma Narrows Bridge and resulted in the testing of all existing and future bridges across the country. New mathematical theories of vibration in suspension bridges were published as a result of the bridge failure (Bleich et al., 1950) and continues today (Peterson, 1990). Aerodynamics, wave phenomena, and harmonics were all part of the new studies. "Based on these investigations (Farquharson, et al., Bleich et al.), procedures for the design of suspension bridges for aerodynamic excitations were set up, and became in important part of the design process for all major cable supported bridges to be built in the future,"¹ wrote Danish engineer Niels J. Gimsung.

The film of the bridge collapsing is a dramatic and on-going teaching tool shown to engineering and physics students, both here and abroad. Physics professors Zollman and Fuller (1982) describe the film as providing "physics teachers with the most captivating demonstration of wave phenomena ever devised."² Ivars Peterson, engineer, describes the film as "among the most dramatic and widely known images in science and engineering."³

The collapse of the Tacoma Narrows Bridge was a singular event in the history of engineering with far-reaching implications in the development of aerodynamics and bridge design, implications which extend beyond political borders and are part of the evolution of civil engineering. The collapse was a failure, but "the most important and spectacular failure in suspension bridge history."⁴ As is common in much of human history, we often learn more from our failures than from our successes. For these reasons, the first Tacoma Narrows Bridge is worthy of listing in the National Register by virtue of its role in the history of civil engineering and bridge design.
HISTORICAL BACKGROUND:

There is one point in the 20,000 square miles of Puget Sound where the Washington mainland and the Olympic Peninsula are close - the Narrows at Tacoma. For years, it had been clear to State officials that the Narrows would have to be bridged in order to open up the spectacular and thinly populated Peninsula. Aware of this situation, the Washington State Legislature created the Washington Toll Bridge Authority in 1937, with a mandate to finance, construct and operate toll bridges.

The City of Tacoma and Pierce County Board of Commissioners asked the State to construct a bridge across the Narrows. The legislature appropriated $25,000 to study the request. Satisfied with the results of the study, on May 23, 1938, the State of Washington submitted an application to the Public Works Administration (PWA) requesting funds for construction of a bridge.

Between the time the state legislature authorized the money to study the proposal and the completion of that study, Lacey Murrow, Director of the Washington State Department of Highways, had given Clark Eldridge, a bridge engineer with the department, a green light to design a bridge to span the Narrows. Eldridge went to work, and when he finished, his plan called for a 5,000 foot, two-lane suspension bridge. When completed, the structure would be the third longest suspension bridge in the world (only the George Washington Bridge in New York City and the Golden Gate Bridge in San Francisco were longer).

After examination of Eldridge's plans in May of 1938, the Public Works Administration agreed to finance 45 percent of the construction, provided that the State of Washington retain a board of independent engineering consultants to reexamine Eldridge's design. The State complied and employed the firm of Moran and Proctor to study the plans for the substructure. Furthermore, the State retained Leon S. Moisseiff, the world-renowned suspension bridge builder who had designed the Golden Gate Bridge, to examine the plans concerning the superstructure. Both Moran and Proctor and Moisseiff made significant alterations to Eldridge's original design. Specifically, Moran and Proctor and Moisseiff wanted an entirely different substructure. As to Moisseiff, he substituted the 25 foot deep open stiffening truss with an eight foot, shallow plate girder, resulting in a much lighter bridge. His international stature as a builder of suspension bridges was immense; his plans for the Narrows Bridge were the culmination of Moisseiff's efforts to combine grace, lightness and flexibility in suspension bridge construction. The Narrows Bridge was "to stretch like a taut ribbon" across the Narrows.
Prior to the opening of the construction bids, a group of contractors notified the engineers they could not meet the specifications for the substructure. As a result, Moran and Proctor's plans for the substructure were scrapped, and Eldridge's original plans for the substructure were reintroduced. After consultation with Moiseiff, it was agreed that Eldridge's design for the substructure would be used in conjunction with Moiseiff’s plans for the superstructure. This modified plan was approved by the Public Works Administration and bids for construction were opened on September 27, 1938. The Pacific Bridge Company's low bid of $5,594,730.40 was accepted. The Bethlehem Steel Company was an associate contractor which supplied and erected the steel and wire. Work on the bridge began in early 1939. On July 1, 1940, the $6.4 million bridge opened; the link between the Washington mainland and the Olympic Peninsula was complete.

Vertical oscillations of the roadbed occurred even during the construction phase and raised questions about the structure's stability. Some breezes as low as four miles per hour caused oscillations, while stronger breezes often had no effect. Hydraulic buffers were installed at the towers to control the stresses, prior to the bridge's opening. The undulations continued, however, and further studies were undertaken at the University of Washington. Their recommendation of the installation of tie-down cables in the side spans were implemented, but to little effect.

Local folks lost no time in nicknaming the bridge "Galloping Gertie." Fascinated by Gertie, thousands of people drove hundreds of miles to experience the sensation of crossing the rolling center span, an experience often times highlighted by the disappearance and then reappearance of cars up ahead. For four months, the Washington Toll Bridge Authority thrived as traffic had trebled from what had been expected. Although concerns about the bridge's stability had been voiced, bridge officials were so confident of the structure, they considered cancelling the insurance policies in order to obtain reduced rates on a new one.

Throughout the early morning hours of Thursday, November 7, 1940, the center span had been undulating three to five feet in winds of 35 to 46 miles per hour. Alarmed by this constant motion, highway officials and state police closed the bridge at 10:00 A.M. Shortly afterwards, the character of the motion dramatically changed from a rhythmic rising and falling to a two-wave twisting motion. The twisting motion grew stronger with each twist; span movement had gone from three to five foot undulations to 25 to 28 foot rises and falls caused by the twisting motion. At this point, the roadbed tilted 45 degrees from horizontal one way, and then 45 degrees from horizontal the other way.
For about 30 minutes, the center span endured the twisting. At about 10:30 A.M., a center span floor panel dropped into the water 195 feet below. The roadbed was breaking up, and chunks of concrete were raining into the Sound. At 11:02 A.M., 600 feet of the western end of the span twisted free, flipped over, and plunged down into the water. Engineers on the scene hoped that once this had happened, the remainder of the span would settle down. This was not to be. The twisting continued, and at 11:09 A.M., the remainder ripped free and thundered down into the Sound. When this happened, the 1,100 foot side spans dropped 60 feet, only to bounce up and then settle into a sag of 30 feet. As for the center span, it rested on the dark and tide-swept bottom of the Narrows.

The spectacular failure was news around the world and was highlighted by the photographs, reports, and film from reports and engineers on the scene. The shock to the engineering profession created much interest in studies of the cause of the collapse. The official investigation team was composed of a prestigious group of engineers from across the country, lead by Professor F. B. Farquharson of the University of Washington, whose studies for the bridge authority began before the bridge's opening. The professional civil engineering society and the U.S. Department of Commerce authorized an Advisory Board on the Investigation of Suspension Bridges, as it was dramatically evident that oscillation and wind effects were not adequately understood.

Although there had been no suspension bridge failures for 51 years, ten suspension bridges were destroyed or damaged by wind in the 19th century, five of these in Great Britain, with the effect that no suspension bridges were built there for over 100 years. During this half century, the trend in bridge design was for spans of ever-increasing length and load-carrying ability, a thin, ribbon-like, artistic appearance, and a belief that a bridge could withstand wind if designed for a static wind pressure of 30 pounds per square foot. The Tacoma Narrows Bridge had met this specification and had been expected to withstand winds greater than the ones which destroyed it.

The aerodynamic studies done after the collapse were the first extensive studies on the effect of wind on bridges. The result was the discovery that the shape of the bridge structure has a primary effect on the bridge's ability to handle wind eddies and stress. The solid floor deck and side panels of Galloping Gertie, when combined with the wind of November 7, 1940, caused stresses which the bridge was not designed to handle. The second Tacoma Narrows Bridge was designed with open side railings and steel grid on the floor deck for the wind to pass through.
The new research stated that the lack of suspension bridge failures for the previous 51 years was due more to a lack of optimum winds for a sufficient period of time than to the design of those bridges. Bridge authorities around the country carried out tests on their suspension bridges with resulting modifications to many structures. Wind tunnel testing became an integral part of the design process for new bridges and for testing existing ones.

The collapse of the Tacoma Narrows Bridge was a hallmark in the history of bridge design and civil engineering. Its impact is still felt in the profession today. The bridge's remains at the bottom of the Sound are a permanent record of man's capacity to build structures without fully understanding the implications of the design and the forces of nature.

FOOTNOTES:


PDS.143.035
9. Major Bibliographical References

See continuation sheet.

Previous documentation on file (NPS):

☐ preliminary determination of individual listing (36 CFR 67) has been requested
☐ previously listed in the National Register
☐ previously determined eligible by the National Register
☐ designated a National Historic Landmark
☐ recorded by Historic American Buildings
Survey #
☐ recorded by Historic American Engineering
Record #

10. Geographical Data

Acreage of property: Approximately 20

UTM References

<table>
<thead>
<tr>
<th>Zone</th>
<th>Easting</th>
<th>Northing</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>10</td>
<td>533620</td>
</tr>
<tr>
<td>B</td>
<td>10</td>
<td>534500</td>
</tr>
<tr>
<td>C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>D</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Verbal Boundary Description

The nominated property is described as that underwater property outlined on the attached site plan, drawn to a scale of 1mm = 3.48 feet. The site is generally described as that underwater area between the east and west pilings of the bridge, and beneath the extant new Tacoma Narrows Bridge.

Boundary Justification

The nominated property includes the underwater area that contains the remains of the collapsed Tacoma Narrows Bridge, as documented by underwater sonar soundings and video photography. The nominated area is generally defined by the east and west pilings of the bridge and the expanse between, now spanned by the new Tacoma Narrows Bridge.

11. Form Prepared By

Valerie Sivinski/Penny Chatfield Sodhi/John M. Simpson
Tacoma Office of Historic Preservation/consultants  January 1991
747 Market Street, Room 900  (206) 591-5220
Tacoma  Washington  98402
Advisory Board on the Investigation of Suspension Bridges, *The Failure of the Tacoma Narrows Bridge*. College Station, Texas: School of Engineering, Texas Engineering Experiment Station, 1944.


TACOMA NARROWS BRIDGE

SONAR MAP OF BRIDGE REMAINS

FAILED NOVEMBER 7, 1940
Tacoma narrow Bridge Ruins
Tacoma, Pierce County, WA
Sonar Map of Submerged Ruins
Scale: 1 mm = 3.48 feet
----- nomination boundary

COPYRIGHT 1991, ROBERT MESTER
SUPPORTING GIRDERs
(TYPICALLY ATTACHED TO
REMAINDER OF ROADBED)

NE ROADBED, TYP.

N FELL IN ONE PECE
# Historic Property Inventory Form

**State of Washington, Office of Community Development**  
Office of Archaeology and Historic Preservation  
1063 S. Capitol Way, Suite 106 – Olympia, WA 98501  
PO BOX 48343 - Olympia, WA 98504-8343 (360) 586-3065 FAX 586-3067

### Identification Section
- **Field Site No.**:  27-06715  
- **OAHP No.**: PI00601  
- **Site Name**: Historic Tacoma Narrows Bridge Rubble  
- **Common Name**: Same  
- **Field Recorder**: Trent DeBoer  
- **Owner's Name**: Washington Department of Transportation  
- **Address**: Olympia, WA 98501  
- **City/State/Zip Code**: Olympia, WA 98501

### Location Section
- **ADDRESS**: Rte 16  
- **City/Town/County/Zip Code**: Pierce County  
- **Street**: Rte 16  
- **City/Town**: Same  
- **County**: Same  
- **State**: Washington  
- **Zip Code**: 98501  
- **Twp./Range**: 21N/2E  
- **Section**: SE 28  
- **Acreage**: Less than one acre  
- **UTM References Zone**: 10  
- **Easting**: 533618  
- **Northing**: 5235494

### Description Section
- **Classification**:  
- **District**: NR  
- **Site**: SR  
- **Building**: LR  
- **Structure**: INV  
- **Object**:  

#### Materials & Features/Structural Types
- **Building Type**: Bridge Rubble  
- **Planirregular**: Structural System reinforced concrete  

#### Roof Type
- **Gable**  
- **Flat**  
- **Monitor**  
- **Gambrel**  
- **Hip**  
- **Pyramidal**  
- **Shed**  
- **Other (specify)**

#### Roof Material
- **Wood Shingle**  
- **Composition**  
- **Wood**  
- **Build-Up**  
- **Tile**  
- **Metal (specify)**  
- **Other (specify)**  
- **Not visible**

#### Foundation
- **Log**  
- **Post & Pier**  
- **Stone**  
- **Brick**  
- **Concrete**  
- **Block**  
- **Poured**  
- **Other (specify)**

#### Cladding (Exterior Wall Surfaces)
- **Log**  
- **Horizontal Wood Siding**: 
  - **Rustic/Drop**  
  - **Wood Shingle**  
  - **Board and Batten**  
  - **Vertical Board**  
  - **Asbestos/Asphalt**  
  - **Concrete/Concrete reinforced**  
  - **Vinyl/Aluminum Siding**  
- **Stucco**  
- **Clapboard**  
- **Brick**  
- **Stone**  
- **Terra Cotta**  
- **Metal (specify)**  
- **Other (specify)**

#### High Styles/Forms
- **Greek Revival**  
- **Revival/Mediterranean**  
- **Gothic Revival**  
- **Italianate**  
- **Second Empire**  
- **Romanesque Revival**  
- **Stick Style**  
- **Queen Anne**  
- **Shingle Style**  
- **Colonial Revival**  
- **Beaux Arts/Neoclassical**  
- **Chicago/Commercial Style**  
- **American Foursquare**  
- **Mission Revival**  
- **Northwest Style**  
- **Commercial Vernacular**  
- **International Style**  
- **Spanish Colonial**  
- **Tudor Revival**  
- **Craftsman/Arts & Crafts**  
- **Bungalow**  
- **Prairie Style**  
- **Art Deco/Art Modern**  
- **Rustic Style**  
- **Residential Vernacular (below)**  
- **Other (specify)**

#### Integrity
- **Changes to plan**: Intact  
- **Changes to windows**: Intact  
- **Changes to original cladding**:  
- **Changes to interior**:  
- **Other (specify)**

### Photography
- **Photography Neg. No.**:  
- **Roll No. & Frame No.**:  
- **View of**: April 22, 2003

---

**Date Recorded**: 4/22/03  
**Site Name**: Historic Tacoma Narrows Bridge Rubble  
**Common Name**: Same  
**Field Recorder**: Trent DeBoer  
**Owner's Name**: Washington Department of Transportation  
**Address**: Olympia, WA 98501  
**City/State/Zip Code**: Olympia, WA 98501  
**Twp./Range**: 21N/2E  
**Section**: SE 28  
**Acreage**: Less than one acre  
**UTM References Zone**: 10  
**Easting**: 533618  
**Northing**: 5235494  
**Date of Recording**: April 22, 2003

**Supplemental Map(s)**

**District/Thematic Nomination Theme**:  
**Scale**: 1:2,400  
**Date**: 06/03/12 - F.H.WA
On 7 November 1940 the Tacoma Narrows Bridge collapsed spectacularly into Puget Sound, barely four months after the opening of the 5,000-foot long suspension bridge. Dubbed "Galloping Gertie" because of the longitudinal oscillations that afflicted the structure in the lightest of breezes, the bridge's failure stemmed from its structural lightness and the build up of wind pressure against its plate girder and deck. The bridge, designed in accordance with current engineering practice, which failed to account for the dynamic effect of wind load, lacked the stiffening necessary to prevent longitudinal "galloping." This design oversight, combined with the large length-to-width ratio of the structure, contributed to the twisting motion that destroyed the bridge.

The second Tacoma Narrows Bridge, built between 1948 and 1951, incorporated design elements intended to prevent the twisting and galloping motions that destroyed the first bridge. These included open trusses, instead of shallow plate girders, for greater stiffness; deck grating between the traffic lanes to lessen wind resistance; and a larger roadway width-to-span length to increase resistance to twisting.

The ruins of the first Tacoma Narrows Bridge, popularly known as "Galloping Gertie," were listed in the National Register of Historic Places on 31 August 1992. The nominated property consists of the underwater remains of the bridge, and is roughly located between the piers of the current bridge. The existing bridge has been determined eligible for listing in the National Register of Historic Places.

The concrete and steel rubble consists of those portions of the original west anchorage that were removed and discarded when the anchorage was retrofitted for the present bridge. This debris is not associated with the bridge superstructure and was not a factor in the failure of the original structure.

Concrete and steel rubble associated with the west anchorage of the first Tacoma Narrows Bridge is evident along the beach and steep slope beneath the current bridge on the west side of Tacoma Narrows. The rubble consists of those portions of the original west anchorage that were removed and discarded when the anchorage was retrofitted for the present bridge. The portions of the rubble that are along the beach are covered with kelp, barnacles, and other marine life. Some rubble pieces above the high tide line display smooth, finished surfaces that were originally part of the exterior surfaces of the anchorage. Other pieces are entirely unfinished, with exposed aggregate, indicating that they were not originally visible surfaces. Some rubble pieces include bits of steel reinforcing. The largest piece of steel within the rubble is a shattered, x-braced beam still embedded in concrete.

Major Bibliographic References:
Tacoma Narrows Bridge: HAER No. WA-99
## Location

<table>
<thead>
<tr>
<th>Field Site No.</th>
<th>DAHP No.</th>
<th>PI00601</th>
</tr>
</thead>
<tbody>
<tr>
<td>Historic Name:</td>
<td>Tacoma Narrows Bridge Ruins</td>
<td></td>
</tr>
<tr>
<td>Common Name:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Property Address:</td>
<td>Highway 16 over the Tacoma Narrows, Tacoma, WA</td>
<td></td>
</tr>
<tr>
<td>Comments:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tax No./Parcel No.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plat/Block/Lot</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acreage</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Supplemental Map(s)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Township/Range/EW</th>
<th>Section</th>
<th>1/4 Sec</th>
<th>1/4 Sec</th>
</tr>
</thead>
<tbody>
<tr>
<td>T21R02E</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Coordinate Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Easting: 1130177</td>
</tr>
<tr>
<td>Northing: 713663</td>
</tr>
<tr>
<td>Projection: Washington State Plane South</td>
</tr>
<tr>
<td>Datum: HARN (feet)</td>
</tr>
</tbody>
</table>
Identification

Survey Name: Legacy for City of Tacoma  Date Recorded: 04/22/2003
Field Recorder: Trent DeBoer
Owner’s Name: WA DOT
Owner Address:
City: Olympia  State: WA
Classification: Structure
Resource Status: Comments:
  National Register
  State Register

Within a District?
Contributing?
National Register: Tacoma Narrows Bridge
Local District:
National Register District/Thematic Nomination Name:
Eligibility Status: Not Determined - SHPO
Determination Date: 1/1/0001
Determination Comments:

Description

Historic Use: Current Use:
Plan: Stories: Structural System:
Changes to Plan: Changes to Interior:
Changes to Original Cladding: Changes to Windows:
Changes to Other:
Other (specify):
Style: Cladding: Roof Type: Roof Material:
Foundation: Form/Type:

Narrative

Study Unit Other
Date of Construction: Builder:
  Engineer:
  Architect:

Property appears to meet criteria for the National Register of Historic Places:
Property is located in a potential historic district (National and/or local):
Property potentially contributes to a historic district (National and/or local):

Statement of Significance:

Description of Physical Appearance:

Major Bibliographic References:
Photos
### Identification

**Survey Name:** Legacy for City of Tacoma  
**Date Recorded:** 01/01/1900

**Field Recorder:**  
**Owner’s Name:**  
**Owner Address:**

**City:**  
**State:**  
**Zip:**

**Classification:**  
**Resource Status:**

**Comments:**

**Within a District?**  
**Contributing?**

**National Register:**  
**Local District:**

**National Register District/Thematic Nomination Name:**

**Eligibility Status:** Not Determined - SHPO  
**Determination Date:** 1/1/0001  
**Determination Comments:**

### Description

**Historic Use:**

**Current Use:**

**Plan:**

**Stories:**

**Structural System:**

**Changes to Plan:**

**Changes to Interior:**

**Changes to Original Cladding:**

**Changes to Windows:**

**Changes to Other:**

**Other (specify):**

**Style:**

**Cladding:**

**Roof Type:**

**Roof Material:**

**Foundation:**

**Form/Type:**

### Narrative

**Study Unit**

**Other**

**Date of Construction:**

**Builder:**

**Engineer:**

**Architect:**

**Property appears to meet criteria for the National Register of Historic Places:**

**Property is located in a potential historic district (National and/or local):**

**Property potentially contributes to a historic district (National and/or local):**

**Statement of Significance:**
Description of Physical Appearance:

Major Bibliographic References:
Photos
Historic Name: Tacoma Narrows Bridge Ruins
(Galloping Gertie)
Address: Highway 16 Over the Tacoma Narrows
City: Tacoma
County: Pierce

Historic Use: Transportation
Style: None
Built: 1940
Architect: Eldridge, Clark H.
Builder: 

Smithsonian Number: 45PI00601
Date Listed: 8/31/1992
Listing Status: WHR/NR
Classification: SITE
Resource Count: 1
Area of Significance: Engineering
Level of Significance: Local
Listing Criteria: A

Statement of Significance

The original Tacoma Narrows Bridge was built between November 1938 and July 1, 1940. Lauded as an essential economic and military portal to the Olympic peninsula, its completion was called a triumph of man’s ingenuity and perseverance. Four months after it opened to the public it fell, in what was later called “the Pearl Harbor of engineering.”

Contemporary accounts appeared to be shocked by the collapse although the bridge began exhibiting wavelike motions during the final stages of construction. Soon after its official opening the bridge gained a reputation for this movement and became informally christened ‘Galloping Gertie.’ Professor F.B. Farquharson, an engineering professor at the University of Washington, and other University engineers were hired to suggest methods to reduce the movement on the bridge. Over the next few months experiments were conducted on a scale model but a solution to the problem proved elusive.

On November 7, 1940 Professor Farquharson was there to witness and document the spectacular collapse of what had been the third longest suspension bridge in the world with the longest single span in the country. In the aftermath many theories were discussed concerning the cause of the bridge’s collapse. Ultimately an investigative board for the Washington State Toll Bridge Authority announced the failure was due to the bridge’s design reacting to the wind in the Narrows.

Although rebuilding the bridge was immediately suggested, investigations on the wreckage found that the entire superstructure to be unusable. The onset of World War II further stalled attempts to rebuild. Salvage activity continued on the bridge through 1942 with the materials going to the U.S. war effort and the profits saved for the construction of a new bridge.

Photos