CONDE B. McCULLOUGH'S OREGON BRIDGES: A TYPOLOGICAL STUDY OF THE DESIGNS AND THE PRESERVATION OF HIS LEGACY

by

ABIGAIL M. GLANVILLE

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Leland M. Roth, Chair of the Examining Committee

May 29, 2009
Date

Committee in Charge: Leland M. Roth, Chair
Robert W. Hadlow

Accepted by:

Dean of the Graduate School

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Approved: ______________________________

Leland M. Roth

Oregon is recognized nationally for its collection of bridges designed by innovative civil engineer Conde B. McCullough in the 1920s and 1930s. His concern for aesthetic value fostered bridge designs that are unique in their architectural details and enhance their natural surroundings. Unfortunately, several of McCullough's bridges have deteriorated with age requiring the Oregon Department of Transportation to devise solutions which keep these bridges safe for public use and at the same time retain their historic quality. The purpose of this thesis project was to develop a typological study of his bridge designs, investigate the results of strategies applied to maintain them, and provide an analysis of the extent to which they sustain the historic integrity of structures they were applied to. It is hoped this study will help inform future decisions made regarding the effective preservation of McCullough's legacy.

CURRICULUM VITAE

NAME OF AUTHOR: Abigail M. Glanville

PLACE OF BIRTH: Ames, Iowa

DATE OF BIRTH: December 1, 1980

GRADUATE AND UNDERGRADUATE SCHOOLS ATTENDED:

University of Oregon, Eugene, Oregon
University of Iowa, Iowa City, Iowa

DEGREES AWARDED:

Master of Science in Historic Preservation, 2009, University of Oregon
Bachelor of Arts in Art History, 2003, University of Iowa

AREAS OF SPECIAL INTEREST:

Preservation Design and Technology
Preservation in Transportation

PROFESSIONAL EXPERIENCE:

Michael Shellenbarger Intern, Visual Resource Collection, School of Architecture and Allied Arts, University of Oregon, Spring term, 2009

Greg Hartell Intern for Historic Preservation, Crater Lake National Park, Oregon August 2008 through September 2008

Performing Arts Coordinator, Project Art, University of Iowa Hospitals and Clinics, Iowa City, Iowa, August 2004 to June 2007

GRANTS, AWARDS AND HONORS:

Italy Historic Preservation Field School Scholarship, University of Oregon, 2008

PUBLICATIONS:

Glanville, Abigail M. *Preservation Guide for Stone Masonry and Dry-Laid Resources at Crater Lake National Park.* Crater Lake National Park: Summer 2008.

Glanville, Abigail M., Adrienne Donovan-Boyd, Tara Ikenouye, and Gregoor Paschier. *North Head Lighthouse Condition Assessment.* University of Oregon: Spring 2008.

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CHAPTER I

INTRODUCTION

Background

In the last thirty years there has been increased interest in Oregon's historic bridges and in the prevention of their loss. This was in part initiated in the 1980s by the perspective loss of the Alsea Bay Bridge at Waldport, one of Conde B. McCullough's five largest spans along the coast. Local residents were disturbed by the thought of losing the bridge that had not only defined the landscape of their town for approximately fifty years but had also become a symbolic representation of it. After exhausting numerous alternatives, the determination was made that deterioration of the bridge was too great and too costly to maintain to keep it in service, and that it would have to be replaced. Public reflections on the bridge's importance to the development of coastal transportation and tourism, and McCullough's overall impact on the state's transportation system were widespread. However acknowledgement of the bridge's significance had come too late, a trend which has enabled historically incompatible alteration or replacement of historic bridges throughout the United States.

The truth is that historic bridges are important cultural resources. Their significance is not always a result of association with a well-known architect or engineer, but rather the developments in technology, science, and education that they represent.

Historic bridges symbolize progress in engineering and more specifically, the evolution of bridge building as a trade skill to a very specialized profession that required the development of academic training programs.[1] This change in education intersects with and reflects the change in bridge building materials from traditional wood and masonry to cast and wrought iron and the eventual development of early steel and concrete. Furthermore, bridge building and the adaptations employed in their designs represent reactions to developments in transportation, city planning, commerce, and education.[2] Because each of these aspects contributed to the progress of our nation, saving historic bridges is a necessary component to preserving our cultural heritage.

Problem Statement

Current research indicates that over half of the documented historic bridges in the United State have been destroyed in the last twenty years.[3] In general, historic bridges are susceptible to damage or loss due to the nature of the purpose they serve. These highly exposed structures provide crossings for large volumes of traffic, often over waterways, making them vulnerable to collisions caused by roadway traffic, waterway traffic, and deterioration from pollution and the elements. The responsibility of state transportation agencies to meet current safety standards and to accommodate modern transportation needs puts historic bridges at risk of historically incompatible repair and alteration that lowers integrity. In extreme cases these issues are resolved by replacing historic bridges with modern ones. Even with legislation such as the Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991, which was instituted to balance lack of funding by requiring that states spend 10 percent of program funds on "transportation enhancements" such as the rehabilitation of historic bridges, these resources are being lost at an alarming rate.[4] This statistic reiterates the importance of promoting public understanding of the significance of historic bridges so that they are maintained through rehabilitation for continued use, and in doing so they are treated sensitively so as to retain the original character of their designs and therefore preserve the important historical and contextual narratives the designs convey.

Many of Oregon's highway bridges were designed and built by Conde B. McCullough from 1919 to 1937 when he served as state bridge engineer for the Oregon State Highway Department. McCullough's distinctive eye for design and concern for scenic value is evident in not only the structures themselves, but also the intricate concrete work of the railings, entrance pylons, piers, and pedestrian plazas that frame the ends of his larger spans. Furthermore, McCullough's bridges are exceptional for their innovative engineering, and are important to transportation history in Oregon. Their construction allowed for the completion of several major highways throughout the state, making them important representations of a progressive era of transportation development which was initiated by wider availability of automobiles.

McCullough was responsible for the design and oversight of hundreds of bridges and other transportation projects in Oregon during his tenure as state bridge engineer. Although his accomplishments as an engineer and bridge designer are recognized nationwide, and several of his bridges have been listed on the National Register of Historic Places, relatively little has been written about his work. While brief acclaim is given to McCullough's work in a few bridge survey texts such as Eric DeLony's *Landmark American Bridges*, published in 1990, and Donald C. Jackson's *Great American Bridges and Dams*, published in 1988, only one comprehensive text on the engineer's life and achievements has been formally published. McCullough's biography, entitled *Elegant Arches Soaring Spans: C. B. McCullough, Oregon's Master Bridge Builder*, was written by Robert W. Hadlow and published in 2001. Two aspects deserving of greater exploration are how McCullough's bridge design philosophy influenced his work, and whether modern efforts employed to prevent his bridges from being replaced uphold the design values he employed, thus preserving his important legacy of bridge building.

The purpose of this thesis project was two-fold. This first was to establish a typological study of McCullough's Oregon bridge designs to better understand the scope of his work and ultimately identify themes and physical attributes which typify it. The second purpose was to examine strategies employed by the Oregon Department of Transportation to maintain McCullough's work as part of the transportation network, and analyze the extent to which these strategies sustain the integrity of identified themes and attributes of these bridges when they cannot be retained as originally designed.

Research Methodology

The Interpretive Methodological Paradigm was used to organize the framework of this research project because of its exploratory nature and primary concern with, "...achieving an emphatic understanding, rather than testing law-like theories...."[5] The

Interpretive Methodological Paradigm influenced the research design by centering it around field work accomplished through the survey of forty-one Oregon bridges designed by McCullough. In addition, architectural drawings and photographs were examined, and a literature review of books, articles, and reports such as those generated for Section 106 compliance, and Environmental Impact Statements concerning McCullough's bridges was conducted. Furthermore, because the Interpretive Methodological Paradigm emphasizes understanding by addressing context, the project included investigation of McCullough's academic training and early work, architectural trends of the period in which he was designing bridges in Oregon, as well as the history of concrete and the developments which allowed for its application in structural design.

Benefits

The insights presented in this document are meant to provide a new perspective on McCullough's body of work, as well as an analysis of the efforts employed to prevent its loss. It is hoped that the final document will be of use to the Oregon Department of Transportation, the Oregon State Historic Preservation Office, and other agencies that deal directly with McCullough's bridges and have the responsibility of determining how best to maintain them. It is further hoped this study provides a reference for individuals or groups who have an interest in historic bridges, their preservation, or McCullough's life and work, such as historical societies and tourism offices. It is my belief that facilitating public understanding of the importance of McCullough's entire body of work, as well as promoting continued public involvement in the effort to maintain it, offers the best prospect for retaining these bridges as cultural resources. Because factors which necessitate bridge alteration or replacement unfortunately can only be monitored and not eliminated, it is hoped this document will help inform and promote decisions which effectively preserve McCullough's important legacy of bridge building.

Notes

[1] Eric DeLony, "The Value of Old Bridges," *Association for Preservation Technology Bulletin* 35, no. 4 (April 2004): 4.

[2] Ibid.

[3] Ibid.

[4] Joseph J. Pullaro and Bala Sivakumar, "New Uses for Old Bridges," *Civil Engineering* 67, no. 10 (October 1997): 58.

[5] W. Lawrence Neuman, *Social Research Methods: Qualitative and Quantitative Approaches* (Boston: Pearson Education, Inc., 2006), 94 and 106.

CHAPTER II

THE HISTORY OF CONCRETE AND ITS APPLICATION IN STRUCTURAL DESIGN

During the years 1919 to 1937, when McCullough was employed as the state bridge engineer for the Oregon State Highway Department, he mastered the art of reinforced-concrete bridge design, utilizing the material for all of his major works either alone or in combination with steel or wood trusses. He also exploited precast concrete to its fullest potential by taking advantage of its economical production for the creation of unique and intricate architectural details which set his work apart from that of other notable bridge engineers of the 20th century. It was therefore decided that concrete's rise to prominence in building construction, and the developments of the material relevant to McCullough's work, should be addressed prior to the typological study presented in the fourth chapter. As will be discussed in the next chapter, McCullough's designs were driven in part by his desire to create bridges for the Oregon State Highway Department that were aesthetically pleasing as well as economical, two factors that also played important roles in the material's emergence in structural design.

While the history of concrete is quite extensive, its rise to prominence was gradual in the United States until nearly 1920. The economic advantage of concrete was rooted in the fact that many of the materials used to produce it were, in most cases, locally available which cut costs relative to shipping vast amounts of materials such as structural steel that were only produced in industrial locations. In addition, concrete was believed to have a lower lifetime maintenance cost than other construction materials. Both of these factors made concrete an attractive building material alternative for the design of civic structures.[1] The economic advantages in part drove the scientific experimentation necessary to determine how concrete would behave in different structural applications and ultimately promoted acceptance of the material for use in a broad range of structural applications. Furthermore, the material's plasticity, or ability to be shaped into a variety of shapes and sizes, fostered realization of the many design possibilities it presented, which eventually inspired use by prominent architects in Europe around the turn of the 20th century, and in the United States in the following two decades.

Early Uses of Cement and the Development of Concrete Blocks

Concrete, which is a building material that consists of gravel, sand, cement, and water, began with the discovery of natural cement by the Romans. Natural cement, which is made of powders from rock deposits, was first used to produce mortars for bonding masonry units. After that time period, it is largely agreed upon by historians that the material was not again used until the middle of the 18th century in England.[2] In the United States, cement mortars were first used for the construction of civic projects such as canals and tunnels beginning in 1825. By 1840, technology had been developed to employ cement for the production of precast concrete blocks for use in building construction. These blocks were widely used by builders because they functioned similar to traditional stone masonry units and therefore, although the technology was new, did not require a new form of skilled labor. By 1868 the popularity of concrete blocks had led to their mass production.

The Development of Reinforced-Concrete

The development and employment of precast concrete blocks was an integral factor in the eventual development of reinforced-concrete because their wide use displayed concrete's most important physical properties. Its impressive performance in compression inspired experimentation with concrete in poured form by mid 19^{th} century engineers for footings and walls. Wide use also illustrated concrete's major downfall, its weakness in tension. This problem prompted further research that led to the solution to embed metal bars into concrete to improve its tensile strength.

In 1875 mechanical engineer William Ward of Port Chester, New York was the first to construct a building entirely of reinforced-concrete. An important innovation that sprung from this venture was Ward's placement of reinforcing bars near the bottom of concrete beams due to his understanding that the bottom was where concrete is least able to absorb tensile forces.[3] Ward never attempted to secure a patent for his particular type of reinforced beam however, so he never profited from his ingenuity as many others would from their own developments relative to reinforced-concrete.[4]

Two years after Ward constructed the first reinforced-concrete building, American inventor Thaddeus Hyatt wrote the first book on reinforced-concrete which described experiments leading to the formulation of the principle that, "concrete had to resist enough tensile stresses to balance existing compressive stresses."[5] He took the next step by developing his findings into American patent number 206, 112 which was secured on July 16, 1878.[6] Hyatt's research led to further inquiry by scientists and engineers to gain a more thorough understanding of the behavior of reinforced-concrete and how to exploit the material's physical properties more effectively.

At the end of the 1870s two other factors played important roles in the rise of reinforced-concrete, the first being the decline in popularity of cast iron. Enthusiasm for cast iron was initially a response to the material's economy due to production technique and proclaimed fire resistance; however the massive Chicago fire of 1871 made it clear that a major deficiency of the material was its poor performance under thermally induced stress. This event brought issues of fireproofing to the forefront and by 1891 many cities began establishing building codes which limited how and where exposed cast iron could be used, essentially eliminating the material's cost-effectiveness.[7] The second factor was the emergence of steel, a material which possesses immense structural potential due to its strength and ability to perform well in both tension and compression. The rise of reinforced-concrete was influenced by both of these factors because concrete was identified as a potential material for fireproofing structural cast iron and steel as it was less expensive than traditional ceramic fireproof cladding materials such as terra cotta.[8] The application of concrete cladding as fireproofing for structural steel demonstrated how effectively the two materials worked together, in turn bolstering acceptance of the idea to reinforce concrete with steel bars.[9]

Builder confidence in reinforced-concrete continued to inspire experimentation with the material by engineers throughout the last decade of the 19^{th} century. Most notable was a process patented by French engineer Francis Hennebique in 1892 for bending reinforcement bars to better resist tension in concrete structural members. Hennebique was also significant for utilizing reinforced-concrete structural systems consistent with those used for construction in wood and steel. This orthogonal system of overlapping members became the basis for slab-beam-column structural systems traditionally employed for reinforced-concrete construction.[10] At this time, architects also began investing interest in the material by attempting to establish an appropriate design aesthetic for it. French architects largely led the way in this respect beginning with the work of Anatole de Baudot, followed by Auguste Perret, and Toni Garnier.

Early Experimentation with Reinforced-Concrete in Architecture

Anatole de Baudot's Church of Saint Jean de Montmartre in Paris from 1894 is considered by many to be one of the first buildings in which an architect attempted to express the distinctive physical properties of reinforced-concrete in a building's design.[11] Baudot chose to highlight the material's strength in compression through the use of soaring vaulted ceilings, as well as its plasticity as demonstrated by the use of concrete tracery. In the decades following, Auguste Perret expanded on his predecessor's design philosophy by also attempting to demonstrate the physical properties of reinforced-concrete in his own designs.[12] His perception of reinforced-concrete as a "continuous monolith" led to highly integrated and linear structural components that reflected the rigidity and linearity of the wooden formwork used in constructing them. Toni Garnier, on the other hand, departed sharply from his contemporary Perret and instead chose to express reinforced-concrete's mass through the use of heavy elements which often echoed classical motifs such as monumental arched entrances.[13] While this is only a small representation of the French architects who laid groundwork early on in the establishment of a reinforced-concrete design aesthetic, many French architects inspired widespread design approaches that became increasingly more expressionistic as time progressed.

Early Reinforced-Concrete Bridge Design

Of greater significance to this study is the evolution of reinforced-concrete bridge design in which Swiss engineer Robert Maillart played an influential role. He was just completing his academic training at the Federal Polytechnical Institute in Zurich in 1894 when Baudot was completing his reinforced-concrete church in Paris. According to David Billington, impeccable timing afforded Maillart the benefit of designing under previously established acceptance of reinforced-concrete in construction, "but before anyone had dared to invent new forms that departed radically from the aesthetic of earlier materials."[14] This meant that although some design experimentation with the material had taken place, Maillart was not subjected to intense influence by other designers. He gained notoriety in the first decade of the 20th century by using reinforced-concrete to generate modern bridge forms that departed sharply from any historic precedence. His understanding of the material's inherent physical properties allowed him to design innovative open-spandrel arch bridges that eliminated the use of excess material, resulting in cohesive lightness of all structural elements.[15] An open-spandrel deck arch is one in which the area between the roadway deck and the bottom of the arch supporting the roadway is open except for the series of supporting elements which connect the roadway deck to the arch. This type of deck arch was believed to be more aesthetically pleasing and saved considerable amounts of material over the closed-spandrel type in which the open space is completely filled-in with material.[16] For this reason Maillart is credited with employing a design philosophy that was rooted in both economy and aesthetics, much like McCullough, who would complete his academic training and enter the engineering profession sixteen years after the Swiss engineer.

Reinforced-concrete deck arch bridges first began appearing in the Unites States in the 1890s. The first major closed-spandrel bridge of this type was the *Melan Arch Bridge* in Topeka, Kansas, designed by Edwin Thacher in 1897.[17] Perhaps most influential to McCullough's early bridge designs in Oregon were those of Charles Purcell and Karl P. Billner who together designed several reinforced-concrete spans on the Columbia River Highway which was constructed from 1913 to 1921. The Shepperd's Dell Bridge from 1914 (figure 1), is a 100-foot, open-spandrel deck arch with the exception of the solid arched curtain walls between the spandrel columns and above the crown of the arch.[18] The Mosier Creek Bridge (figure 2) and the Dry Canyon Creek Bridge that McCullough designed for the Columbia River Highway in 1920 and 1921 respectively, echo the designs of Purcell and Billner in the treatment of the open-spandrel wall and intricate architectural detailing of the brackets. In turn, McCullough's work may have also inspired other bridge engineers in Oregon such as Portland city bridge engineer, Fred T. Fowler, who designed the South West Vista Avenue Viaduct in 1926 (figure 3). The open-spandrel design with square columns connecting the arch ribs to the roadway deck and decorative brackets is reminiscent of McCullough's early deck arch bridges, as well as the work of Purcell and Billner.

Figure 1: Shepperd's Dell Bridge, 1914, designed by Charles Purcell and K. P. Billner
Source: Dwight A. Smith, James B. Norman, and Pieter T. Dykman, *Historic Highway Bridges of Oregon* (Salem: Oregon Department of Transportation, 1986), 139.

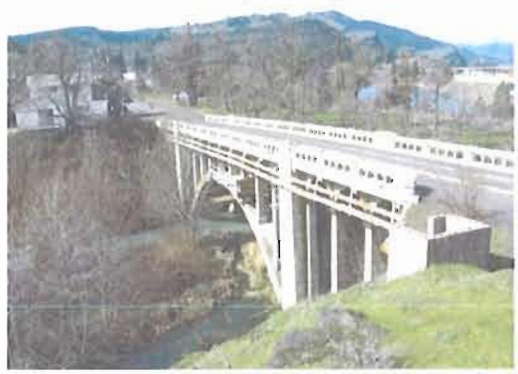


Figure 2: Mosier Creek Bridge, 1920
Source: Author

Figure 3: South West Vista Avenue Viaduct, 1926, designed by Fred T. Fowler,
Source: Dwight A. Smith, James B. Norman, and Pieter T. Dykman, *Historic Highway Bridges of Oregon* (Salem: Oregon Department of Transportation, 1986), 211.

Further Developments in Concrete

The development of precast concrete was another innovation which furthered the economic advantages of concrete bridge design. The use of precast concrete for decorative elements repeated throughout the bridge design was economical because it eliminated a portion of expenses accrued through the use of formwork due to the cost of the materials and the cost of erecting it. By using precast elements, a single mold could be used to cast several identical components. McCullough made extensive use of precast concrete in the production of repetitive decorative architectural details such as dentil moldings and brackets that he employed for many of his bridge designs.[19]

The final development significant to McCullough's work that will be discussed is a method of concrete arch pre-compression developed by French bridge engineer Eugène Freyssinet in the early 1920s. Freyssinet's technique was applied to mitigate structural weakening caused by bending stresses in arch bridges that were a result of deformation of the concrete.[20] In most basic terms, this method eliminated "elastic and plastic shortening" of deck arch ribs after the falsework was removed.[21] As an alternative to combating this problem with the costly addition of concrete and steel applied to the arches and piers, Freyssinet's system instead inserted hydraulic jacks into the crowns of the arch ribs to lengthen each one by an amount calculated to equal the deformation.[22] McCullough employed this technique for the first time in the United States for construction of the Rogue River (Isaac Lee Patterson) Bridge at Gold Beach in 1932 with the hope that it would reduce the overall cost of construction materials.[23] Although Freyssinet's system did prove useful in reducing the amount of materials needed for construction of the bridge, the cost of extra labor required to employ the technique cancelled out any savings in materials so McCullough did not attempt to employ the technique on any of his other spans.[24]

The history of concrete exemplifies not only the immense scientific experimentation which led to its acceptance as a building material, but also the struggle of designers and architects to determine an appropriate design aesthetic that was independent of those established for traditional materials. As will be discussed in the following chapter, McCullough's interest in reinforced-concrete bridge design was fostered early in his academic training. This interest developed into a more comprehensive understanding of the material when he was encouraged to research reinforced-concrete bridge design during his first job post-graduation with the Marsh Engineering Company in Des Moines, Iowa, and again while employed by the Iowa State Highway Commission. As the state bridge engineer in Oregon, McCullough's extensive knowledge of and experience with reinforced-concrete bridge design translated into hundreds of structures which express the material's plasticity and strength through the complex detailing and expansive arches that make his work recognizable.

Notes

[1] John W. Snyder, *Preservation Information: Preserving Historic Bridges* (Washington D. C.: National Trust for Historic Preservation, 1995), 3.

[2] Amy E. Slaton, *Reinforced Concrete and the Modernization of American Building* (Baltimore: The Johns Hopkins University Press, 2001), 15.

[3] Ibid., 16.

[4] Ibid.

[5] Aly Ahmed Raafat, *Reinforced Concrete in America* (New York: Reinhold Publishing Corporation, 1958), 23.

[6] Ibid.

[7] Donald Friedman, *Historical Building Construction: Design, Materials, and Technology* (New York: W. W. Norton and Company, 1995), 38.

[8] Slaton, 16.

[9] Ibid.

[10] Raafat, 29.

[11] Ibid., 43.

[12] Ibid.

[13] Ibid., 45.

[14] David P. Billington, *The Art of Structural Design: A Swiss Legacy* (New Haven: Yale University Press, 2003), 32.

[15] Ibid.

[16] Donald C. Jackson, *Great American Bridges and Dams* (New York: John Wiley and Sons, Inc., 1988), 37.

[17] Ibid., 35.

[18] Kenneth J. Guzowski, *Historic American Engineering Record: Columbia River Highway, HAER OR-56* (HABS/HAER: 1990), 8.

[19] Robert W. Hadlow, "C. B. McCullough: The Engineer and Oregon's Bridge-Building Boom, 1919-1936," *Pacific Northwest Quarterly* 82, no. 1 (January 1991): 10.

[20] Albin L. Gemeny and Conde B. McCullough, *Application of Freyssinet Method of Concrete Arch Construction to the Rogue River Bridge in Oregon* (Salem: Oregon State Highway Commission, 1933), 1.

[21] Robert W. Hadlow, *Elegant Arches, Soaring Spans: C. B. McCullough, Oregon's Master Bridge Builder* (Coravallis: Oregon State University Press, 2001), 70.

[22] Ibid.

[23] Hadlow, "C. B. McCullough: The Engineer and Oregon's Bridge-Building Boom, 1919-1936," 13.

[24] Ibid., 14.

CHAPTER III

McCULLOUGH'S ACADEMIC TRAINING AND EARLY WORK EXPERIENCE

As previously mentioned, McCullough's life and work was chronicled by Robert W. Hadlow, Senior Historian for the Oregon Department of Transportation in his Ph.D. dissertation, Washington State University, 1993 which then evolved into the bridge designer's biography, *Elegant Arches Soaring Spans: C. B. McCullough, Oregon's Master Bridge Builder*, Corvallis: Oregon State University Press, 2001. Given the comprehensive nature of the book it seemed unnecessary to provide extensive biographical information about the portion of McCullough's life leading up to his employment with the Oregon State Highway Department, but more appropriate to instead highlight the academic training, work experiences, and influential relationships formed that impacted the bridge design philosophy he utilized as the Oregon state bridge engineer from 1919 to 1937.

Academic Training at Iowa State College

Conde B. McCullough was born on May 20, 1887 in Redfield, Dakota Territory, although the majority of his childhood and teenage years was spent living in Fort Dodge, Iowa. Upon graduating from high school in 1905 McCullough took a job as a surveyor's assistant for the Illinois Central Railway.[1] The following year he made the decision to enroll in the civil engineering program at Iowa State College in Ames, Iowa. It was there that McCullough became acquainted with Anson Marston, the institution's first dean of the school of engineering. At the time, Marston was revered as a progressive educator in the engineering profession, requiring that his students not only obtain the technical education necessary to work in the field, but also practical experience gained through employment prior to graduation.[2]

Marston had attended college at Cornell University in Ithaca, New York, from 1885 to 1889, receiving a Bachelor of Science in Civil Engineering. According to Hadlow, Marston had been influenced by his instructor Estévan Anotonio Fuertes, who began teaching at Cornell in 1873 and changed the program from a "traditional short technical training course" into a "rigorous four-year undergraduate program."[3] Fuertes likely inspired Marston's belief that practical experience, in addition to classroom learning should be the basis of preparation for entering the engineering profession. In addition, Fuertes emphasized that an engineer's education should include study of the arts so that knowledge from those fields of study could be applied to the practice of engineering.[4] Marston brought these values to his teaching career when he was hired as a faculty member at Iowa State College in 1892.

According to notes from Marston's lectures delivered to the senior engineering students at Iowa State College, he embraced engineering as "the art of directing the great sources of power in nature for the use and convenience of man."[5] This definition had originally been developed by Thomas Tredgold for the charter of the British Institution of

Civil Engineers, the first professional engineering society which was formed in 1818, and whose establishment, according to Marston, "marked a decisive point in the change of engineering from a trade to a profession."[6] Marston incorporated this definition into his History of Engineering course at Iowa State College using it as a springboard for discussion of the role of the engineer in society. Marston imparted on students his perception of the responsibilities of an engineer and the qualifications necessary to become a respectable member of the profession. The following quote was taken from his lecture on the fundamental qualifications of an engineer.

> First, and most fundamental and important, he must have honesty, morality and the highest character; second, he must have good judgment, good sense, energy, persistency, confidence, ability; third, he must have the best technical training; fourth, he must have extensive experience in the practice of his profession in addition to technical training; fifth, he must keep up with the times by constant reading of technical literature, by membership in technical societies, and by intercourse with his fellow engineers; sixth, he must be a broad well rounded man, and a good citizen.[7]

While the first and second points listed above are qualities that would enhance most any individual's performance in their chosen profession, it is difficult to determine the extent of influence Marston had on his students in obtaining those particular qualities. However, based on McCullough's enrollment records from his four years at Iowa State College, it is clear that Marston established an engineering program curriculum that would foster the qualifications found in points three through six.

The Iowa State College civil engineering curriculum balanced technical courses and labs, with courses in English, composition, foreign language, history, and literature. In addition, fieldwork and summer surveying courses provided practical, hands-on training. Table 1 on the following page lists the courses McCullough took during his four years in the civil engineering program at Iowa State College from 1906 to 1910 and was provided by the Iowa State University archivist.[8]

Table 1: Courses McCullough enrolled in by year at Iowa State College
Source: Iowa State University Archives

Freshmen Year	**Sophomore Year**
English 1 - Grammar English 2 - Rhetoric and composition Math 20 - College Algebra Math 21 – Plane Trigonometry Language 5 – German English 10 – Narration and Description Chemistry 41 – General Chemistry Civil Engineering 2 – Field Work Civil Engineering 41 – Technical Field Work Civil Engineering 1 – C. E. Drawing Military 1 Math 6a – Solid and Spherical Geometry Math 5 – Plan Geometry Literature 9 – English Classics Language 6 – German Mechanical Engineering 19 – Drawing Math 22 – Plane Trigonometry English 11 – Exposition Chemistry 49 Military 2 Civil Engineering 42 – Technical Lecture Civil Engineering 3 – Field Work Civil Engineering 4a – Descriptive Geometry Civil Engineering 31 – Summer Surveying Mechanical Engineering 21a – Mechanical Drawing	Math 24 – Plan Analytic Geometry Math 25 – Calculus English 12 – Argumentation Physics 303 – Mechanics and Heat Civil Engineering 308 – Surveying Civil Engineering 343 – Technical Lecture History 17 – American People Military 3 Math 26 – Calculus Civil Engineering 409 – Surveying Civil Engineering 456 Descriptive Geometry Civil Engineering 444 – Technical Lecture Civil Engineering 432 – Summer Surveying History 18 – American Statesman Civil Engineering 349 – Descriptive Geometry Civil Engineering 305 – Drawing and Pen Topography Civil Engineering 407 – Drawing, Plans, and Structures Mechanical Engineering 1a – Analytical Mechanics
Junior Year Physics 523 – Physical Laboratory Civil Engineering 510 – Railway Engineering Math 7 – spherical Trigonometry Civil Engineering 514 – Engineering Laboratory Engineering 603 Civil Engineering 653 – Materials of Construction Economic Science – Outlines of Economics Civil Engineering 628 – Engineering Seminar Civil Engineering 633 – Summer Surveying Civil Engineering 611 – Railway Engineering Mechanical Engineering 686 – Analytic Mechanics Mechanical Engineering 502 – Analytic Mechanics Electrical Engineering 503 Civil Engineering 524 – Practical Astronomy and Geodesy	**Senior Year** Civil Engineering 718 – Structural Engineering Civil Engineering 712 – Roads and Pavements Engineering 702 – Specifications and Contracts Civil Engineering 721 – Sanitary Engineering Civil Engineering 716 – Engineering Laboratory Civil Engineering 729 – Engineering Seminar Civil Engineering 738 – Structural Engineering Civil Engineering 819 – Structural Engineering Civil Engineering 839 – Structural Engineering Geology 803 – Engineering Geology Civil Engineering 826 – Thesis Engineering 801 – History of Engineering Civil Engineering 830 – Engineering Seminar Mechanical Engineering 784 – Steam Engines and Boilers Civil Engineering 820 – Arches and Reinforced Concrete Civil Engineering 822 – Water Supply Engineering Civil Engineering 723 – Masonry Structures and Foundations

As noted in the table of courses, Marston also required his students to produce a senior thesis, an assignment that was meant to expose them to the type of work they would encounter as professional engineers. This project involved the identification of a particular engineering problem, review of current literature relevant to that problem, and production of research which demonstrated original thought, critical analysis, and thorough understanding of that problem.[9] Ultimately this assignment provided Marston's students with the opportunity to make a meaningful contribution to existing engineering scholarship early in their professional lives.

Through this assignment McCullough explored his developing interest in the inherent problems associated with concrete bridge design. This interest was likely inspired by John Edward Kirkham who began teaching at Iowa State College in 1907 and brought knowledge of current developments in reinforced-concrete arch construction to his lectures.[10] For his project, McCullough and classmate H. B. Walker investigated the effects of external temperature variation of concrete bridges and concluded that expansion and contraction due to temperature variation had the potential to cause structural failure if these changes were not accounted for in the design.[11] Later on while working for the Iowa State Highway Commission McCullough would further his research on this topic, determining that bridges could be sufficiently designed to withstand these changes without overbuilding, and that establishment of standard specifications for bridge types would help eliminate wasteful spending due to overbuilding.[12] McCullough's research made an important contribution to the promotion of economic bridge design, and furthered his ability to apply economic principles to the design of highway bridges during his tenure as state bridge engineer in Oregon.

Another notable influence Marston had on his students was his emphasis on the need for overlap of the architecture profession with the engineering profession. The following quote was delivered by Marston in a lecture on the history of engineering.

> On the one hand we have the architectural student, given a comparatively thorough training in art, but with only a smattering of engineering training. On the other hand we have the engineer, trained almost entirely along utilitarian lines, with no instruction in the artistic principles of design. A double misfortune has resulted."[13]

It is clear from his statement that Marston believed professionals from both disciplines should have at least some training in the other to better exploit knowledge gained from each. He believed architects could not make the best use of construction materials unless they had a thorough understanding of their engineering properties, and likewise, the engineer should have some training in the principles of design because, he stated, "there is no reason why utilitarian structures should not be designed with some reference to their appearance."[14]

Early Work Experience with the Marsh Engineering Company

After graduating from Iowa State College in 1910 McCullough had the opportunity to apply his interest in reinforced-concrete bridge design when he began working for the Marsh Engineering Company in Des Moines, Iowa. During this time McCullough gained further insight into the construction of economically and aesthetically founded bridge designs. James Marsh, the owner of the company, would eventually become well known for the design of two specific reinforced-concrete bridge types, the “rainbow arch” bridge, and the “tied arch” bridge. Marsh promoted the former by highlighting its economic design and low cost of maintenance saying that it was, “frost proof, flood proof, and fire proof.”[15] He eventually went on to secure a patent for the design in 1912.[16]

Iowa State Highway Commission

In 1911 McCullough left the Marsh Engineering Company to accept a position as chief draftsman for the Iowa State Highway Commission. A short time later he was promoted to the position of design engineer after demonstrating exceptional promise through the creation of several standardized bridge spans.[17] In 1914 an important event took shape that would later influence McCullough’s career path. His former employer, the Marsh Engineering Company, was being sued by Daniel B. Luten, president of the Luten Engineering Company, for allegedly using one of Luten’s patented reinforced-concrete arch bridge designs illegally for a structure in Albert Lea, Minnesota.[18] This was one of several federal law suits filed by Luten in an attempt to collect royalties for his patented bridge designs. Having previously worked for Marsh, the company asked McCullough to provide research and collect evidence to assist their case during litigation. In 1918 the court ruled in favor of the Marsh Engineering Company, determining that Luten’s patents were invalid because, “they did not disclose new knowledge, but rather mechanical or engineering details of the application of knowledge that is old,” and further meant that Luten was not entitled to the royalties he was demanding.[19] In 1916

McCullough was further promoted to assistant state highway engineer where he continued to conduct research in bridge design and maintain interest in litigation concerning bridge patents.

Teaching at Oregon Agricultural College

That summer McCullough left the Iowa State Highway Commission to take a position as assistant professor of civil engineering at Oregon Agricultural College in Corvallis (later renamed Oregon State University). While teaching at OAC, McCullough began fostering a friendship with Charles Purcell, Oregon's first state bridge engineer. This interaction was significant because several years earlier Purcell had been involved in a research project with Samuel Lancaster to determine the potential for constructing a road along the Washington side of the Columbia River Gorge.[20] Although the project was denied funding by the Washington state legislature, it evoked interest by the Oregon state legislature, and evolved into the construction of the Columbia River Highway for which Charles Purcell along with Karl P. Billner designed several bridges, some of which provided design precedence for spans McCullough would later design as the state's bridge engineer.

Oregon State Highway Department

In the spring of 1919 McCullough was offered Charles Purcell's former job and on April 9th of that year he officially became the second bridge engineer for the Oregon State Highway Department.[21] Two years prior to McCullough's acceptance of the position, the Oregon state legislature had approved the sale of 6 million dollars in bonds for the construction of new roads. The events leading up to the approval began in 1913 after public demand for better roads due to increased production and sale of automobiles in the United States led to the formation of the Oregon State Highway Commission to begin highway planning.[22] When the first automobiles arrived in Oregon the only connections between many coastal towns were beaches so one of the first undertakings of the newly established Oregon State Highway Commission was to introduce a bill to the state legislature establishing the entire Oregon beach as a public highway.[23] In 1914 further development began to take shape as Oregon's first state highway engineer, Henry L. Bowlby, proposed a network of five major state highways which included the Pacific Highway (modern day Interstate 5), the Dalles-California Highway (modern day US 97), the Columbia River Highway (which runs parallel to Interstate 84), an east-west highway along the McKenzie River (modern day Oregon 126), and the Oregon Beach Highway (modern day US 101). In 1919, two years after the bond approval, another 10 million dollars in the sale of bonds was approved for highway construction. That same year, Oregon enacted the first state gas tax in the nation, requiring that 1 cent of every gallon of gas sold go towards the improvement of state roads.

Increased funding meant a large influx of highway design and construction projects that could not be properly handled by the staff available so after accepting the position as state bridge engineer, McCullough immediately recruited four of his former classmates from Iowa State College, including William Reeves, Orrin Chase, Merle Rosecrans, and Edward S. Thayer.[24] To further mitigate the lack of staff, he also requested permission from Oregon Agricultural College to hire four seniors from the structural engineering department prior to their graduation. This group of young men included Ellsworth Ricketts, A. G. Skelton, Raymond Archibald, and P. Mervyn Stephenson, who went on to become state bridge engineer in 1955.[25] McCullough's persistence in providing an early professional opportunity for these four men reflects the value he was taught by Anson Marston at Iowa State College of gaining practical engineering experience prior to completing academic training.

During his tenure as state bridge engineer McCullough supervised the design and construction of hundreds of bridges throughout Oregon, several of which will be discussed in the next chapter. His life's accomplishments, however, went far beyond his work for the highway department. In 1928 his tenacity for furthering his knowledge led him to find the time and energy to earn a law degree from Willamette University by attending night classes, an endeavor which was likely the result of the interest he developed while assisting with the Luten Engineering Company patent dispute in 1914. He also received an honorary doctor of engineering degree from Oregon Agricultural College in 1934 and wrote and co-authored several books throughout his career. Among them were *Economics of Highway Bridge Types*, published in 1929; *Elastic Arch Bridges,* which he wrote with his Iowa State College colleague, Edward S. Thayer; and *The Engineer at Law: A Resume of Modern Engineering Jurisprudence,* which he wrote with his son John, who later pursued a career as a lawyer.[26]

After nearly 16 years of service as Oregon's state bridge engineer McCullough accepted an invitation by the United States Bureau of Public Roads to design several bridges for the Inter-American Highway in Central America.[27] The Inter-American Highway is the Central American portion of the Pan-American Highway, which stretches from Alaska to the tip of South of America. United States involvement in this project was meant to provide federal funding assistance, although limited due to the economic effects of the Depression, as well as professional bridge engineering supervision.[28] While abroad McCullough designed three suspension bridges which again demonstrated his sensitivity to aesthetic design through the integration of decorative themes based on cultures from around the region.

In 1937 McCullough returned to Oregon where he was promoted to assistant state highway engineer, a position that he is said to have found unfulfilling given that it was limited mostly to administrative duties.[29] To combat his restlessness, McCullough took on a variety of extra-curricular activities, including chairing Salem's Long Range Planning Commission in the 1940s. The formation of this group was a result of the Salem Chamber of Commerce's concern for "haphazard development due to post World War II population growth," and McCullough eagerly guided them through the development of plans to ensure cohesive and practically-minded expansion of the city.[30] Sadly, McCullough died of a massive cerebral hemorrhage later that decade in May of 1946 at only 59 years of age. The following year his bridge at North Bend spanning Coos Bay was renamed the *Conde B. McCullough Memorial Bridge* to honor his numerous life achievements and the integral role he played in expanding Oregon's transportation network.

Conclusion

As the next chapter will illustrate, McCullough's Oregon bridge designs are a culmination of the academic training he received and the work experience he gained while in Iowa. McCullough's work reflects his philosophy that structures should be designed with respect to aesthetic quality, current developments in the field of engineering, and responsible and economic use of materials, notions that were undoubtedly inspired by Anson Marston's influential voice. Throughout Oregon, these values are the essence of McCullough's bridges, making them easily recognizable as the result of his incredible ingenuity and creativity, and setting them apart from the work of other notable bridge engineers of his time.

Notes

[1] Robert W. Hadlow, "C. B. McCullough: The Engineer and Oregon's Bridge-Building Boom, 1919-1936," *Pacific Northwest Quarterly* 82, no. 1 (January 1991): 8.

[2] Herbert J. Gilkey, *Anson Marston: Iowa State University's First Dean of Engineering* (Ames: Iowa State University, College of Engineering, 1968), preface.

[3] Robert W. Hadlow, *Elegant Arches, Soaring Spans: C. B. McCullough, Oregon's Master Bridge Builder* (Coravallis: Oregon State University Press, 2001), 11.

[4] Ibid.

[5] Anson Marston, *The History of Engineering: A Course of Lectures to the Senior Engineering Students of the Iowa State College* (Ames: Iowa State College, 1912), 24.

[6] Ibid.

[7] Ibid., 35.

[8] Michele Christian, personal communication with the author, February 27, 2009.

[9] Gilkey, 189.

[10] Hadlow, *Elegant Arches, Soaring Spans: C. B. McCullough, Oregon's Master Bridge Builder*, 16.

[11] Ibid., 17.

[12] Ibid., 31.

[13] Marston, 30.

[14] Ibid., 31.

[15] Hadlow, "C. B. McCullough: The Engineer and Oregon's Bridge-Building Boom, 1919-1936," 8.

[16] Ibid.

[17] Hadlow, *Elegant Arches, Soaring Spans: C. B. McCullough, Oregon's Master Bridge Builder*, 24.

[18] Ibid., 33.

[19] Ibid., 34.

[20] Hadlow, "C. B. McCullough: The Engineer and Oregon's Bridge-Building Boom, 1919-1936," 9.

[21] Ray Bottenberg, *Images of America: Bridges of the Oregon Coast* (Chicago: Arcadia Publishing, 2006), 7.

[22] Joe R. Blakely, *Lifting Oregon Out of the Mud: Building the Oregon Coast Highway* (Wallowa: Bear Creek Press, 2006), 8.

[23] Ibid.

[24] Bottenberg, 7.

[25] Louis F. Pierce, *C. B. McCullough, Structural Artist in Bridges*, paper delivered to "A Salute to Bridge Engineers" for the American Society of Civil Engineers sponsored conference held in San Fancisco on May 21, 1987.

[26] Ibid.

[27] Hadlow, *Elegant Arches, Soaring Spans: C. B. McCullough, Oregon's Master Bridge Builder*, 112.

[28] Ibid.

[29] Ibid., 123.

[30] Ibid.

CHAPTER IV

A TYPOLOGICAL STUDY OF McCULLOUGH'S OREGON BRIDGES

McCullough's Oregon bridges are famous for their aesthetic beauty and sensitivity to their natural surroundings. The soaring curves of his arch spans reflect the rise and fall of Oregon's topography and the intricate architectural details provide a framework through which to appreciate it. Although McCullough did not have any formal architectural design training, his profound understanding of the unique physical properties of the materials he employed allowed him to execute structural masterpieces in reinforced-concrete and steel that today are considered important historic resources.

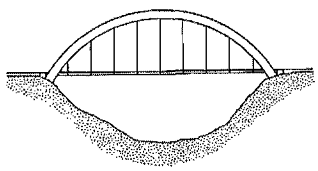
Because he was not formally trained in the theory of design we cannot associate his design philosophy with a particular school of thought. In order to better understand McCullough's work we must instead identify influential threads that may have helped shape his ideas. Having already examined the academic training, early work experience, and material that he used in the two previous chapters, it is clear that aesthetics and economy were two values he brought to his position as state bridge engineer. This portion of the research project aims to identify further influences specific to the time period he was working in Oregon through the establishment of a typological study of his bridge designs.

What Is a Typological Study?

A typological study or analysis is one that systematically classifies types.[1] This approach is useful for examining various forms of architecture because it can provide insight into the designer's perceptions of the world, and how he or she manipulated them in their designs. When establishing a typology of bridges, difficulty results in the fact that these structures all serve the same general purpose. Bridges are first and foremost designed to provide safe crossings for an otherwise impassable section of terrain whether it is a small creek, large bay, or river canyon. There are many bridge types which can be employed to satisfy particular engineering needs relative to the size of the crossing, terrain upon which the supporting structure must be built, and even specific needs of the roadway traffic traveling over it and, if applicable, the water or rail traffic moving under it.

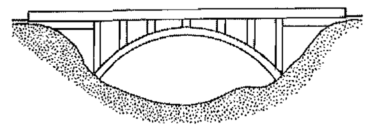
McCullough designed a variety of bridge types throughout his career in Oregon including deck arches, through arches, trusses, and moveable spans, decisions that were logically based on specific engineering needs for particular crossings. Table 2 on the following page illustrates the main bridge types McCullough employed in Oregon and is meant to provide the reader with a basic understanding of each one as the terminology will be used throughout Chapters IV and V. It should be noted, however, that the typology developed during this project looks beyond McCullough's selection of bridge type, and instead focuses on why he included particular elements in his bridge designs that were not necessarily a result of specific engineering needs, as well as how he chose to treat them with different architectural styles.

Table 2: Bridge types McCullough employed in Oregon
Source: Illustrations and descriptions from Dwight A. Smith, James B. Norman, and Pieter T. Dykman, *Historic Highway Bridges of Oregon* (Salem: Oregon Department of Transportation, 1986), 86, 57, 121, 114.



Elevation

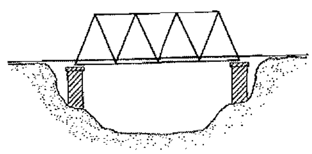
Through Arch



Elevation

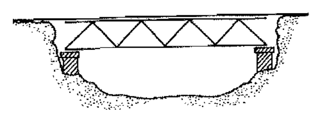
Deck Arch

Arch bridges are comprised of convexly curved structural members that span openings and carry the roadway. Loads are transferred to piers or abutments at the end of the span through compression.



Elevation

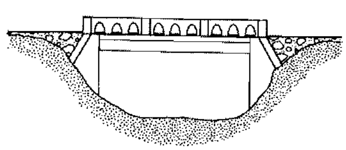
Through Truss



Elevation

Deck Truss

Truss bridges are those which are supported by a rigid structural frame whose geometry is based on that of a triangle.

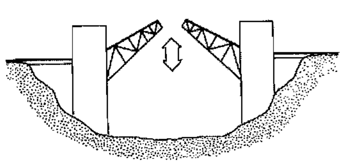


Elevation

Transverse Section

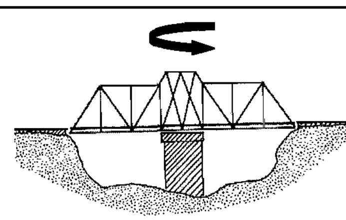
Concrete Girder (T-Beam)

In a girder bridge the deck is supported by one or more longitudinal structural members. Girder bridges may be constructed of timber, steel, or reinforced-concrete.



Elevation

Bascule



Elevation

Swing span

In a bascule bridge the leaf of the bridge lifts upward to allow for clearance of large water vessels. In a swing span the bridge deck rotates so that it is perpendicular to the roadway to allow for water vessels to pass on either side of the central pivot point.

Site Visit Selection

To develop a typological study of McCullough's Oregon bridges, it was first necessary to investigate his range of work. For this purpose, site visits were made to forty-one of McCullough's bridges in Oregon. Bridges chosen for site visits were selected on the basis that individual design and construction dates covered the eighteen years that he was employed as bridge engineer for the Oregon State Highway Department. They were also selected on the basis that they covered the range of bridge types, materials used, and span sizes he employed, as well as the variety of locations he built them. Visiting such a broad range of bridges allowed for the investigation of the entire scope of McCullough's work in Oregon, rather than just a few designs that may have been the result of isolated conditions, such as terrain or crossing size.

Of the forty-one bridges visited, locations ranged from larger cities such as Grants Pass and Oregon City, to smaller communities such as Rock Point and Scottsburg, to rural locations on highways outside of cities and towns. The primary construction material used by McCullough was reinforced-concrete; however several spans visited were constructed with a combination of reinforced-concrete and steel through arches, through trusses, or deck trusses. In addition, three bridges surveyed were constructed of reinforced-concrete combined with wood. Span lengths of bridges surveyed ranged from approximately 100 feet to approximately 5,300 feet. The map in figure 4 on the following page illustrates the locations of all forty-one bridges surveyed. Additional maps with labeled bridge locations can be found in Appendix A, and specific data for each bridge surveyed is provided in Appendix B.

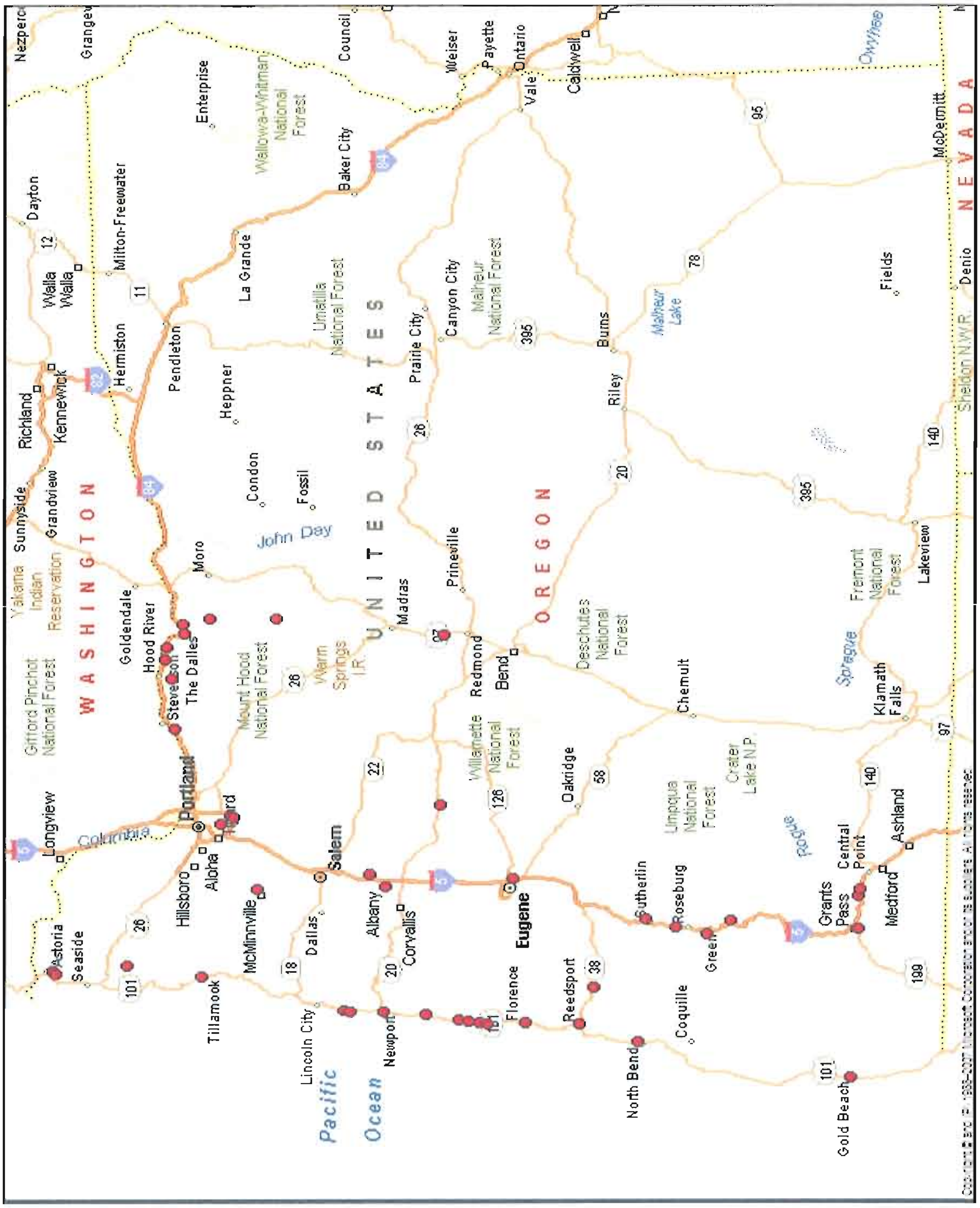


Figure 4: Distribution map of McCullough bridges surveyed with locations indicated by red dots.
Source: Map generated using Streets and Trips Software, with bridge locations augmented by the author

As discussed in the previous two chapters, McCullough invested much time and interest in economizing bridge construction while at the same time creating aesthetically pleasing designs. These interests were initially imparted on him by his former instructor and mentor, Anson Marston, but his work experience after graduating from Iowa State College undoubtedly refined his individual approach to bridge design. The following excerpt from McCullough's book, *Economics of Highway Bridge Types*, published in 1929, reflects his belief that an appropriate bridge type for a particular crossing should in part be determined by taking aesthetics into account, as well as the viewpoint of those using the bridge.

> In (bridge) type selection for architectural effect, consideration should be given to the degree to which the structure will be exposed to view. If the alignment is such that the structure is plainly visible in side elevation from the approaching highway, more attention should naturally be paid to a type selection which gives a pleasing side elevation outline than if only the roadway were visible.[2]

Although this particular passage discusses only one aspect of McCullough's approach to bridge design, it exemplifies his concern for creating aesthetically pleasing bridges not only because it was instilled in him early in his academic training that utilitarian structures should be designed with artistry, but that doing so would enhance the experience of those who used them.

During the survey of McCullough's bridges it therefore seemed logical to find embellishments on his bridges that could be viewed by passing motorists from the roadway, however, it was discovered that nearly all of his bridges and all of the elements, regardless of whether they could be seen from the roadway, were highly embellished, and could only truly be appreciated when one stopped and got out of the car. For this reason, it is proposed that McCullough created bridge designs to provide for a broader range of use as a response to changing social values.

As wider availability of automobiles led to the construction of more roads, and in turn increased accessibility to recreational pursuits it is believed that McCullough began to envision bridges not simply as utilitarian structures for motorized traffic to get from point A to point B, but rather as destinations in themselves, places in which to get out of the car, enjoy the view, or even spend an afternoon. He was perceptive of this potential in the 1920s and 1930s, given that the arrival of the automobile allowed more people than ever to get out and enjoy Oregon's natural landscape.[3] Furthermore, technological innovations of that time period promoted an increase in free time and therefore a drive to the ocean or along a scenic highway became a valuable and enjoyable way to spend it.[4] Even today many of McCullough's bridges serve as stopping points along scenic highways, and their elaborate railings and entrance pylons or towers invite further investigation on foot. Those who venture beyond the roadway to explore the substructures of his bridges are provided views of scenic vistas framed by the outlines of his dramatic designs. The typological study of his bridges found in the following pages therefore highlights the architectural devices McCullough employed to create bridges as destinations for recreation, as well as the architectural styles he used to design these features.

After the survey was complete, bridges were divided into groups based on whether they had the following characteristics: no pedestrian walkways, identified as type 1; pedestrian walkways only, identified as type 2; pedestrian walkways and entrance pylons, identified as type 3; and pedestrian walkways and entrance towers or pedestrian plazas, identified as type 4. It was concluded that these features most aggressively promote bridges as destinations because they invite pedestrian use, which assumes that one must stop and get out of the car. Pedestrian walkways were defined as raised sidewalks on one or both sides of the bridge. Entrance pylons were defined as vertical decorative elements that extend above the height of railings, and entrance towers were defined as small decorative structures that one could enter. Pedestrian plazas were identified as areas at the ends of spans characterized by balustrades that extend beyond the width of the bridge on either side to define a scenic overlook or resting place for pedestrians, and have staircases which lead up to the pedestrian walkways. Table 3 on the following page illustrates the distribution of bridges surveyed into these types.

It should be noted that division of bridges into these four types for the most part indicated a chronological progression of McCullough's work, meaning that those classified as type 1 were the earliest bridge designs of the forty-one surveyed and those classified as type 4 were the latest, however there were several exceptions which seemed to be affected by location. In some cases, bridges that were constructed over crossings in larger cities or towns along the coast where there is a higher volume of traffic tended to have one or more of these features, even early on in his career. A good example of this trend is the Old Young's Bay Bridge in Astoria, Oregon, which was completed during the second year of McCullough's tenure as state bridge engineer in 1921. Although it was designed early in his career it has pedestrian walkways and especially unique entrance pylons so it was classified as a type 3 structure. It should also be noted that the Eagle

Creek Bridge was not classified into a type because all that remains from this bridge are the piers. The location of this bridge is however noted on the map in figure 4, and more information about this bridge is included in Appendix B.

Table 3: Distribution of McCullough bridges surveyed by type. Type 1: no pedestrian walkways; Type 2: pedestrian walkways only; Type 3: pedestrian walkways and entrance pylons; Type 4: pedestrian walkways and entrance towers or pedestrian plazas
Source: Author

Type 1: No pedestrian walkways	**Type 2: Pedestrian walkways only**	**Type 3: Pedestrian walkways and entrance pylons**	**Type 4: Pedestrian walkways and entrance towers or pedestrian plazas**
Rogue River (Rock Point) Bridge	Oswego Creek (Sucker Creek) Bridge	Old Young's Bay Bridge	Rogue River (Gold Beach) Bridge
Fifteenmile Creek (Seufert) Viaduce	Mill Creek Bridge	Willamette River (Oregon City) Bridge	Yaquina Bay Bridge
Mosier Creek Bridge	North Yamhill River Bridge	Willamette River (Albany) Bridge	Alsea Bay Bridge
Dry Canyon Creek Bridge	North Umpqua (Robert A. Booth) Bridge	Crooked River (High) Bridge	Coos Bay (McCullough Memorial) Bridge
South Umpqua River (Myrtle Creek) Bridge	Depoe Bay Bridge	Willamette River (Springfield) Bridge	
Lewis and Clark Bridge	Santiam River (Cascadia State Park) Bridge	Clackamas River (McLaughlin) Bridge	
Fifteenmile Creek (Adkisson) Bridge	Deschutes River (Maupin) Bridge	Santiam River (Jacob Conser) Bridge	
Calapooya Creek (Oakland) Bridge	Rogue River (Caveman) Bridge	Umpqua River (Reedsport) Bridge	
Rogue River (Gold Hill) Bridge	Big Creek Bridge	Siuslaw River (Florence) Bridge	
Rocky Creek (Ben F. Jones) Bridge	Cummins Creek Bridge		
Soapstone Creek Bridge	Ten Mile Creek Bridge		
Umpqua River (Scottsburg) Bridge	Wilson River Bridge		
Hood River (Tucker) Bridge	Cape Creek Bridge		
	South Umpqua River (Winston) Bridge		

Stylistic Influences

As will become obvious throughout the explanation of data gleaned from the typological study, McCullough tended to design using two architectural styles. Work from approximately the first half of his career, 1919 to 1930, incorporated architectural styles based on classical influences, and in one instance Tudor style influence. During the last decade of the 19^{th} century eclectic references to classicism were made popular by American architects trained at the Ecole des Beaux-Arts Academy in Paris for the construction of large civic buildings in the United States.[5] One of the most widely recognized illustrations of this style was in buildings constructed for the Chicago Worlds Fair in 1893, an event which grew out of the influential City Beautiful Movement. The intent of the City Beautiful Movement was to use beautification as a tool for promoting more harmonious social existence among populations in increasingly over-crowded North American cities, a problem which had tended to foster hostility and violence as a means for survival.[6] Equally important is that the idea of city planning also grew out of this movement and emphasized the integration of public green space and open plazas that provided opportunities for recreation and an escape from the discomforts caused by over-crowding. Although McCullough was likely too young to attend the Chicago World's Fair, he may have been influenced by other illustrations of the Beaux-Arts style that were found at events such as the Panama-Pacific Exposition of 1915 held in San Francisco, and in the design of numerous civic buildings and monuments constructed throughout the country into the beginning of the 1920s. This may be one of the reasons McCullough believed that it was appropriate to make use of these styles in his own work since it is clear that he intended his bridges to create ease of travel, as well as enjoyment through outdoor recreation.

Around 1930 there was a prominent shift in McCullough's work as he began incorporating the geometric shapes, hard-lined scoring, vibrant textures, and stylized floral motifs of the progressive Art Deco style, which drew inspiration from a variety of cultural sources from such places as Japan, Russia, Assyria, and Egypt. The Art Deco style grew out of the European Art Nouveau movement, which was highly ornamental and applied mostly to interior architecture and decorative furnishings. Applied to architecture this style was meant to generate optimism in a nation on the brink of an economic depression through its energy and vibrancy.[7] Moreover, this style was evidently viewed as immensely versatile as it was applied for a variety of building types from the soaring skyscrapers of New York City to small diners and even hotels and residential architecture. The Streamline Moderne style, which he also used at this time, was a smoother variation of the Art Deco style that was heavily influenced by industrial designers intending to reduce turbulence around moving objects by creating rounded surfaces.[8] Although it is not certain why McCullough chose to move away from his established practice of incorporating more traditional architectural styles we can speculate that he may have believed this modern style was appropriate for his bridges because they were symbolic of the technological developments that had allowed the nation to move forward in transportation through the wider production and availability of cars.

Type 1 Structures

Bridges identified as type 1 are those which do not have any pedestrian features other than ornate balustrades, which also serve as safety features for vehicular traffic. Because employment of features such as pedestrian walkways and plazas naturally suggests higher traffic areas, it is not surprising that bridges in the first group are all located in smaller communities or on rural highways where there were lower volumes of traffic and therefore fewer pedestrians. The only two exceptions in this group are the Lewis and Clark Bridge located in Astoria, and the Fifteenmile Creek (Seufert) Viaduct located in The Dalles. Construction dates of bridges in this group represent work completed in the first half of McCullough's career as state bridge engineer, with the exception of the Hood River (Tucker) Bridge, which was built in 1932. Of the thirteen spans in this group, eight of them were constructed prior to 1925, and nine of these are reinforced-concrete deck arch spans. The exceptions were the Calapooya Creek (Oakland) Bridge classified as a reinforced-concrete deck girder span with a steel Warren deck truss; the Umpqua River (Scottsburg) Bridge classified as a continuous steel through truss span; the Lewis and Clark Bridge classified as a steel central bascule span with pile trestle and stringer spans; and the Fifteenmile Creek (Seufert) Viaduct classified as a reinforced-concrete deck girder span.

Although this group of bridges lacks the pedestrian utilities of later designs, most are still quite elaborate in the treatment of their railings and substructures. The exception is the Lewis and Clark Bridge in Astoria, which is void of decorative details, aside from the segmental arch openings and clean stucco finish of the operator houses on either side of the south end of the single leaf bascule draw span. For the rest of these bridges, McCullough employed a variety of different balustrade designs. The earliest design, which is found at the Rogue River (Rock Point) Bridge, echoes a typical stair railing with its urn-shaped balusters (figure 5). McCullough's balustrade designs eventually evolved into that which is illustrated in figure 6 by replacing individual balusters with segmental arch panels reminiscent of tiny colonnades. With the exception of the later Hood River (Tucker) Bridge, this balustrade design was employed for the rest of the bridges in this group with only slight variation found in the solid vertical divisions spaced at equal intervals to break up the monotony of the design.

Figure 5: Balustrade on Rogue River (Rock Point) Bridge, 1920, illustrating urn-shaped balusters
Source: Author

Figure 6: Balustrade on Dry Canyon Creek Bridge, 1921, illustrating segmental arch design
Source: Author

Figures 7 and 8 illustrate the variation in designs that McCullough employed for this balustrade. It should be noted that this segmental arch design was employed for several bridges classified as type 2 as well.

Figure 7: Balustrad on Fifteenmile Creek (Akdisson) Bridge, 1925, illustrating variation in design
Source: Author

Figure 8: Balustrade on Rocky Creek (Ben F. Jones) Bridge, 1927, illustrating variation in design
Source: Author

Although there are no other decorative features on the roadway decks of bridges classified as type 1, the balustrades allude to the elaborate substructures found below the roadway, especially in his deck arch bridges. The Dry Canyon Creek Bridge, constructed in 1921 as part of the Columbia River Highway with its reinforced-concrete open-spandrel deck arch, is an excellent example of this idea (figure 9 on the following page). Viewed in elevation from the side of the road, the lightness of the deck arch is amplified by the arched openings in the spandrel wall which spring from thin square columns. Aligned with the columns are large brackets which provide a visual connection between the roadway deck and the spandrel wall.

Figure 9: Dry Canyon Creek Bridge, 1921, illustrating open-spandrel deck arch design
Source: Author

Deck girders and truss spans in this group are not quite as elaborate early in McCullough's career as deck arches tended to be, although he relied on some of the same classical treatment strategies. One of the best examples from this group is the Calapooya Creek (Oakland) Bridge built in 1925. The intricate segmental arch panel balustrade on the roadway and brackets supporting the deck are nearly identical to those found at the Dry Canyon Creek Bridge, however the substructure below consisting of a steel Warren deck truss and nine reinforced-concrete deck girder approach spans is quite utilitarian in comparison. The only decorative details to be found are in the piers which consist of two round columns connected by a solid curtain/spandrel wall (figure 10).

Figure 10: Calapooya Creek (Oakland) Bridge, 1925, illustrating mild decoration in the treatment of the piers
Source: Author

Type 2 Structures

The bridges classified as type 2 are characterized by the inclusion of pedestrian walkways, or in the case of the North Umpqua (Robert A. Booth) Bridge at Winchester, pedestrian balconies. The fourteen bridges in this group range in date from 1920 to 1934 and tend to be located in larger communities or on US 101 in or around coastal communities. This group also includes new structural types of bridges that were not seen in type 1, including a reinforced-concrete through tied arch, which represents the first time this span type was employed in the Pacific Northwest region of the United States, as well as steel through tied arches, and a timber Howe deck truss. Bridges in this group also exemplify greater complexity in their detailing and inventiveness in the designs of their substructures.

The inclusion of pedestrian walkways was the next step in promoting bridges as destinations rather than vehicular crossings. For his through arch spans, whether they were constructed of reinforced concrete or steel, McCullough integrated walkways into the designs by widening the roadway deck at the location where the arch begins to extend above it, allowing the pedestrian to walk along the outside of the superstructure (figure 11). For shorter spans of this type, as well as for reinforced-concrete deck arch spans, he was simply able to add a sidewalk on either side of the roadway without extending the width of the roadway deck (figures 12 and 13).

Figure 11: South Umpqua River (Winston) Bridge, 1934, illustrating deck widening for inclusion of pedestrian walkway
Source: Author

Figure 12: Wilson River Bridge, 1931, illustrating pedestrian walkway
Source: Author

Figure 13: Pedestrian walkway at Cape Creek Bridge, 1932
Source: Author

Two particularly innovative designs classified as type 2 are the North Umpqua (Robert A. Booth) Bridge at Winchester, and the Cape Creek Bridge along US 101 in Lane County. At Winchester pedestrian access was employed through the integration of four balconies which are embellished with inset panels dressed with red ceramic tile (figures 14 and 15). The sidewalks that are there today were added when the bridge was widened in 2007.

Figure 14: North Umpqua River (Robert A. Booth) Bridge, 1924, illustrating elevation of pedestrian balcony
Source: Author

Figure 15: Pedestrian balcony on North Umpqua River (Robert A. Booth) Bridge, 1924, illustrating view from the road deck
Source: Author

As mentioned previously, this is the only bridge surveyed where McCullough incorporated Tudor style detailing. His use of this style came at a time when architects throughout the United States were designing buildings, especially residential architecture, that incorporated historical references and therefore exhibited their knowledge of historic sources as a result of academic training and extensive travel.[9]

The Cape Creek Bridge constructed in 1932 is equally unique in that the substructure integrates a deck arch with two tiers of columns reminiscent of a Roman aqueduct (figure 16). Like the bridge at Winchester, the design used for Cape Creek was unique to this site and was never used again by McCullough.

Figure 16: Substructure of Cape Creek Bridge, 1932, illustrating parabolic deck arch and tiers of columns
Source: Author

Bridges classified as type 2 also illustrate a second balustrade type used by McCullough. The segmental arch railing panel used previously in the balustrades of the earliest bridges in this group eventually evolved into a round arch panel. This type of balustrade was utilized for many of his later bridges from 1929 on, again with variation in the vertical divisions (figure 17).

Figure 17: Balustrade on Deschutes River Bridge, 1929, illustrating round arch railing panel
Source: Author

As discussed earlier in the chapter, around 1930 McCullough began moving away from eclectic variations of classical styles and his designs began to show influence of a new national trend in architecture. He began employing architectural details inspired by the Art Deco and Streamline Moderne movements which were believed to be particularly suitable for concrete structures.[10] These styles are apparent in the vertical and horizontal scoring he employed on the abutments, balusters, and through arches of this group (figure 18). He also began employing stylized floral motifs in the railing panels of the balusters, which was another common design used during these two artistic movements (figure 19).

Figure 18: Rogue River (Caveman) Bridge, 1931, illustrating vertical and horizontal scoring in the concrete
Source: Author

Figure 19: Balustrade on Rogue River (Caveman) Bridge, 1931, illustrating floral motif
Source: Author

Type 3 Structures

Bridges in this group are characterized by their highly elaborate entrance pylons. While they also serve as a safety device for alerting drivers to the fact that they are going over a bridge, these pylons create monumental entrances to these spans. With the exception of the Crooked River (High) Bridge, all the bridges in this group are located in larger cities and coastal towns. The earliest bridge in this group is the Old Young's Bay Bridge built in 1921 in Astoria. The two latest bridges in this group are the Siuslaw River Bridge and the Umpqua River Bridge, both on US 101. While a few of the early bridges in this group again show evidence of historic reference in their architectural details, many illustrate McCullough's continued exploration of the Art Deco and Streamline Moderne styles.

The Willamette River Bridge in Oregon City from 1922 and the Willamette River Bridge in Albany from 1925 (figure 20) are both unique examples from this category in that McCullough employed Egyptian-style obelisk designs for the entry pylons. These are the only two bridges surveyed that used this style of architecture and may have been a result of the popular interest in Egyptian architecture which was initiated by the discovery of King Tutankhamen's burial chamber by Howard Carter in 1922.[11]

Figure 20: Egyptian-style obelisk at Willamette River (Albany) Bridge, 1925
Source: Author

Most notably this interest was seen in the design of highly decorative movie palaces such as the Egyptian Theater in Coos Bay, Oregon, designed by Lee Arden Thomas in 1925.

Later entrance pylon designs, much like the railings McCullough employed, evolved into the Art Deco style with combinations of reinforced-concrete and metal as found at the Siuslaw River Bridge in Florence. Also characteristic of this style was the integration of setbacks in the pylons, piers, and railings, as well as sunburst and floral motifs (figures 21, 22, 23).

Figure 21: Primary entrance pylon at Siuslaw River Bridge, 1936, illustrating metal grate and sunburst motif
Source: Author

Figure 22: Secondary entrance pylon at Siuslaw River Bridge, 1936, illustrating incorporation of setbacks
Source: Author

Figure 23: Entrance pylon at Umpqua River Bridge, 1936, illustrating scored concrete and floral motif
Source: Author

The Santiam River (Jacob Conser) Bridge in Jefferson has a particularly unusual style of pylon which has the eclectic classicism of McCullough's early work in the triangular pediments, combined with Egyptian style (in the obelisk) and hard-line scoring typical of Streamline Moderne styles (figure 24).

Figure 24: Entrance pylon at Santiam River (Jacob Conser) Bridge, 1933, illustrating eclectic style
Source: Author

Type 4 Structures

The bridges classified as type 4 exemplify the pinnacle McCullough's career with regard to emphasizing their monumentality and status as destinations. There are only four bridges in this group and all are characterized by having elaborate pedestrian plazas, entrance towers, or both. The entrance towers provide a space to enjoy the view in inclement weather and the pedestrian plazas direct the public to outstanding views of Oregon's landscape. The four bridges in this group represent the largest spans McCullough designed in Oregon and also provided some of the most complex engineering challenges. In addition, three of these bridges were completed during the final years of McCullough's career as state bridge engineer for the Oregon State Highway Department in 1936, and were a result of work financed by the Public Works Administration, a program created by the National Industrial Recovery Act of 1933. Initiated by the Roosevelt Administration, this program was meant to stabilize the devastating economic effects of the Depression by putting people back to work through the funding of public construction projects all over the country.[12] It was estimated that the construction of all five bridges for this project would require nearly 2.1 million man-hours of labor and increase tourism along the coast by 72 percent in only one year.[13] It is not surprising that McCullough again employed progressive designs for these bridges using Art Deco and Streamline Moderne motifs which were viewed as representations of optimism in the trying times of the Great Depression.[14]

Construction of monumental entrance towers at the Rogue River (Isaac Lee Patterson) Bridge at Gold Beach in 1932 continued McCullough's effort to provide recreation for pedestrians. The rectangular structures have a stucco finish which contrasts with the horizontal and vertical scoring and Palladian style openings. Each structure is capped with three incremental set-backs, emulating skyscrapers constructed during that time period (figures 25 and 26). The use of set-backs in high rise architecture was a result of zoning requirements imposed in 1916 by officials in large cities such as Chicago and Manhattan to prevent tall buildings from casting imposing shadows onto city streets, "robbing the public of light and air."[15]

Figure 25: West elevation of entrance tower at Rogue River (Isaac Lee Patterson) Bridge, 1932
Source: Author

Figure 26: North elevation of entrance tower at Rogue River (Isaac Lee Patterson) Bridge, 1932
Source: Author

At the Coos Bay (McCullough Memorial) Bridge at North Bend and the Yaquina Bay Bridge at Newport, McCullough framed the ends with elaborate pedestrian plazas and elegant stairways, almost Baroque in form, which lead up to the pedestrian walkways on the bridges (figures 27 and 28). They were both executed in the Streamline Moderne style with grooved and scored surfaces that cast light and shadows on the plaza walls. The curved staircases also provided pedestrian access to the dramatic substructures of these bridges. The supporting bents at both bridges were fashioned with stylized Gothic arch openings and diagonal lines radiating out in sunburst patterns similar to those found on the entrance towers of the Rogue River Bridge at Gold Beach (figure 29). He framed the bents with column-like devices which again utilized the set-back motifs he employed for the pylons and entrance towers of earlier bridge designs. This design is repeated in the balustrade railing panels of these two bridges (figure 30).

Figure 27: Pedestrian plaza at Yaquina Bay Bridge, 1936
Source: Author

Figure 28: Pedestrian plaza at Coos Bay (McCullough Memorial) Bridge, 1936
Source: Author

Figure 29: Substructure of Yaquina Bay Bridge, 1936, illustrating Gothic arch opening in the supporting bents framed by Art Deco setbacks
Source: Author

Figure 30: Balustrade at Yaquina Bay Bridge, 1936, illustrating Gothic arch opening framed by Art Deco setbacks
Source: Author

The Yaquina Bay Bridge also has pylons as well as entrance towers (figure 31) positioned at the ends of the through arch span just as the Coos Bay Bridge has spires positioned at the ends of the cantilever truss span, again repeating the set-back motif that is characteristic of the Art Deco style (figure 32).

Figure 31: Entrance tower at Yaquina Bay Bridge, 1936
Source: Author

Figure 32: Entrance spires at Coos Bay (McCullough Memorial) Bridge, 1936
Source: Author

The final bridge classified as type 4 is the former Alsea Bay Bridge. Unfortunately the original bridge was lost to extensive deterioration and was demolished after construction of the new span was completed in 1991. The original entrance towers remain, however, along with the pedestrian plazas and pylons. These features were also designed in the Art Deco style with set backs and arched openings, as well as an elegant flared staircase (figures 33 and 34).

Figure 33: North pedestrian plaza and entrance tower at Alsea Bay Bridge, 1936
Source: Author

Figure 34: South pedestrian plaza and entrance tower at Alsea Bay Bridge, 1936
Source: Author

Although McCullough's bridges have a distinctly historic quality to them today, his work was innovative in both its engineering and appearance at the time it was constructed. As mentioned previously, he did not have any formal architectural design training but had been advised early during his academic training that utilitarian structures should be designed with some reference to artistic lines.[16] It is clear that he took that advice to heart and paid close attention to architectural styles developed during the 1920s and 1930s, and applied them in ways that gave his bridges symbolic meaning. Besides creating safe crossings for vehicular traffic, McCullough's bridges were meant to provide viewing platforms for those who wanted to enjoy the scenic beauty that Oregon has to offer, a recreational activity that was made possible by wider availability of automobiles. Today the unique decorative features of McCullough's bridges can still be enjoyed at bridges throughout Oregon. They are the elements that announce to motorists and pedestrians that crossing a bridge is a unique experience. An artistic rhythm is reflected in the decorative pylons, railings, and spires he designed that allows one the ability to read the beginning and end of his spans, as well as points of major support in the substructure below. Modern bridges tend to lack the artistic quality that McCullough employed and are often only designed with respect to utilitarian value so that at times it is not even clear where the road ends and the bridge begins. It is hoped that the balustrades, entrance pylons, pedestrian plazas, and other unique features which set McCullough's work apart from that of many others will be retained when the effort to modernize these structures challenges the effort to preserve his legacy of bridge building.

Notes

[1] Webster's Universal College Dictionary, s.v. "Typology."

[2] Conde B. McCullough, *Economics of Highway Bridge Types* (Chicago: Gillette Publishing Company, 1929), 23.

[3] Joe R. Blakely, Lifting Oregon Out of the Mud: Building the Oregon Coast Highway (Wallowa: Bear Creek Press, 2006), 15.

[4] Wayne Craven, *American Art: History and Culture* (Boston: McGraw Hill, 1994), 408.

[5] Ibid., 394

[6] Ibid.

[7] Patricia Bayer, *Art Deco Architecture: Design, Decoration, and Detail from the Twenties and Thirties* (New York: Harry N. Abrams, Inc., 1992), 8.

[8] Leland M. Roth, *American Architecture: A History* (Boulder: Westview Press, 2001), 374.

[9] Roth, 350.

[10] Bayer, 7.

[11] Ibid., 15.

[12] Ray Bottenberg, *Images of America: Bridges of the Oregon Coast* (Chicago: Arcadia Publishing, 2006), 7.

[13] Ibid.

[14] Bayer, 8.

[15] Ibid.

[16] Anson Marston, *The History of Engineering: A Course of Lectures to the Senior Engineering Students of the Iowa State College* (Ames: Iowa State College, 1912), 31.

CHAPTER V

THE EFFORT TO PRESERVE McCULLOUGH'S LEGACY

The effort to maintain McCullough's work is a difficult task given that it often must be altered to remain a safe and efficient part of Oregon's transportation network. In some cases his bridges have had to be entirely replaced due to extensive deterioration resulting in difficult decisions on how best to preserve his legacy without insulting it. This task is the responsibility of the Oregon Department of Transportation given that they oversee the network of highways and city streets upon which his bridges were constructed. The formation of the Oregon Department of Transportation Bridge Preservation Team was largely a result of the discovery of corrosion of the steel reinforcements in the pier foundations of the Alsea Bay Bridge in 1972, which resulted in the realization that traditional treatments would not eliminate the problem.[1] Although attempts were made to mitigate the situation, the corrosion was far too extensive to be solved with traditional treatments. By the mid-1980s continued deterioration of the bridge led to ODOT's determination that a new bridge would have to be constructed to ensure safe crossing over the expansive bay. Although this was not an ideal solution, the situation at Alsea Bay prompted a statewide survey of historic bridges in an effort to gain better understanding of potential problems and to identify those which were eligible for listing on the National Register of Historic Places.[2] This project marked the development of an engineering unit within ODOT's Bridge Section dedicated to the rehabilitation of historic bridges throughout the state.

The identification of eligible bridges was an important step in the effort to preserve McCullough's legacy of bridge building because it encouraged recognition of the significance of these historic resources. Of the forty-one bridges surveyed for this project, eleven are now individually listed on the National Register of Historic Places and two more are listed as contributing resources on the Columbia River Highway nomination from 1983.[3] In addition, McCullough's Rogue River Bridge at Gold Beach and the Columbia River Highway were each designated National Historic Civil Engineering Landmarks by the American Society of Civil Engineers in 1982 and 1984 respectively.[4] Listing of a historic resource on the National Register of Historic Places requires evaluation of its historic integrity. If listed, the structure is provided with insurance against alterations as a result of issues such as deterioration or negative impact on the resource, without first undergoing evaluation, discussion, and review of alternatives to minimize that impact.[5] Many of McCullough's bridges have already undergone rehabilitative treatment to halt deterioration or to accommodate modern transportation needs and satisfy safety standards. The purpose of this chapter is to analyze the result of treatments employed to maintain McCullough's bridges as part of Oregon's transportation network, and discuss the extent to which they serve as strategies for sustaining each structure's integrity, therefore preserving his priceless legacy of work.

Integrity is defined by the United States Department of the Interior as a historic structure's ability to convey its significance.[6] In other words, a structure's historic integrity is its ability to tell the story it symbolizes. In the case of McCullough's Oregon bridges, this translates to whether or not they retain their essential character defining features which are attributes that convey McCullough's design philosophy. These attributes include his attention to economy and aesthetic value which has been discussed several times throughout this paper, as well as his intent to design bridges as destinations as discussed in the previous chapter.

For nomination of a historic resource to the National Register of Historic Places, its integrity is evaluated according to seven aspects: location, design, setting, materials, workmanship, feeling, and association.[7] The following definitions of these terms were developed by the United States Department of the Interior and are used in the discussion of treatments applied to McCullough's bridges.[8]

Location: Location is defined as the place where the historic structure was constructed. Complemented by its setting, the location is particularly important to recapturing the sense of historic events and persons associated with the structure as well as understanding why it was constructed.

Design: Design is defined as the combination of elements that create the form, plan, space, structure, and style of a historic resource. It results from conscious decisions made during the original conception and planning of the design and includes such elements as organization of space, proportion, scale, technology, ornamentation, and materials.

Setting: Setting is defined as the physical environment of a historic property. It refers to the character of the place in which the structure was built, and involves the relationship to surrounding features and open space.

Materials: Materials are defined as the physical elements that were combined during a particular period of time and the particular patterns used to configure a historic structure. The choice and combination of materials reveals the preference of those who created the structure and indicates the availability of particular types of materials and technologies.

Workmanship: Workmanship is defined as the physical evidence of the crafts of a particular culture or people during any given period in history or prehistory. It is the evidence of labor and skill in constructing a structure and can apply to the structure as a whole or to its individual components.

Feeling: Feeling is defined as a structure's expression of the aesthetic or historic sense of a particular period of time. It results from the presence of physical features that, taken together, convey the structure's historic character.

Association: Association is defined as the link between an important historic event or person and a historic structure. A structure retains association if it is in the place where the event or activity occurred and is sufficiently intact to convey that relationship to an observer. Like feeling, association requires the presence of physical features that convey a structure's historic character.

Reuse of Historic Bridge Components

The controversial decision to construct a new bridge at Waldport required extensive discussion and evaluation of how best to design a new bridge that was sensitive to the cultural importance of the old bridge. While retaining the old bridge as a pedestrian and bicycle bridge alongside the new one was taken into consideration, the decision to remove it was a result of the high cost of maintaining the old bridge, the inability to insure the safety of those using it, and aesthetic concerns. It was determined that even with initial substantial maintenance of the old bridge, corrosion of the structure would continue, requiring frequent maintenance at a high expense. Furthermore, the structure would eventually be unable to support the snooper crane used to suspend inspection crews below the structure, and ongoing deterioration and spalling of the concrete would expose those using the bridge, as well as the area around the bridge, to hazardous conditions.[9] It was further decided that retention of the old bridge next to a new bridge would compromise the natural setting by obscuring views of the bay, as well as limit designs of the new bridge to those which mirror the old bridge.[10]

Because of these determinations, the need for a new bridge was imminent, requiring that negative impacts to the historic bridge be mitigated through the Section 106 process. As part of the National Historic Preservation Act of 1966, the Section 106 process requires federal agencies that identify the need for alteration of a historic structure to "take into account the effects of their actions on historic properties, and afford the Advisory Council on Historic Preservation a reasonable opportunity to comment on their actions."[11] This process further ensures a forum for public feedback and the discussion of alternatives ultimately leads to a memorandum of agreement between, in this case, the Federal Highway Administration, and the Advisory Council on Historic Preservation and Oregon State Historic Preservation Office.

The memorandum of agreement for the Alsea Bay Bridge replacement project included two major stipulations that allowed the project to move forward. This first required the Federal Highway Administration to request documentation of the bridge through photographs and measured drawings by the Historic American Engineering Record prior to demolition.[12] The second stipulation required selection and salvage of architectural elements from the old bridge by the State Historic Preservation Office for use in interpretive and memorial displays in the vicinity of the new bridge, as well as in an information and visitors center in Waldport.[13]

Several designs for the new bridge were reviewed including a variety of cable-stayed spans, a deck arch span, a girder span, and different types of steel through tied-arch spans. The design selected is a steel through-tied arch which echoes the form of the previous bridge and others designed throughout McCullough's career. Construction of the new bridge began in 1988 and was completed by 1991 (figure 35).

Figure 35: New Alsea Bay Bridge at Waldport, 1991
Source: Author

In accordance with Section 106 stipulations, two of the original entrance pylons were incorporated into the north wayside of the new bridge along with the spires which originally marked each end of the three consecutive arch spans (figure 36). Pylons from the south end of the bridge were reused by integrating them into the south entrance of the new bridge and the pedestrian plazas and entrance towers were retained on either side of both ends of the bridge (figure 37). An Interpretive Center constructed on the west side of the south approach contains interactive exhibits, several photographs and drawings of historic bridges, a large display containing information about McCullough's career as state bridge engineer, a model of the old Alsea Bay Bridge, as well as other exhibits illustrating Oregon's transportation history (figure 38). A tile mural of the original Alsea Bay Bridge stretches across the back wall of the Interpretive Center.

Figure 36: North wayside of the new Alsea Bay Bridge at Waldport, 1991, illustrating reuse of entrance pylons and spires
Source: Author

Figure 37: Reuse of entrance pylons, towers, and staircase at new Alsea Bay Bridge at Waldport, 1991
Source: Author

Figure 38: Alsea Bay Bridge Interpretive Center on west side of the south entrance to the new Alsea Bay Bridge at Waldport, 1991
Source: Author

Preserving McCullough's legacy at this particular site is difficult because the bridge is completely gone. Although the location and setting are the same and the materials used in construction of the new bridge are similar to those in the old structure, the design, workmanship, feeling and association with respect to integrity are lost in the new design. However, retaining the entrance spires, pylons, and towers was an important step. As discussed in the previous chapter, McCullough employed these types of architectural features to create bridges as destinations. Given that these architectural features were reused in locations similar to their original placement, their integration into the new design echoes that part of McCullough's design philosophy.

Feeling and association are partially retained at the new bridge because pedestrians can still access it in the same way they would have in the 1930s. The elegant staircases at each end of the bridge are intact and lead to the pedestrian walkways. In addition, one can still take shelter in the large towers or stop there to absorb the breath taking views of the bay. In addition, the Interpretive Center provides an excellent informational resource for those who are curious about what happened to the old bridge and why some of the old portions were retained. Exhibits there provide an explanation of what went on, how solutions were resolved, and why decisions were made. The wonderful model of the bridge also provides a more in depth view of the form of the old bridge, and because it is viewed in three dimensions rather than two, visitors are offered a better sense of the scale of the bridge relative to its surroundings.

The reuse of old bridge parts was also discovered where the Eagle Creek Bridge was originally located on Interstate 84 in Multnomah County. Concrete piers from the original bridge McCullough designed were retained for use on a new bridge after the original structure was dismantled in 1969 (figure 39). Unfortunately none of the aspects of integrity are retained here. The intricacy of the old piers contrasts heavily with the modern concrete and steel deck girder bridge it supports. Furthermore, although the interstate exit for the Eagle Creek Overlook directs visitors underneath this bridge affording them a close-up view of McCullough's piers, there is no indication of their significance through the use of interpretive text panels or plaques.

Figure 39: Reused piers from the original Eagle Creek Bridge constructed in 1936
Source: Author

Although these particular bridge elements may not be the most significant of his body of work, they still deserve acknowledgement through a simple interpretive device such as a sign. One of the reasons the reuse of bridge parts works well at the Alsea Bay Bridge is the fact that there is some explanation for why these obviously historic architectural elements are juxtaposed with an overtly modern-looking structure. While it is realized that interpretive centers cannot be constructed everywhere that historic structures exist, a simple text panel could provide some insight for curious visitors, as well as a reference for obtaining further information.

A third example of adaptive reuse is found at the Crooked River (High) Bridge in Jefferson County near Terrebonne (figure 40). This steel deck arch bridge was designed by McCullough in 1926, however in the 1990s ODOT made the decision to replace the narrow, 26-foot wide, two-lane structure with a more efficient 79-foot wide, four-lane, reinforced-concrete deck arch structure to better handle the ever increasing size of vehicular traffic on US 97 (figure 41).[14] Although construction on the new bridge began in 1997 and was completed in 2000, the old bridge remains completely intact to the west of the new bridge in the Peter Skene Ogden State Scenic Viewpoint.[15]

Figure 40: Crooked River (High) Bridge, 1926
Source: Author

Figure 41: New US 97 bridge over the Crooked River Gorge, 2000
Source: Author

The old bridge is now open only to pedestrian and bicycle traffic and serves as an observation deck for enjoying views of the 300-foot deep Crooked River gorge. The bridge also offers excellent views of the new highway bridge to the east and an older steel arch bridge built for the Oregon Trunk Railroad and designed by Ralph Modjeski in 1911 (figure 42). In retaining the entire bridge as a pedestrian and bicycle crossing, all aspects of historic integrity are retained. Although feeling is slightly affected by the rush of traffic on the new bridge to the east, the juxtaposition of all three bridges in one location provides an intriguing time line of technological developments that have shaped bridge building. Furthermore, interpretive text panels are used to describe the events which led to construction of the three bridges (figure 43).

Figure 42: Oregon Trunk Railroad Bridge designed by Ralph Modjeski, 1911
Source: Author

Figure 43: Interpretive text panel at the Peter Skene Ogden Scenic Viewpoint
Source: Author

Cathodic Protection

The next strategy to be examined is a treatment called cathodic protection, which is implemented to prevent corrosion of the steel in reinforced-concrete structures and ultimately increase their lifespan. Structures in coastal environments are particularly vulnerable to accelerated deterioration due to chlorides in the air and sea spray which penetrate the concrete.[16] When chlorides from the environment and oxides from the reinforcing steel combine they create rust which expands and creates internal pressure in the concrete causing it to crack, spall, and delaminate.[17] This not only weakens the structure but allows for more rapid penetration of chlorides to the reinforcing steel. In a cathodic protection system, all of the damaged concrete and reinforcing steel must first be removed and replaced and then a coat of zinc is applied to the structure. Cathodic protection works by placing a more chemically active metal, zinc, at the surface of the concrete and then applying low voltages to it and the reinforcing steel within the structure.[18] The voltage causes the reinforcing steel to act as the cathode releasing a negative ion, and the zinc to act as the anode releasing a positive one. The negative ion, which normally causes the reinforcing steel to rust, is instead attracted to the zinc causing it to corrode rather than the reinforcing steel. Although this is not a permanent fix, as the zinc is eventually used up and requires another coating, ODOT officials can closely monitor this system through computer modems attached to the structures. The other advantage lies in the fact that zinc can be sprayed on the structure, which provides ease in application to the intricate details of McCullough's bridges.[19]

When it was discovered that the Cape Creek Bridge on US 101 was in need of repair, preventing entire loss of this unique structure was a major priority. The Cape Creek Bridge was the first in Oregon where this method of treatment was used on the entire structure. Cathodic protection is a strategy that has fairly low impact on the integrity of the resource. It does not affect the location or setting of the bridge; however it does have minimal impact on the design, workmanship, feeling, and association of the structure. Most notable is that this treatment results in a change in coloration and texture of the structure's fabric. This change is not as apparent if the treatment is applied to the entire structure, however on bridges where it is only used on the substructure, there is an obvious difference in coloration and texture between the zinc coated section and the untreated concrete (figure 44).

Figure 44: Detail of Big Creek Bridge on US 101, 1931, illustrating difference in coloration and texture of bridge fabric where cathodic protection was applied
Source: Author

In the larger scheme of things this is not a major issue because the bridge itself has been retained with all of its character defining features in tact, a far superior alternative to bridge replacement. The result is a more modern look due to the grayish tint that is reminiscent of unpainted steel. This treatment has been applied to eleven of McCullough's coastal bridges since its first implementation on the Cape Creek Bridge in 1993.

Alteration to Accommodate Modern Traffic Needs and Safety Standards

Over the years, several of McCullough's bridges have required alteration to accommodate modern traffic needs and safety standards, rather than deterioration. This has resulted in the widening of several of his bridges which has required ODOT to either replicate the existing substructure of the bridge or utilize another type of span to support additional traffic lanes. While decorative features on the roadway deck can either be moved or replicated with precast concrete, the substructures can pose problems due to funding or limitations caused by the surrounding terrain.

The bridge at Depoe Bay was widened only thirteen years after its construction in 1927.[20] This project set precedence for historically compatible widening projects as the deck arch of the new portion on the seaward side mirrors that of the older portion almost exactly (figure 45). This allows the two portions of the structure to conceal one another when viewed from the side on either elevation. Furthermore it eliminates competition between the original fabric and that of the new construction.

Figure 45: Historically compatible 1940 deck widening at Depoe Bay Bridge on US 101, 1927
Source: Author

This was unfortunately not the case with the Sucker (Oswego) Creek Bridge which was originally constructed in 1920 and widened in 1983 to provide additional traffic lanes and safer conditions.[21] The new portion, which was constructed on the downstream side of the original structure, is a concrete deck girder span. The angular lines of the new bridge contrast sharply with the graceful arch of the historic bridge and the new piers conceal part of the historic deck arch making it appear much heavier than it did prior to alteration (figure 46). Although the substructure is not visible from the approach as site lines are concealed by trees, a path leading below the bridge affords a clear view of the alteration. It changes the design, feeling, and association of the bridge because of the stark contrast of the historic structure with that of the modern structure.

Moreover the addition changes the aesthetic quality of the bridge because the new structure not only detracts from the old, but conceals the design of the original deck arch.

Figure 46: Historically incompatible deck widening from 1983 at Sucker Creek (Oswego) Bridge in Lake Oswego, 1920
Source: Author

Incompatible alteration was also discovered in the balustrades of several of McCullough's bridges. Modern safety standards require that railings be able to withstand specific crash ratings and meet minimum requirements for height and size of openings. The Oregon Department of Transportation has developed innovative solutions over the years that meet these requirements and at the same time respect the historic character of McCullough's bridges. Figure 47 illustrates a stealth railing currently being installed at the Coos Bay (McCullough Memorial) Bridge at North Bend. A stealth railing is one designed with much more reinforcing steel than the original railing, and can be bolted to the bridge deck at multiple points so that it can withstand the impact of a vehicle if necessary. The style of the old railing was replicated, however it was made taller and the openings were made narrower. The installation of a stealth railing is a much better alternative than the installation of a steel guard rail (figure 48) which conceals the historic fabric of the bridge, and in reality will do little to protect it if the steel guard rail is hit.

Figure 47: Stealth rail at Coos Bay (McCullough Memorial) Bridge
Source: Author

Figure 48: Historically incompatible guard rail at Cape Creek Bridge
Source: Author

Figures 49 and 50 demonstrate two other strategies ODOT has used to meet requirements for minimum opening sizes in balustrades. Figure 49 illustrates application of stainless steel rope on the exterior of the balustrade, and figure 50 illustrates the integration of stainless steel hoops which echo the form of the arched openings. Both solutions are ideal in that they retain the original fabric of the balustrades, but can also be removed if necessary without causing damage.

Figure 49: Stainless steel rope applied to balustrade at the Rogue River (Isaac Lee Patterson) Bridge
Source: Author

Figure 50: Stainless steel hoops installed in arched openings of balustrade at the North Umpqua River (Robert A. Booth) Bridge
Source: Author

Recommendations and Conclusions

The maintenance of historic bridges poses difficult challenges because of cost, issues of safety, and logistical problems relative to traffic. In these cases it often makes more sense to apply rehabilitative treatments than preservative treatments because they solve the problem, rather than work with it through expensive and time consuming periodic maintenance that may or may not work. Furthermore, the catastrophic collapse of the Interstate 35 bridge in Minneapolis, Minnesota, on August 1, 2007 reiterates the importance of addressing safety issues to prevent the tragedy that occurs when bridges fail. Due to these reasons there is always the risk of historically incompatible alteration that lowers the integrity of historic bridges. Several of McCullough's spans have succumbed to that fate over the years so it is wise to periodically review what has worked well and determine what could be done differently. It seems that only in rare cases it is economically feasible for a bridge to be retained as originally designed and reused as a pedestrian bridge along side a replacement bridge, as was the case with the Crooked River (High) Bridge, so it is advisable that every effort be made to try and preserve McCullough's overall legacy so that even when his bridges are changed over time, the approach he applied to bridge design is not misinterpreted or forgotten. The following recommendations were formulated to assist in this effort.

1. Greater Promotion of the Scope of McCullough's Work

It is first suggested that greater effort be made to promote broader understanding of the scope of McCullough's work. Most are aware of the five major bridges he designed along the coast in the mid 1930s, but few are aware that he was responsible for the design of hundreds of bridges both large and small throughout Oregon, several of which are still intact and which collectively provide one of the richest collections of 1920s and 1930s reinforced-concrete bridges in the nation. This situation could be remedied through the expansion of previously constructed websites to include maps that identify the locations of McCullough's bridges and have links to current photographs. Another solution is to work with local tourism offices and visitor information agencies in specific cities which have McCullough bridges located in or around them. This could potentially spark interest in these bridges as destinations for heritage tourism, as well as promote local pride in these resources. Greater community awareness of these bridges may also lead to increased public feedback when these resources are in need of maintenance, and could also have the potential to help reduce vandalism.

2. Greater Accessibility to Information on McCullough's Work

One of the problems encountered in the effort to survey these bridges was the lack of information available on them. While it was again quite easy to obtain information on McCullough's larger spans through various websites and investigation of Historic American Engineering Record documentation and National Register Listings, it was quite difficult to locate basic information on some of his smaller spans that are located in rural areas. The Oregon Department of Transportation bridge log proved useful in tracking down the locations of many of the bridges surveyed, however the document is not easily navigated or understood by first time users, and therefore should not be the primary resource for those trying to locate some of the more obscure McCullough Bridges. During the survey of these bridges their locations were scrupulously tracked and recorded by mile marker as well as with GPS coordinates so that this information will be available to those who are interested in visiting some of the lesser-known bridges he designed. It would also be possible to link bridge location information to a website map as discussed in the previous recommendation. Future documentation by the Historic American Engineering Record is also suggested for those bridges that have not already been recorded.

3. Increased Use of Interpretive Devices at Bridge Sites

Another useful tool for preserving McCullough's legacy is the inclusion of interpretive devices such as text panels or plaques at bridge sites. Although this was discussed previously, it should be reiterated that a brief sign which discusses aspects of McCullough's work or alterations that have been made to a particular bridge can spark further interest in those who read them. While it is understood that many of McCullough's bridges along the coast have these types of interpretive devices installed near them, it is felt that installation of panels or plaques near some of the lesser-known bridges would assist in bolstering public interest in them.

4. Greater Accessibility at Bridge Sites

Finally, it was also discovered during the survey that several of these bridges did not allow for easily accessible investigation. For example, several of the bridges on US 101 do not offer a convenient place to pull over and view the bridge up close. Although this may not be a desire for everyone, these bridges have pedestrian walkways that are going unused because heavy traffic prevents safe access to them. While it is understood that it is not economically feasible to install parking lots near every one of his bridges, it is suggested that in the future, if a bridge maintenance project permits, scenic overlooks be created at bridge sites in conjunction with maintenance projects so that more people will be encouraged to stop and enjoy McCullough's work. The author observed while making this survey that turnouts at the Cummins Creek and Rocky Creek Bridges along US 101 appeared to be quite popular as destinations for sightseers.

In sum, greater access to information about McCullough's work, as well as greater accessibility to it, will provide broader understanding of its significance and has the potential to increase interest in retaining it through rehabilitative efforts. When alteration of his bridges are necessary to maintain them as part of Oregon's transportation network, they should still be able to reflect their significant role in Oregon's transportation history, recreation history, and how in five instances, their construction was part of a revolutionary plan to help stimulate the failing economy in the 1930s. Furthermore, McCullough's work should be used to tell the often overlooked evolution of reinforced-concrete in structural design. Experience has been such that courses in the history of building technology and architecture often jump from the demise of cast-iron to the rise of steel, often implying that the former was partially the result of the latter. While this is not a false statement, it omits discussion of the fascinating experimentation and development that took place in both the scientific and academic worlds, as well as the design world that contributed to reinforced-concrete's extensive history.

It is probable that future advancements in transportation, development of cities and towns, and growing populations will continue to affect McCullough's Oregon bridges, and that alteration or loss will always pose a risk. As preservationists it is our job to ensure that McCullough's work is understood so that his legacy is not lost even when his bridges are. His designs were driven by economy to reduce the strain of publically funded construction projects, and by aesthetics to enhance the experience of those who use his bridges. Furthermore, McCullough's numerous life achievements demonstrate his commitment to furthering his knowledge so that he was better able to incorporate these ideals into his designs. In my opinion, that is the essence of McCullough's work. If at some point in the future a bridge cannot be retained, those are the ideals that should be preserved.

Notes

[1] Robert W. Hadlow, *Elegant Arches Soaring Spans: C. B. McCullough, Oregon's Master Bridge Builder* (Corvallis: Oregon State University Press, 2001), 130.

[2] Ibid., 132.

[3] National Park Service, "National Register of Historic Places," National Park Service, http://www.nps.gov/history/nR/ (accessed Spring 2009).

[4] American Society of Civil Engineers, "History and Heritage: Designated Historic Civil Engineering Landmarks," American Society of Civil Engineers, http://www.asce.org/history/landmark/search.cfm (accessed Spring 2009).

[5] National Park Service, "National Register of Historic Places," National Park Service, http://www.nps.gov/history/nR/ (accessed Spring 2009).

[6] United States Department of the Interior, *National Register Bulletin: How to Apply the National Register Criteria for Evaluation* (Washington D. C.: Department of the Interior, 1997), 44.

[7] Ibid.

[8] Ibid., 44-45.

[9] Oregon Department of Transportation, *Alesa Bay Bridge: Final Environmental Impact Statement* (Washingon D. C.: Federal Highway Administration, 1986), 6f.

[10] Ibid.

[11] Thomas F. King, *Cultural Resource Laws and Practice: An Introductory Guide* (Lanham: AltaMira Press, 2004), 81.

[12] Oregon Department of Transportation, Appendix D: Memorandum of Agreement.

[13] Ibid.

[14] Gordon Gregory, "Building the Crooked River Highway," *The Oregonian*, September 17, 2000.

[15] Ibid.

[16] H. M. Laylor, *Demonstration Project: Soffit Cathodic Protection System in a Coastal Environment,* (Salem: Oregon Department of Transportation, 1987), 1.

[17] Ibid.

[18] Hadlow, 133.

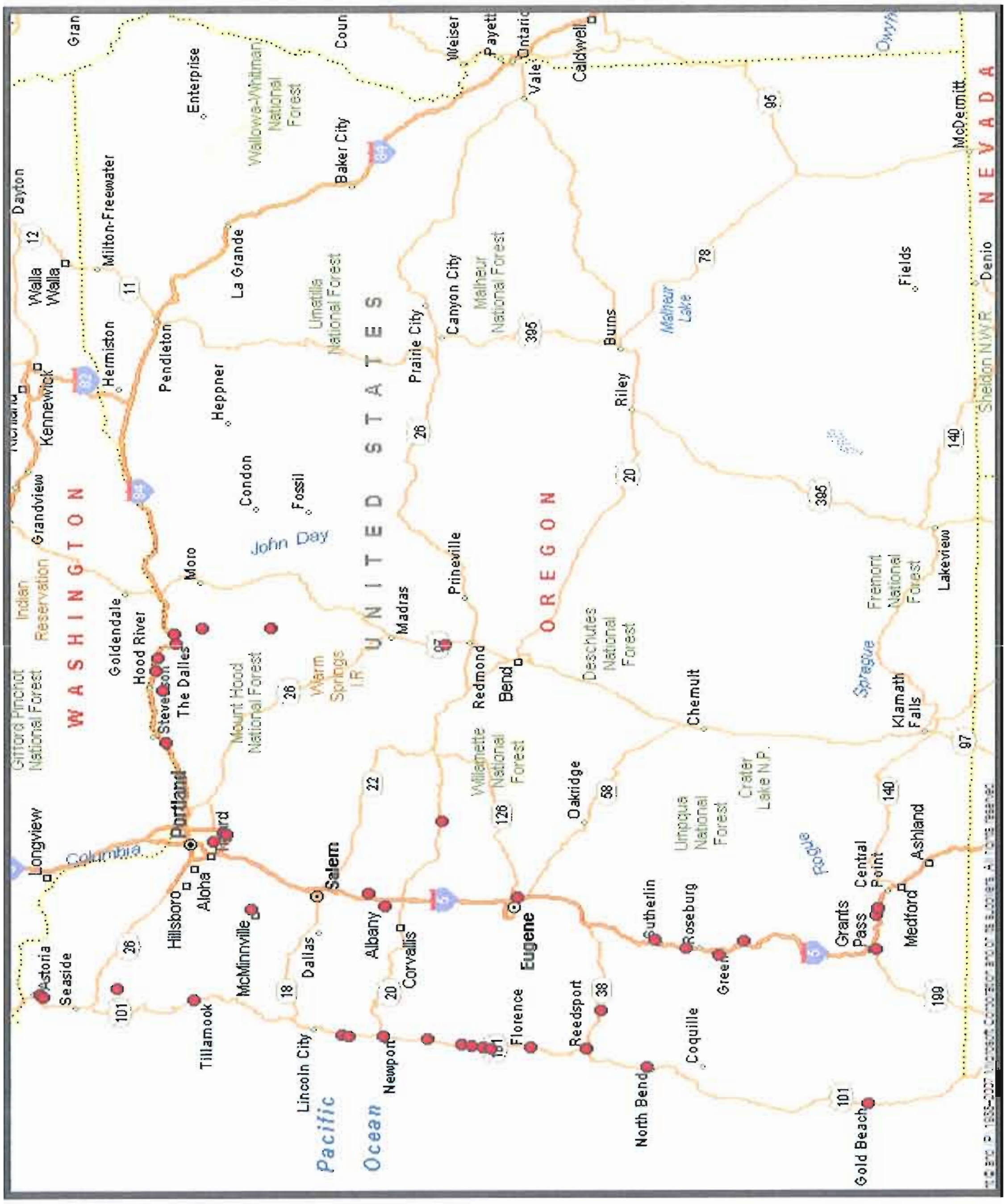
[19] Ibid.

[20] Dwight A. Smith, James B. Norman, and Pieter T. Dykman, *Historic Highway Bridges of Oregon* (Salem: Oregon Department of Transportation, 1986), 101.

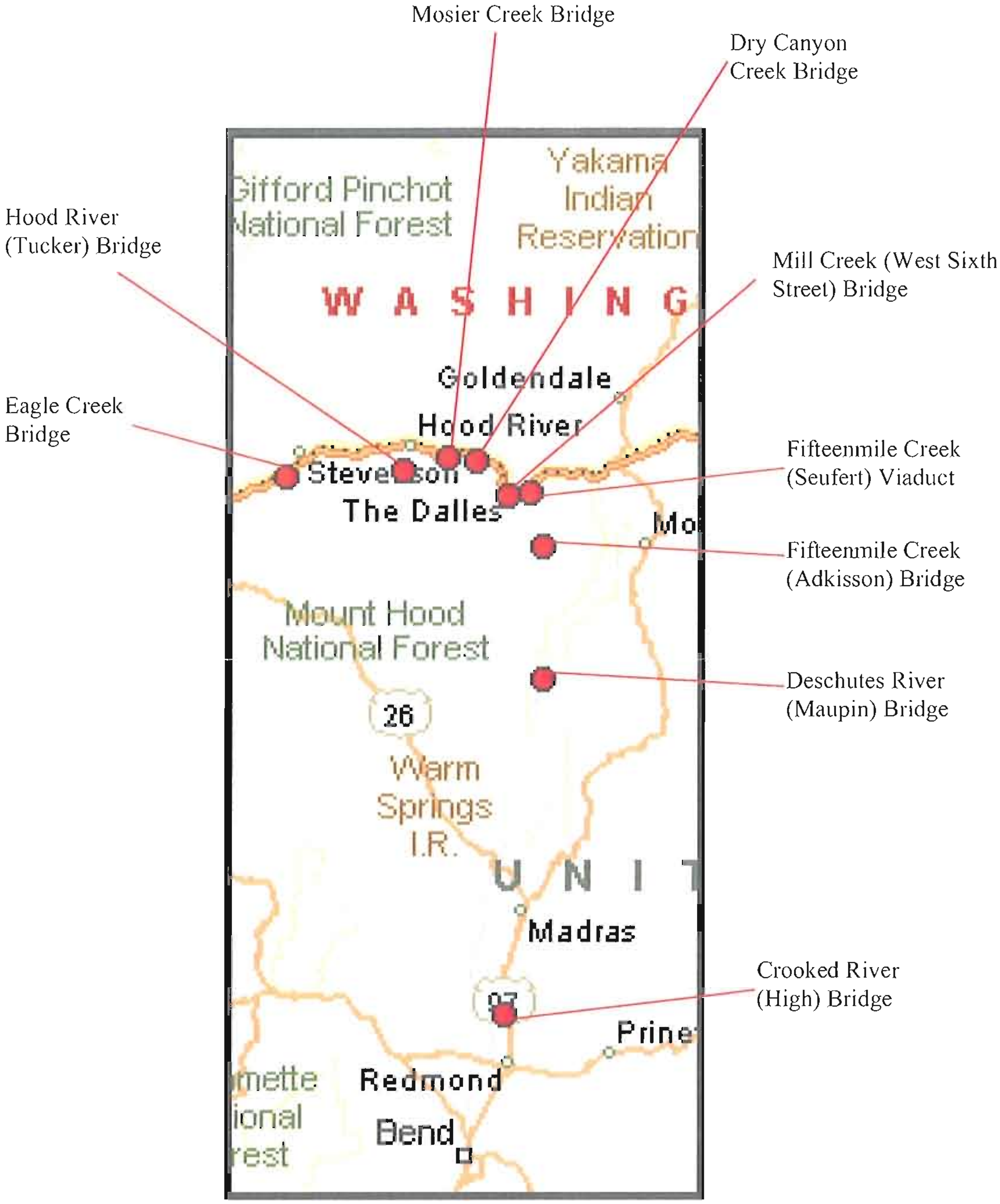
[21] Ibid., 210.

APPENDIX A

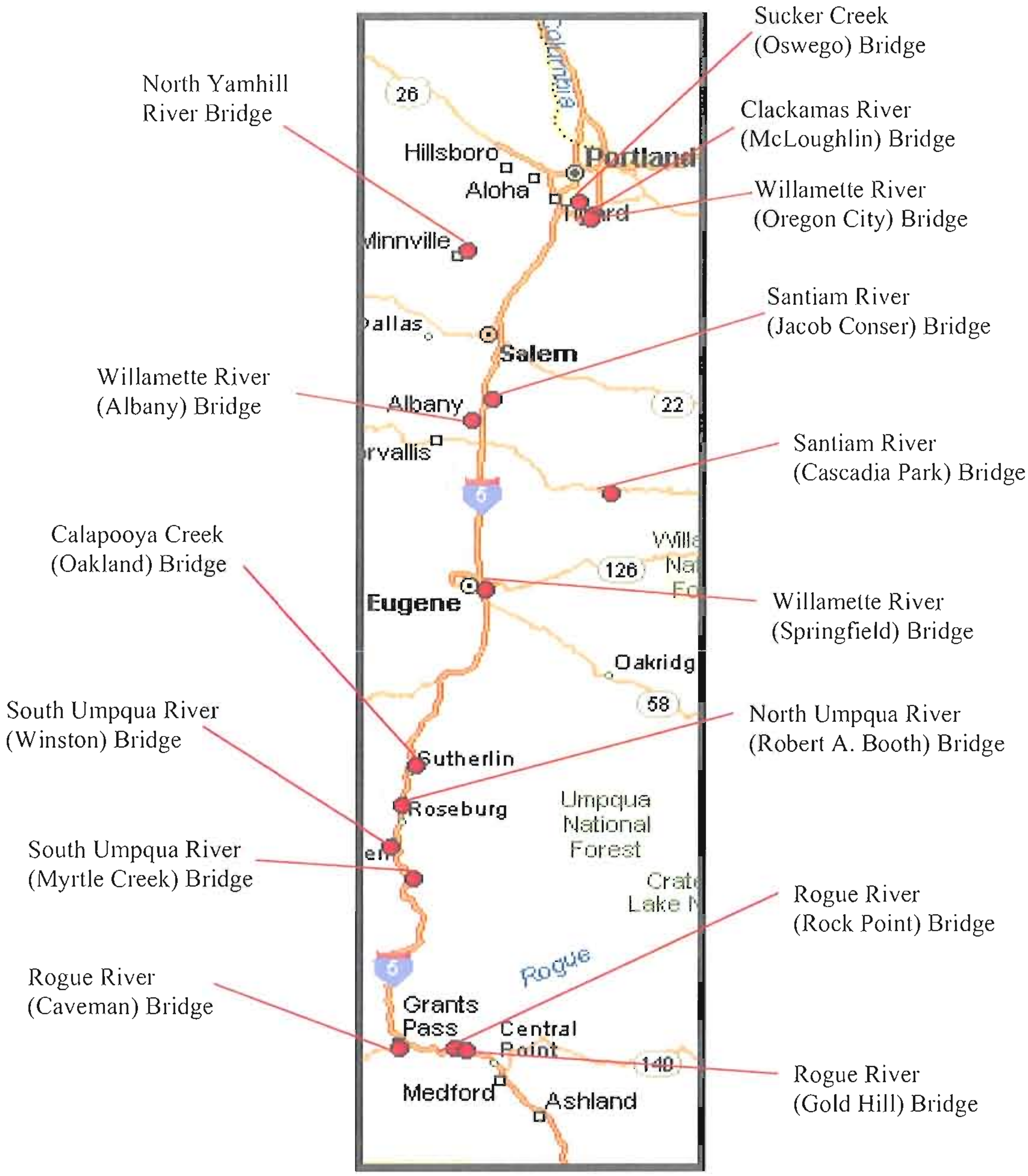
DISTRIBUTION MAPS OF McCULLOUGH BRIDGES SURVEYED



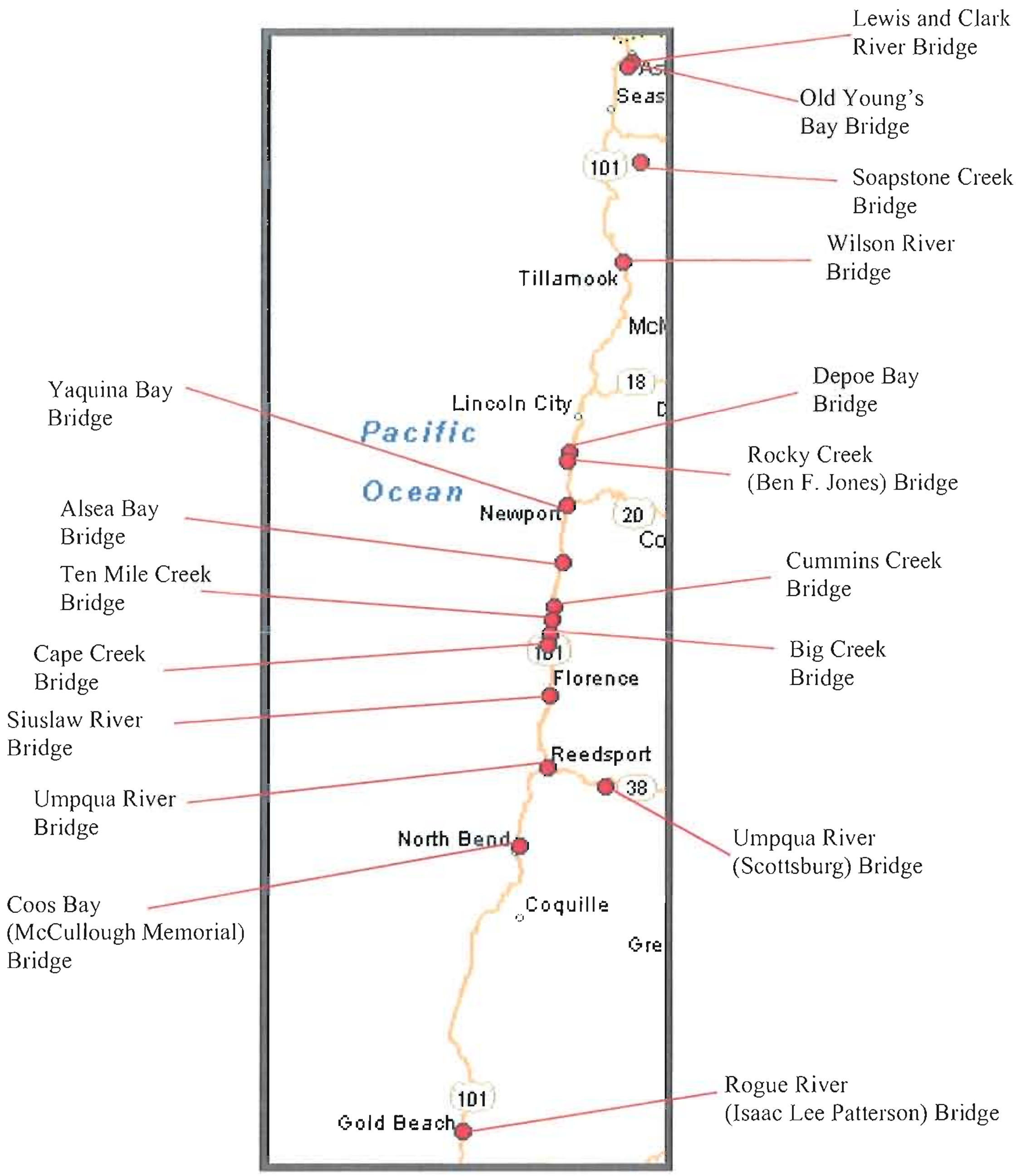
Distribution map of McCullough bridges surveyed in Oregon with locations indicated in red
Source: Map generated using Streets and Trips Software with bridge locations augmented the author



Detail of distribution map of McCullough bridges surveyed in central and north central Oregon
Source: Map generated using Streets and Trips Software with bridge locations augmented by the author



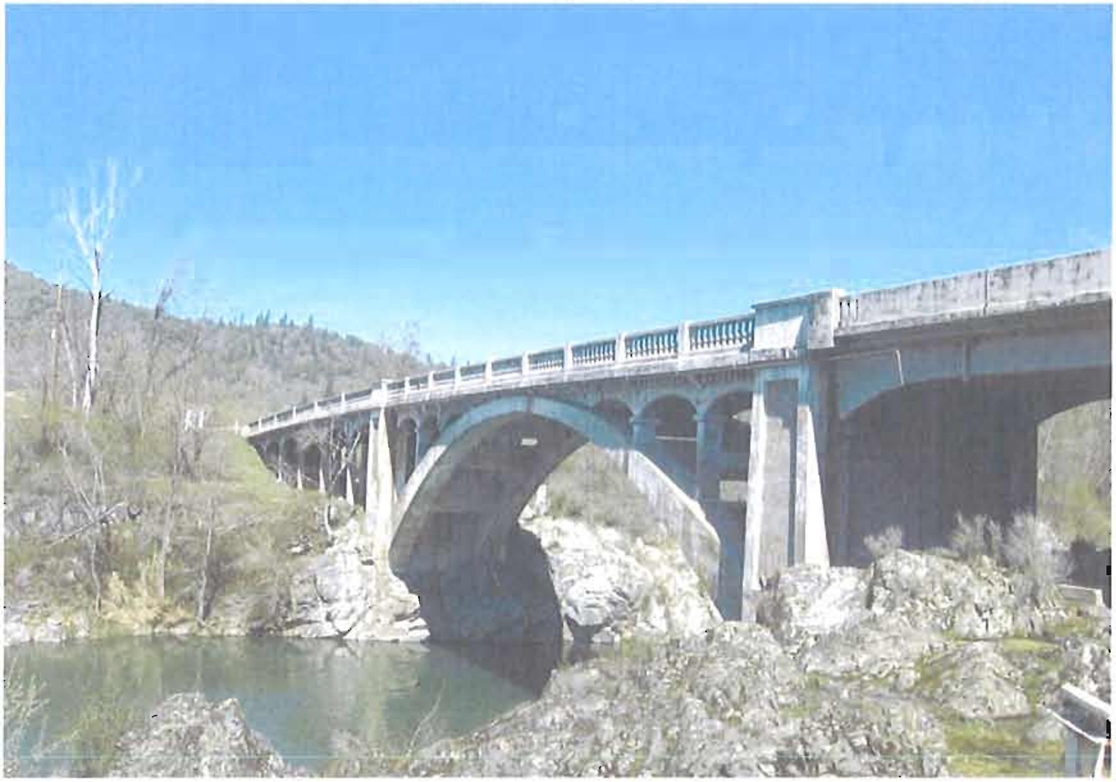
Detail of distribution map of McCullough bridges surveyed in western Oregon
Source: Map generated using Streets and Trips Software with bridge locations augmented by the author



Detail of distribution map of McCullough bridges surveyed along the Oregon coast
Source: Map generated using Streets and Trips Software with bridge locations augmented by the author

APPENDIX B

DATA PAGES FOR BRIDGES SURVEYED



Bridge Name Rogue River (Rock Point) Bridge

Date of Completion	**National Register Listing**	**ODOT Number**
1920	No	00332A

Location Description

Near Gold Hill, Oregon. Take exit #43 off of Interstate 5 and follow Oregon 99 east for approximately 0.5 miles.

GPS Coordinates

N 42.43193°
W 123.09037°

Bridge Type

One 113-foot reinforced-concrete deck arch

Major alterations

Modern deck railings installed on north approach. Rehabilitation scheduled for Fall 2009.

Bridge Name		
Sucker Creek (Oswego Creek) Bridge		
Date of Completion	**National Register Listing**	**ODOT Number**
1920	No	00409

Location Description
Lake Oswego, Oregon. Oregon 43 at mile post 6.76.

GPS Coordinates
N 45.41071°
W 122.66428°

Bridge Type
One 130-foot reinforced-concrete deck arch

Major Alterations
Bridge was widened on downstream side in 1983

Bridge Name
Mosier Creek Bridge

Date of Completion	**National Register Listing**	**ODOT Number**
1920	Yes	00498

Location Description
Mosier, Oregon. Take exit #69 off of Interstate 84 and follow US 30 east for 2.7 miles. Bridge is located at mile post 57.84.

GPS Coordinates
N 45.68457°
W 121.39494°

Bridge Type
One 110-foot reinforced-concrete deck arch

Major Alterations
None

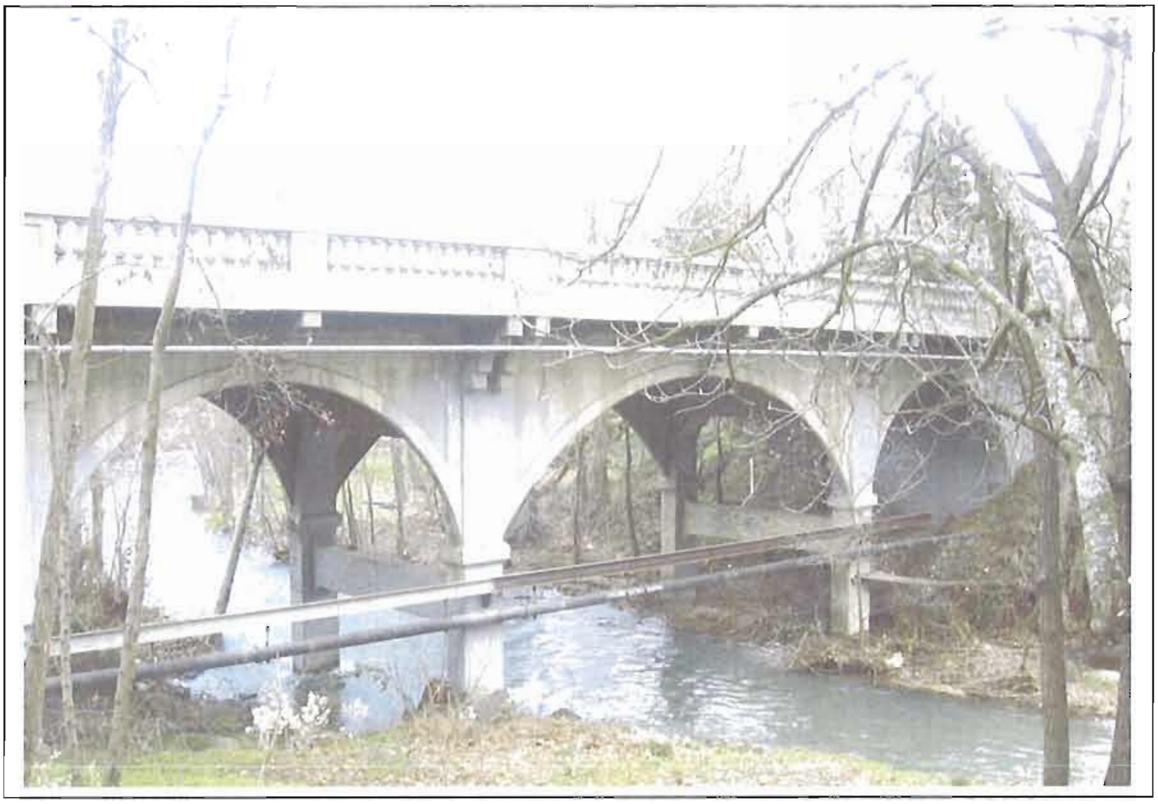
Bridge Name		
Fifteenmile Creek (Seufert) Viaduct		
Date of Completion	**National Register Listing**	**ODOT Number**
1920	No	00308

Location Description
The Dalles, Oregon. Take exit #87 of off Interstate 84. Turn right at US 197/US 30, then turn right at East 2nd Street, then turn right at Columbia View Drive, and then take a slight left at Viewpoint road and drive approximately 1 mile.

GPS Coordinates
N 45.61132°
W 121.12247°

Bridge Type
One 22-foot reinforced-concrete deck girder span and five 40-foot spans

Major Alterations
None



Bridge Name Mill Creek (West Sixth Street) Bridge		
Date of Completion 1920	**National Register Listing** No	**ODOT Number** 00464
Location Description The Dalles, Oregon. US 30 (West Sixth Street) at mile post 84.49 **GPS Coordinates** N 45.60339° W 121.19418°		
Bridge Type One 124-foot reinforced-concrete deck girder span **Major Alterations** Rehabilitation completed in 2001		

Bridge Name
Dry Canyon Creek Bridge

Date of Completion	**National Register Listing**	**ODOT Number**
1921	Yes	00524

Location Description
Wasco County, Oregon. Take exit #69 off of Interstate 84. Follow US 30 for approximately 8.9 miles, bridge is located at mile post 63.79.

GPS Coordinates
N 45.68181°
W 121.30289°

Bridge Type
One 75-foot reinforced-concrete deck arch

Major Alterations
None

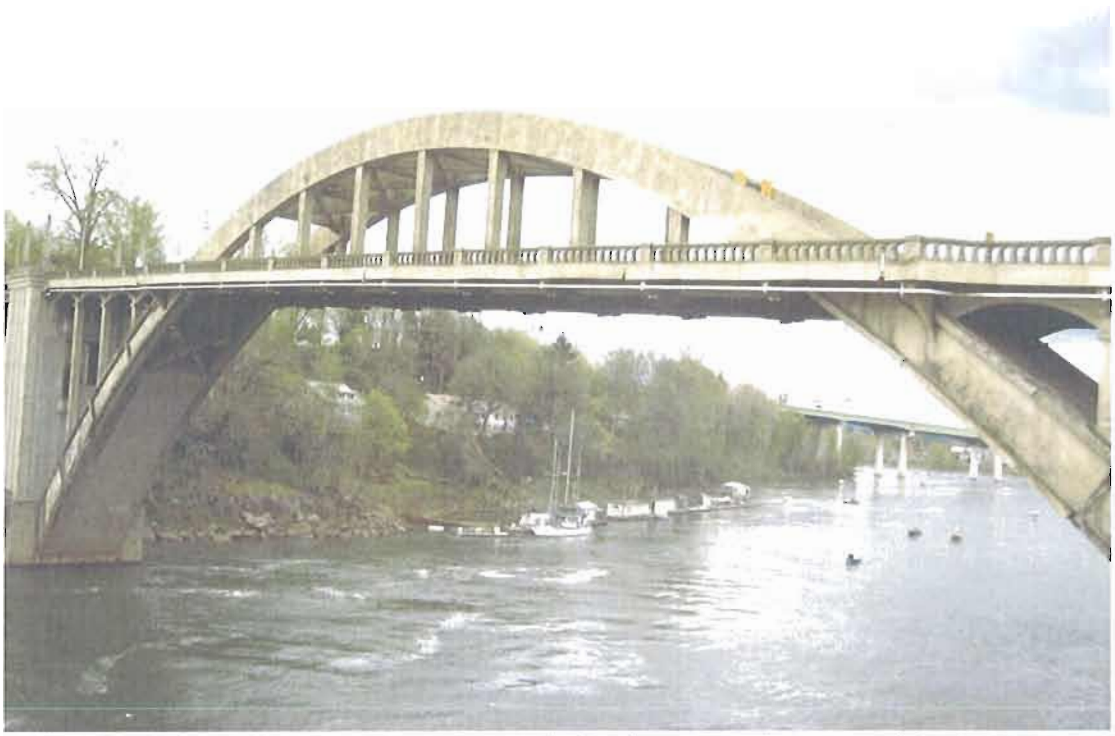
Bridge Name		
North Yamhill River Bridge		
Date of Completion 1921	**National Register Listing** No	**ODOT Number** 00441
Location Description McMinnville, Oregon. Located at mile post 34.96 on Oregon 99W, southbound only **GPS Coordinates** N 45.23221° W 123.16033°		
Bridge Type One 80-foot steel Warren deck truss and seven 40-foot reinforced-concrete deck girder spans **Major Alterations** None		

Bridge Name Old Young's Bay Bridge

Date of Completion 1921	**National Register Listing** No	**ODOT Number** 00330

Location Description Astoria, Oregon. US 101 Business Loop at mile post 6.89 **GPS Coordinates** N 46.17081° W 123.83817°
Bridge Type Two 75-foot steel central bascule spans, fifty-eight pile trestle secondary spans, and ten timber stringer spans **Major Alterations** None

Bridge Name		
South Umpqua River (Myrtle Creek) Bridge		
Date of Completion 1922	**National Register Listing** No	**ODOT Number** 00490A
Location Description Myrtle Creek, Oregon. Take exit #108 off of Interstate 5, bridge is adjacent to interstate **GPS Coordinates** N 43.02507° W 123.29618		
Bridge Type Three 130-foot reinforced-concrete deck arches **Major Alterations** Twin structure built adjacent to the original bridge in 2007 to widen the roadway deck		



Bridge Name Willamette River (Oregon City) Bridge

Date of Completion 1922	**National Register Listing** Yes	**ODOT Number** 00357

Location Description Oregon City, Oregon. Oregon 99 at mile post 11.43 **GPS Coordinates** N 45.35841° W 122.60889°
Bridge Type One 360-foot steel half-through arch **Major Alterations** Rehabilitation in progress

Bridge Name
Lewis and Clark River Bridge

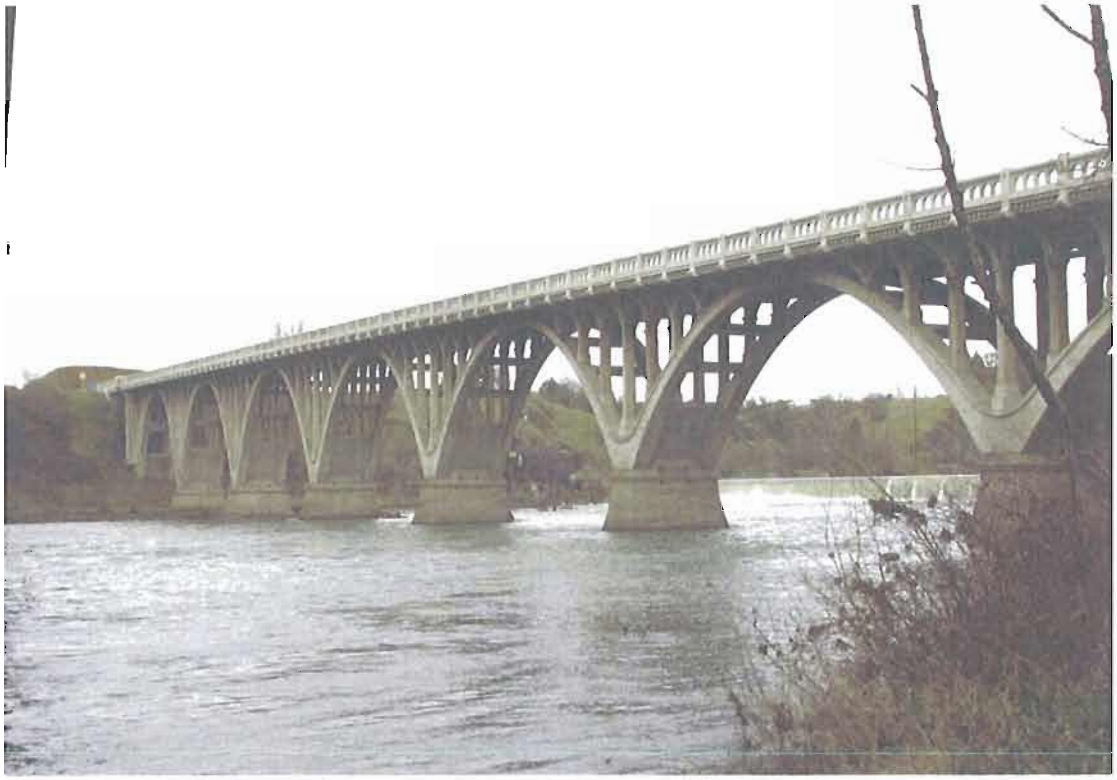
Date of Completion	**National Register Listing**	**ODOT Number**
1924	No	00711

Location Description
Astoria, Oregon. US 101 Business Loop at mile post 4.78

GPS Coordinates
N 46.15273°
W 123.86174°

Bridge Type
One 112-foot steel central bascule span and forty-eight pile trestle and stringer spans

Major Alterations
None



Bridge Name		
North Umpqua River (Robert A. Booth) Bridge		
Date of Completion 1924	**National Register Listing** No	**ODOT Number** 00839
Location Description Winchester, Oregon. Take exit #129 off of Interstate 5, bridge is adjacent to the interstate **GPS Coordinates** N 43.28150° W 123.35540°		
Bridge Type Seven 112-foot reinforced-concrete deck arches **Major Alterations** Rehabilitation completed in 2007 and included deck widening to allow for pedestrian walkways		

Bridge Name
Fifteenmile Creek (Adkisson) Bridge

Date of Completion	**National Register Listing**	**ODOT Number**
1925	No	01095

Location Description
South of Boyd, Oregon. Bridge is located approximately 3.20 miles from the southern junction of Boyd Loop Road and US 197

GPS Coordinates
N 45.47960°
W 121.08143°

Bridge Type
One 120-foot reinforced-concrete deck arch

Major Alterations
None

Bridge Name		
Willamette River (Albany) Bridge		
Date of Completion	**National Register Listing**	**ODOT Number**
1925	No	01025

Location Description
Albany, Oregon. Take exit #233 off of Interstate 5, turn west and follow US 20 for approximately 2.60 miles. Bridge carries eastbound traffic only.

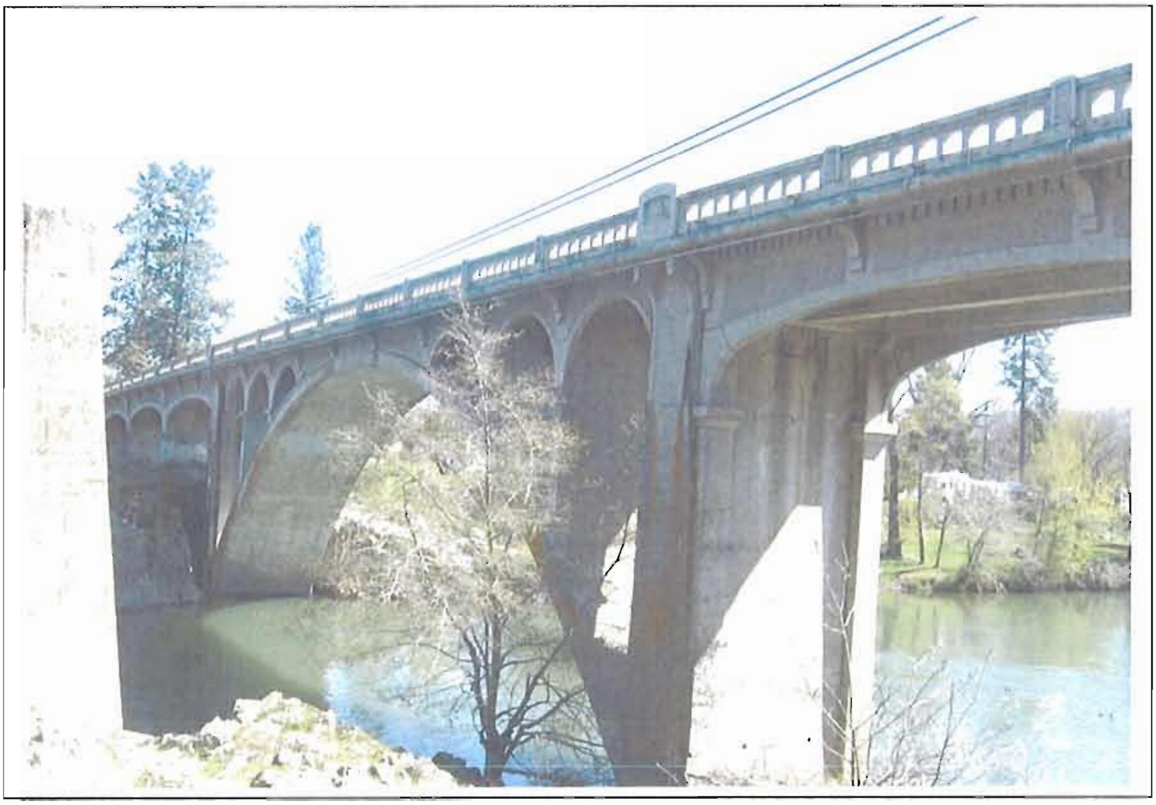
GPS Coordinates
N 44.64026°
W 123.10770°

Bridge Type
Four 200-foot steel Parker through trusses, 290 feet of reinforced-concrete deck girder approach spans

Major Alterations
None

Bridge Name		
Calapooya Creek (Oakland) Bridge		
Date of Completion 1925	**National Register Listing** No	**ODOT Number** 00603
Location Description Oakland, Oregon. Take exit #140 off of Interstate 5 and follow Oregon 99 for approximately 1.0 mile **GPS Coordinates** N 43.42536° W 123.30196°		
Bridge Type One 100-foot steel Warren deck truss, nine reinforced-concrete deck girder approach spans **Major Alterations** None		

Bridge Name Crooked River (High) Bridge		
Date of Completion 1926	**National Register Listing** No	**ODOT Number** 00600
Location Description Jefferson County, Oregon. US 97 at mile post 112.64. Bridge is accessible from the Peter Skene Ogden State Scenic Viewpoint on the west side of the highway **GPS Coordinates** N 44.39267° W 121.19391°		
Bridge Type One 330-foot steel deck arch **Major Alterations** Adapted as a pedestrian and bicycle bridge after completion of the new US 97 bridge in 2000.		



Bridge Name
Rogue River (Gold Hill) Bridge

Date of Completion	**National Register Listing**	**ODOT Number**
1927	No	00576

Location Description
Gold Hill, Oregon. Take exit #43 off of Interstate 5 and follow Oregon 99 east for approximately 3.0 miles

GPS Coordinates
N 42.43083°
W 123.04231°

Bridge Type
One 143-foot reinforced-concrete barrel arch

Major Alterations
None

Bridge Name
Depoe Bay Bridge

Date of Completion	**National Register Listing**	**ODOT Number**
1927	Yes	02459

Location Description
Depoe Bay, Oregon. US 101 at mile post 127.61

GPS Coordinates
N 44.81054°
W 124.06215°

Bridge Type
One 150-foot reinforced-concrete deck arch

Major Alterations
Second deck arch added to seaward side of the bridge in 1940. Cathodic protection system installed to treat corrosion.

Bridge Name		
Rocky Creek (Ben F. Jones) Bridge		
Date of Completion 1927	**National Register Listing** Yes	**ODOT Number** 01089
Location Description Lincoln County, Oregon. US 101 at mile post 130.0 **GPS Coordinates** N 44.77902° W 124.07169°		
Bridge Type One 160-foot reinforced-concrete deck arch **Major Alterations** Cathodic protection system installed to treat corrosion.		

Bridge Name Soapstone Creek Bridge

Date of Completion 1928	**National Register Listing** No	**ODOT Number** 01319

Location Description
Clatsop County, Oregon. Oregon 53 at mile post 6.5

GPS Coordinates
N 45.82653°
W 123.78056°

Bridge Type
One 108-foot reinforced-concrete deck arch

Major Alterations
None

Bridge Name
Santiam River (Cascadia Park) Bridge

Date of Completion	**National Register Listing**	**ODOT Number**
1928	No	01356

Location Description
Linn County, Oregon. US 20, 14.5 miles west of junction with Oregon 228 in Sweet Home

GPS Coordinates
N 44.39778°
W 122.48113°

Bridge Type
One 120-foot timber and steel Howe deck truss

Major Alterations
Current bridge was built in 1994 and is a replica of the original 1928 design

Bridge Name		
Willamette River (Springfield) Bridge		
Date of Completion	**National Register Listing**	**ODOT Number**
1929	No	01223

Location Description
Springfield, Oregon. Oregon 126 Business Loop at mile post 1.34, westbound only

GPS Coordinates
N 44.04600°
W 123.02657°

Bridge Type
One 550-foot steel continuous through truss with reinforced-concrete deck girder approach spans

Major Alterations
None

Bridge Name Deschutes River (Maupin) Bridge		
Date of Completion 1929	**National Register Listing** No	**ODOT Number** 00966
Location Description Maupin, Oregon. US 197 at mile post 45.84 **GPS Coordinates** N 45.17277° W 121.07662°		
Bridge Type One 200-foot steel Warren deck truss and thirteen reinforced-concrete deck girder approach spans **Major Alterations** None		

Bridge Name		
Umpqua River (Scottsburg) Bridge		
Date of Completion	**National Register Listing**	**ODOT Number**
1929	No	01318
Location Description Scottsburg, Oregon. Oregon 38 at mile post 16.43 **GPS Coordinates** N 43.65439° W 123.82490°		
Bridge Type Three-span, 643-foot continuous steel through truss **Major Alterations** None		

Bridge Name
Wilson River Bridge

Date of Completion	**National Register Listing**	**ODOT Number**
1931	Yes	01499

Location Description
Tillamook, Oregon. US 101 at mile post 64.23

GPS Coordinates
N 45.47870°
W 123.84459

Bridge Type
One 120-foot reinforced-concrete tied arch

Major Alterations
None

Bridge Name Ten Mile Creek Bridge		
Date of Completion 1931	**National Register Listing** Yes	**ODOT Number** 01181
Location Description Lane County, Oregon. US 101 at mile post 171.44 **GPS Coordinates** N 44.22380° W 124.10974°		
Bridge Type One 120-foot reinforced-concrete through tied arch **Major Alterations** Cathodic protection system installed to treat corrosion.		

Bridge Name Big Creek Bridge

Date of Completion 1931	**National Register Listing** Yes	**ODOT Number** 01180

Location Description Lane County, Oregon. US 101 at mile post 175.02 **GPS Coordinates** N 44.17516° W 124.11491°
Bridge Type One 120-foot reinforced-concrete through tied arch **Major Alterations** Cathodic protection system installed to treat corrosion.

Bridge Name		
Rogue River (Caveman) Bridge		
Date of Completion	**National Register Listing**	**ODOT Number**
1931	No	01418
Location Description		
Grants Pass, Oregon. Oregon 99 at Riverside Park		
GPS Coordinates		
N 42.42938° W 123.33083°		
Bridge Type		
Three 150-foot reinforced-concrete half-through arches		
Major Alterations		
None		

Bridge Name Cummins Creek Bridge

Date of Completion	**National Register Listing**	**ODOT Number**
1931	No	01182

Location Description Lane County, Oregon. US 101 at mile post 168.44 **GPS Coordinates** N 44.26498° W 124.10683°
Bridge Type One 115-foot reinforced-concrete deck arch with reinforced-concrete deck girder approach spans **Major Alterations** Cathodic protection system installed to treat corrosion.

Bridge Name Rogue River (Isaac Lee Patterson) Bridge		
Date of Completion 1932	**National Register Listing** Yes	**ODOT Number** 01172
Location Description Gold Beach, Oregon. US 101 at mile post 327.70 **GPS Coordinates** N 42.42970° W 124.41312°		
Bridge Type Seven 230-foot reinforced-concrete deck arches **Major Alterations** Cathodic protection system installed to treat corrosion.		

Bridge Name Hood River (Tucker) Bridge

Date of Completion	**National Register Listing**	**ODOT Number**
1932	No	01600

Location Description Hood River, Oregon. Tucker Road at mile post 4.95 **GPS Coordinates** N 45.65450° W 121.54897°
Bridge Type One 100-foot reinforced-concrete deck arch **Major Alterations** None

Bridge Name		
Cape Creek Bridge		
Date of Completion 1932	**National Register Listing** Yes	**ODOT Number** 01113
Location Description Lane County, Oregon. US 101 at mile post 178.35 **GPS Coordinates** N 44.13399° W 124.12222°		
Bridge Type One 220-foot parabolic reinforced-concrete deck arch, 399 feet of reinforced-concrete deck girder spans on concrete columns **Major Alterations** Cathodic protection system installed to treat corrosion.		

Bridge Name		
Santiam River (Jacob Conser) Bridge		
Date of Completion	**National Register Listing**	**ODOT Number**
1933	No	01582

Location Description

Jefferson, Oregon. Take exit #238 off of Interstate 5 and follow Oregon 99E east for 1.8 miles

GPS Coordinates

N 44.71443°
W 123.01599°

Bridge Type

Three 220-foot reinforced-concrete through arches

Major Alterations

None

Bridge Name
Clackamas River (McLoughlin) Bridge

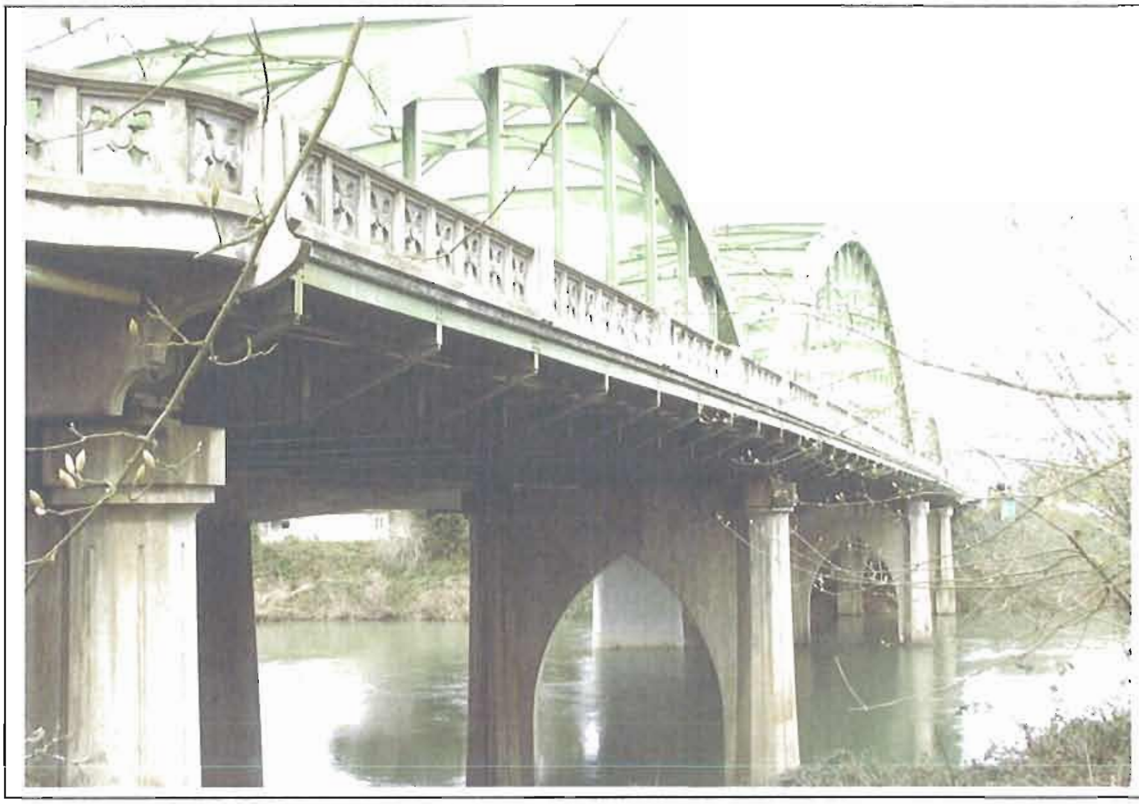
Date of Completion	**National Register Listing**	**ODOT Number**
1933	No	01617

Location Description
Oregon City, Oregon. Take exit #9 off of Interstate 205 and follow Oregon 99E to mile post 11.20

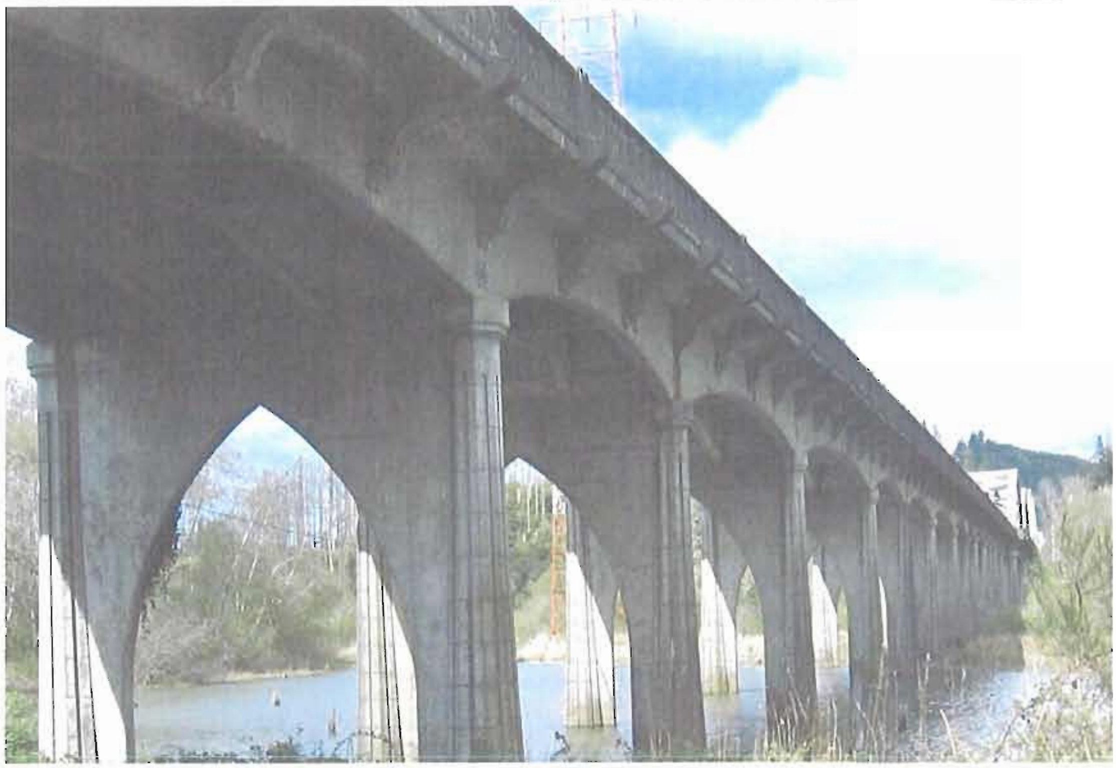
GPS Coordinates
N 45.37428°
W 122.60185°

Bridge Type
Two 140-foot and one 240-foot steel through tied arches, and four 50-foot reinforced-concrete deck girder spans

Major Alterations
None



Bridge Name		
South Umpqua River (Winston) Bridge		
Date of Construction	**National Register Listing**	**ODOT Number**
1934	No	01923
Location Description Winston, Oregon. Oregon 99 at mile post 74.47, eastbound only **GPS Coordinates** N 43.13355° W 123.39925°		
Bridge Type Three 180-foot steel through tied arches **Major Alterations** None		



Bridge Name Umpqua River Bridge		
Date of Completion 1936	**National Register Listing** No	**ODOT Number** 01822
Location Description Reedsport, Oregon. US 101 at mile post 211.21 **GPS Coordinates** N 43.71112° W 124.10021°		
Bridge Type One 430-foot steel through truss tied arch swing span, four 154-foot reinforced-concrete through tied arches **Major Alterations** None		

Bridge Name
Siuslaw River Bridge

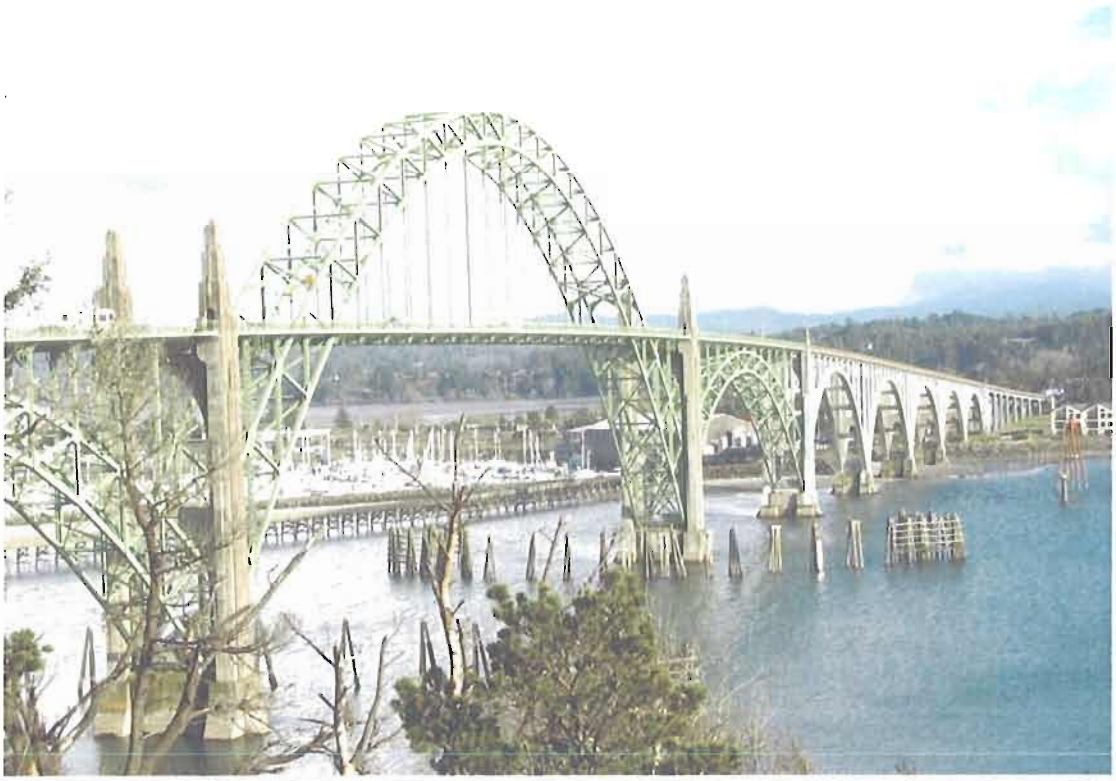
Date of Completion	**National Register Listing**	**ODOT Number**
1936	Yes	01821

Location Description
Florence, Oregon. US 101 at mile post 190.98

GPS Coordinates
N 43.96206°
W 124.10885°

Bridge Type
One 140-foot double-leaf bascule steel draw span, two 154-foot reinforced-concrete through tied arches

Major Alterations
None



Bridge Name		
Yaquina Bay Bridge		
Date of Completion	**National Register Listing**	**ODOT Number**
1936	Yes	01820

Location Description
Newport, Oregon. US 101 at mile post 141.67

GPS Coordinates
N 44.62432°
W 124.05886°

Bridge Type
One 600-foot steel though arch, two 350-foot steel deck arches, five 265-foot reinforced-concrete deck arches

Major Alterations
Cathodic protection system installed to treat corrosion.

Bridge Name
Eagle Creek Bridge

Date of Completion	**National Register Listing**	**ODOT Number**
1936	No	02063

Location Description
Multnomah County, Oregon. Take exit #41 (eastbound access only) off of Interstate 84 and follow road for approximately 0.25 miles

GPS Coordinates
N 45.64042°
W 121.93033°

Bridge Type
Original bridge was two 142-foot and one 182-foot steel through tied arches. Current bridge is a steel deck girder structure supported by original piers

Major Alterations
Original bridge was dismantled in 1969, only the original piers remain

Bridge Name
Coos Bay (McCullough Memorial) Bridge

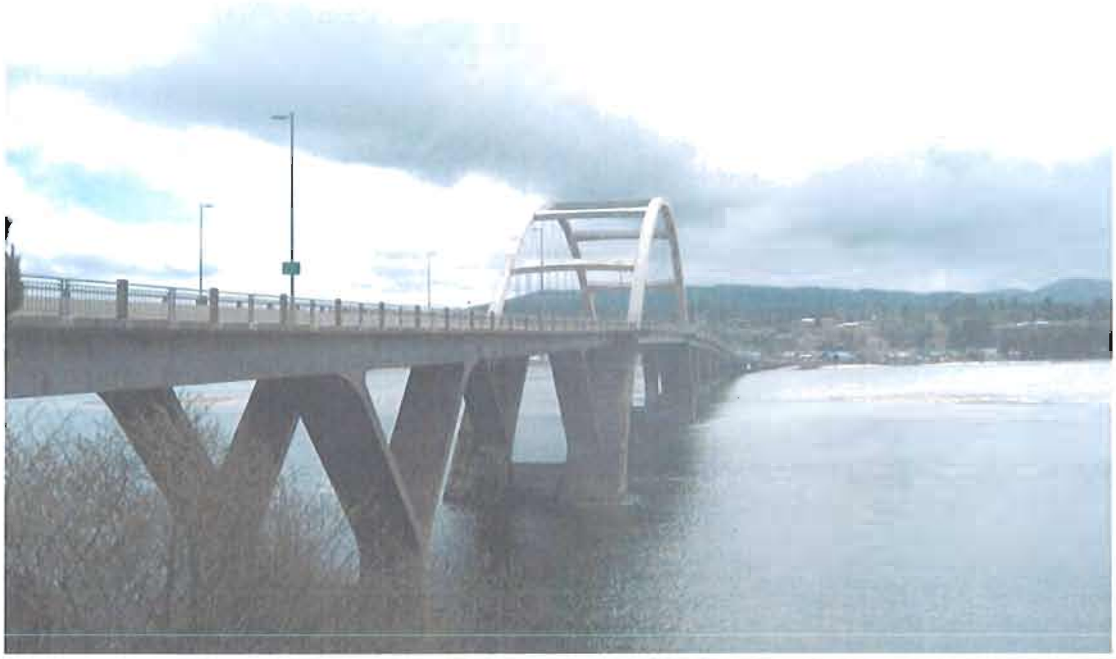
Date of Completion	**National Register Listing**	**ODOT Number**
1936	Yes	01823

Location Description
North Bend, Oregon. US 101 at mile post 233.99

GPS Coordinates
N 43.43433°
W 124.22076°

Bridge Type
One 793-foot and two 457-foot steel cantilever truss spans, thirteen 265-foot reinforced-concrete deck arches

Major Alterations
Cathodic protection system installed to treat corrosion.



Bridge Name		
New Alsea Bay Bridge		
Date of Completion 1991	**National Register Listing** No	**ODOT Number** 01746B
Location Description Waldport, Oregon. US 101 at mile post 155.52 **GPS Coordinates** N 44.42791° W 124.06774°		
Bridge Type Original bridge was one 210-foot and two 154-foot reinforced-concrete through tied arches and six 150-foot reinforced-concrete deck arches. Current bridge is a steel through tied arch with reinforced-concrete box girder approach spans **Major Alterations** Original bridge replaced by current bridge in 1991 due to extensive corrosion. Only decorative entrance pylons, spires, and pedestrian plazas and towers remain.		

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