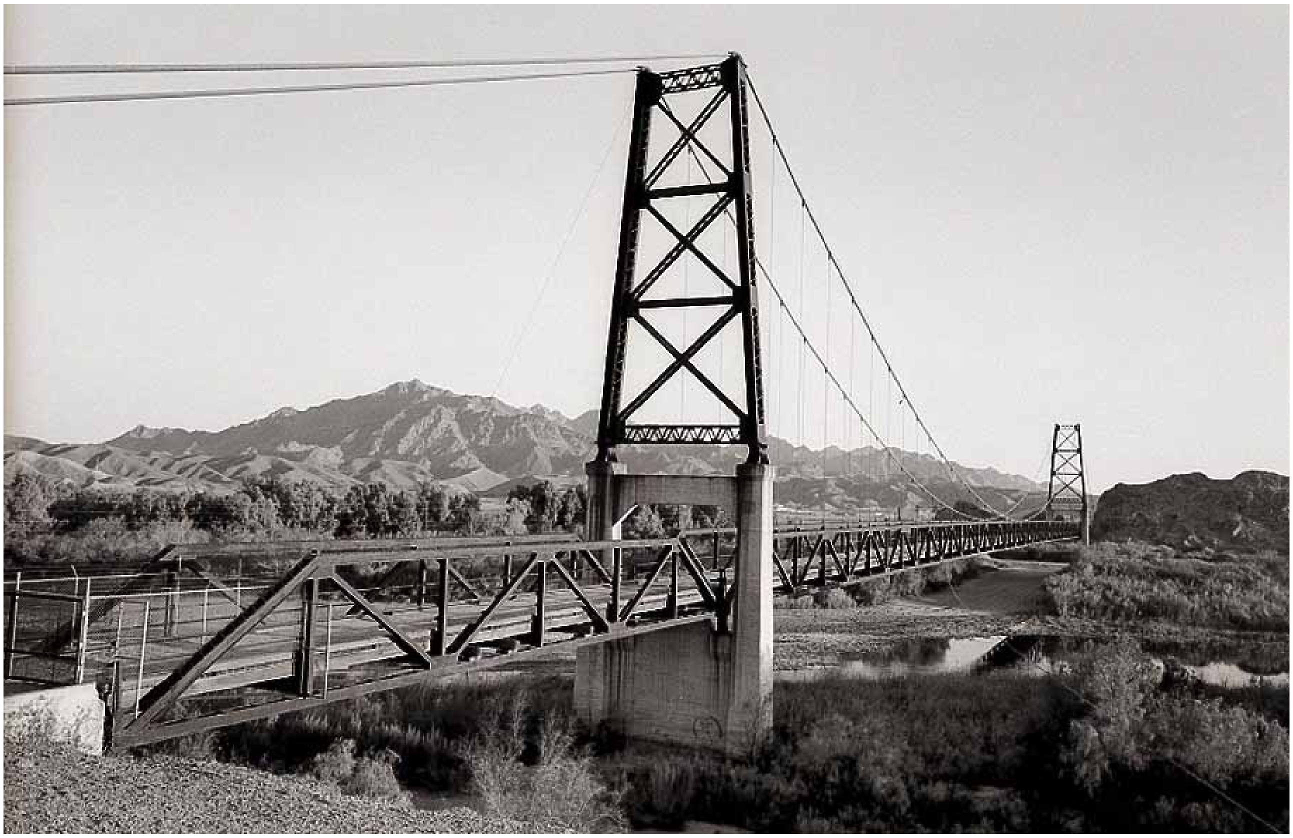

McPhaul Suspension Bridge - Yuma County

B R I D G E S

A R I Z O N A H I S T O R I C B R I D G E I N V E N T O R Y

submitted to:

Arizona Department of Transportation
205 South 17th Avenue
Phoenix, Arizona 85007

produced by:

FRASERdesign
420 South County Road 23E
Loveland, Colorado 80537

in association with:

EcoPlan Associates, Inc.
701 West Southern Avenue Suite 203
Mesa, Arizona 85210

January 2008

United States Department of the Interior
National Park Service

National Register of Historic Places
Multiple Property Documentation Form

This form is for use in documenting multiple property groups relating to one or several historic contexts. See instructions in *How to Complete the Multiple Property Documentation Form* (National Register Bulletin 16B). Complete each item by entering the requested information. For additional space, use continuation sheets (Form 10-900-a). Use a typewriter, word processor, or computer to complete all items.

____ New Submission   __x__ Amended Submission

A. Name of Multiple Property Listing

Vehicular Bridges in Arizona 1880 - 1964

B. Associated Historic Contexts

Vehicular Bridges in Arizona 1860 - 1964

C. Form Prepared By

name/title Clayton B. Fraser, Principal

organization FRASER design   date 15 January 2008

street & number 5700 Jackdaw Drive   telephone 970.669.7969

city or town Loveland   state Colorado   zip code 80537

D. Certification

As the designated authority under the National Historic Preservation Act, as amended, I hereby certify that this documentation form meets the National Register documentation standards and sets forth requirements for the listing of related properties consistent with the National Register criteria. This submission meets the procedural and professional requirements set forth in 36 CFR Part 60 and the Secretary of the Interior's Standards for Archeology and Historic Preservation. (__ See continuation sheet for additional comments.)

Signature of certifying official   date

State or Federal agency or bureau

I, hereby, certify that this multiple property documentation form has been approved by the National Register as a basis for evaluating related properties for listing in the National Register.

Signature of commenting or other official   date

Vehicular Bridges in Arizona 1880 - 1964 | Arizona
Name of Multiple Property Listing | State

Table of Contents

Provide the following information on continuation sheets. Cite the letter and the title before each section of the narrative. Assign page numbers according to the instructions for continuation sheets in *How to Complete the Multiple Property Documentation Form* (National Register Bulletin 16B). Fill in page numbers for each section in the space below.

Section | **Page number**

see continuation sheet

Primary Location of Additional Data

____State Historic Preservation Office
__x__ Other state agency (Arizona Department of Transportation)
____Federal agency
____University
____Other

see continuation sheet

Pinal County (cont.)

Santa Cruz County

Yavapai County

Yuma County

I Introduction

The Arizona Historic Bridge Inventory, which forms the basis for this Multiple Property Documentation Form [MPDF], was produced for the Arizona Department of Transportation [ADOT] by Fraserdesign of Loveland, Colorado, under a subcontract agreement with EcoPlan Associates, Inc., of Mesa, Arizona. The study was undertaken with the cooperation of the Arizona State Historic Preservation Office. This inventory is a sequel to an earlier study completed in 1987 by Fraserdesign that focused primarily on identifying National Register-eligible bridges constructed before 1945. This follow-up study broadened the scope of work of the original inventory to examine bridges built before 1964. The earlier study culminated with the production of a National Register Multiple Property Documentation Form entitled "Vehicular Bridges in Arizona." This MPDF is intended to function as an amendment to the earlier document.

It is structured in conventional manner, with the Statement of Historic Contexts as Section E, followed by Associated Property Types as Section F. The former is a narrative discussion of vehicular bridges in Arizona, organized more-or-less chronologically beginning with early bridge building in America and ending with construction of the interstate highway network in Arizona. The latter section lists the major structural types encountered in Arizona, discussing for each its history and aspects of National Register significance and registration requirements. This discussion of National Register eligibility is exhaustive because, even though the Historic Bridge Inventory has identified and documented what appear to be Arizona's NRHP-eligible structures, other structures may emerge in the future that require evaluation for significance and eligibility.

Section F is followed by Geographical Data (Section G) and a Summary of Identification and Evaluation Methods (Section H). Section H includes a listing of the 125 eligible and listed structures as well as a comprehensive listing of all 2,504 structures included in the Inventory. The MPDF concludes with Section I, which presents a Bibliography of sources used in the Inventory. Section I also contains the inventory forms for structures identified by the Inventory as NRHP-eligible and -listed. All the sections—including the inventory forms—are numbered sequentially, beginning with this page. The bridges listed in Sections H and I are organized by structure number within each county.

The bridges identified in the Inventory as NRHP-eligible generally exhibit a degree of historical or technological significance that is clearly greater than others within their class or structural type. To maximize the bridges' interpretive value, premiums have been placed on thorough historical documentation and maintenance of physical integrity. As discussed in the National Register guidelines given in Bulletin 16, bridges can be considered eligible for their representation of general trends—either transportation or engineering—or for their exemplification of outstanding—or at least noteworthy—technological achievement. Many of the structures listed here have been identified as NRHP-eligible for their well-preserved representation of standard structural types. Others have been selected as superlative examples (e.g., oldest, longest, best-preserved of type) of bridge construction in Arizona. The superlative examples have been listed in Section F with each structural type.

see continuation sheet

2 Bridge Development in America

Bridges, as integral elements of a developing transportation network, have played a pivotal part in the development of America. Generally the most sophisticated components of any overland transportation system, they are also the most prominent. Bridges not only function as gauges of technological advancement in design and construction, they reflect the tenets, values and ambitions of the people who erected them. "There can be little doubt that in many ways the story of bridge building is the story of civilization," President Franklin Roosevelt stated in 1932. "By it we can readily measure an important part of a people's progress." While descriptive of the United States in general, this was especially true for Arizona, a state in which overland transportation forms a central historical theme. From the earliest wooden spans on the territorial toll roads to the later steel trusses and concrete arches on early state routes to the precast bridges on the interstate highway network, bridges have facilitated, and in some instances created, settlement across the state.

A plethora of bridge forms, variously employing such materials as stone, timber, iron, steel and concrete, has been developed in America through years of empirical usage. The first wooden bridges were merely plank structures—the equivalent of a log thrown across a stream. Limited in span to the wooden beam's length and carrying capacity, they were used for only the shortest crossings. Without proper support, they became unduly strained by bending moment forces, leading to structural failure: i.e., the log broke. An advancement over this was the first significant bridge form used extensively in America, the pier bridge, also called the pike-and-beam bridge. Another ancient bridge type, it consisted of heavy timber or log stringers spanning between timber pile bent piers, spaced at intervals of between 10 and 30 feet. In places where loose or shifting sediment proved unsuitable or was too deep for stone foundations, vertical wooden piles were driven into the riverbed to support the roadwork and joined to form bents. A variation on the pile design, the crib bridge, used stacked logs for the piers in lieu of driven piles, often with stone ballast in the piers' centers. Timber stringer bridges were used extensively throughout America and continue to be commonly used for minor bridges.

The use of stone as a building material was also transferred to America from Europe. Long known for its superior compressive strength, stone (or more specifically the mortar joints between the stones) has virtually no tensile strength and must rely on compressive forces through arching. Although used extensively in Europe, stone was largely eschewed in this country in favor of timber and was used only marginally for bridge superstructures. While some stone bridges were built in situations in which strength and permanence outweighed the importance of initial cost, the use of stone was generally restricted to substructural work. There its rigidity and resistance to scouring from water made it the preferred material for piers and abutments until the development of concrete early in the 20th century.

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VEHICULAR BRIDGES IN ARIZONA

Though by far the most common structural type, the timber stringer bridge was not really very sophisticated. More technologically innovative was a bridge type that has been termed "primarily an American achievement"—the truss. The introduction of the truss marked the beginning of more involved bridge design in America. As with other structural types, the truss form had been imported from Europe. First employed in ancient Greece and Rome as a roof support, the truss was not formally associated with bridge design in Europe until the Renaissance. But while the first timber trusses were erected there, the greater development of truss design occurred in America during the 19th century.[1] Between 1820 and 1850 truss design evolved from empirically based craftsmanship into a science. Several major truss patents were issued during this period, a fact directly attributable to railroad development and the concurrent need for bridges of increased strength, capacity and rigidity.

These patents described a wide variety of truss configurations, the Town lattice, Burr arch-truss, bowstring and Howe being the most commonly employed in timber and iron configurations. By the time that Arizona began building trusses on its roads in the late 19th century, the number of bridges practically available had been winnowed down considerably to include two basic truss families—the Pratt and the Warren. The Pratt was more common. Patented in 1844 by Thomas and Caleb Pratt, this truss type featured verticals and upper chords that acted in compression (that is, the forces pushed inward along the members' lengths) and diagonals and lower chords in tension (the forces tended to pull outward). These were built using a combination of wood for compression members and iron for tension. Because of their large use of cast or wrought iron components, which were expensive to manufacture in the mid-19th century, Pratt trusses did not gain widespread popularity until the 1870s and 1880s, when the improved quality and decreased cost of iron made feasible the construction of all-metal trusses. The Warren truss was introduced four years after the Pratt by two British engineers in 1848 and quickly adopted in America. With its web comprised of repetitive triangles, the Warren in its classic form included only diagonal members (and no verticals) that carried alternating compressive and tensile forces. Its straightforward design made it a standard form for later all-metal trusses.

The Pratt and Warren became the truss types of choice for bridge engineers in the late 19th and early 20th centuries. The Warren featured minor variations in its web configuration and its upper chord shape, but its general profile was unmistakable. The basic Pratt design was split into a variety of sub-types—the Parker, with its polygonal upper chord; the Pennsylvania, so named for its extensive use by the Pennsylvania Railroad; the Baltimore, used by the B&O Railroad; the Camelback, a Parker variant described by one influential engineer as "uncompromisingly ugly"; the Kellogg; and the lenticular truss— which as a group constituted the overwhelming majority of vehicular trusses fabricated in the 19th century.[2]

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[1]David Plowden, *Bridges: The Spans of North America* (New York: Viking Press, 1974), 34. Plowden states: "It is probable that most literate men among [Americans] were aware of European developments. It is also conceivable, however, that the truss, such an obvious device to anyone familiar with the rudiments of roof framing, may have evolved independently in America."

[2]J.A.L. Waddell, *Bridge Engineering* (London: John Wiley and Sons, 1916), 23-27.

see continuation sheet

VEHICULAR BRIDGES IN ARIZONA

The evolution of truss components and connection methods in America paralleled that of truss design. Cylindrical pins were first used to connect metal truss members on a Lehigh Valley Railroad bridge in 1859. Two years later a complementary truss member—the forged iron eyebar—was introduced. Steel eyebars, made using the Bessemer and open-hearth forging processes, appeared in the 1870s. Pinned connections, assembled over falseworks in what was termed the "American style" of truss construction, allowed quick erection, but they lacked rigidity and could loosen from vibrations caused by traffic and wind. Riveting created stronger, sturdier connections but was not practical in the field before portable riveters became available in the late 1880s.[3]

After the turn of the century the pattern was well-set, and no new truss designs of significance were patented. Truss design was by then a matter of refinement and expansion of existing ideas. The only major change in truss erection occurred after 1910, when rigid connections began to supercede pinned. Bridge companies used both structural types—occasionally combining the two on a single structure—during the transitional period in the early 1910s. By 1920 erection of pin-connected bridges had virtually ceased. Concurrent with this was the emergence of the Warren truss for vehicular use. Pratt trusses were inherently better suited to American style pin-connected erection, but Warren trusses proved more difficult to assemble in the field using pinned connections. When rigid-connected trusses became more feasible in the 1910s, Warrens came into their own, receiving more widespread acceptance among American bridge engineers.

Although the truss received much of the attention from the engineering profession, other types of metal bridges were undergoing simultaneous development in the 19th century. One of these was the girder structure. An elaboration on the simple stringer bridge, with two to six main spanning beams to which floor beams are attached perpendicularly, the girder form was associated primarily with railroad construction. The first patent for an all-iron bridge was taken out by August Canfield in 1833, and as early as 1846 an iron plate girder railroad bridge had been erected. As the cost of wrought iron decreased, girders began to proliferate during the 1870s and 1880s. With their deep profiles made up of iron or steel plates to which rolled metal flanges and web stiffeners were riveted, girders were ideally suited for railroad use because of their inherent rigidity and relative ease of construction.

Their drawbacks were that they weighed more than similar-length trusses and they were typically built in-shop and hauled and assembled to the sites, limiting their effective span to the length of a railroad flatcar. Nonetheless, deep-profile girders were used extensively for short- to medium-span railroad bridges from the 1880s to the 1920s. Although roadway girders were also built at that time, they tended to be significantly less economical than other bridge types and were employed principally for special-use situations such as heavily trafficked urban bridges and viaducts.

[3]Waddell; Donald C. Jackson, *Great American Bridges and Dams* (Washington, D.C.: Preservation Press, 1988), 28.

see continuation sheet

Two other metal bridge types that received use during the late 19th and early 20th century were suspension and cantilever bridges. The first suspension bridge in America was erected in 1786; by 1808 over 40 had been built. Used only intermittently by the railroads due to their inherent lack of rigidity, suspension spans received increasing vehicular use through the end of the 19th century and the early 20th century. The Kentucky River Bridge at Dixville, Kentucky, built in 1876, marked the beginning of long-span modern cantilever construction. Like the suspension bridge, it is a design that received only limited use in the early 20th century.

After the turn of the century, another structural form—the reinforced concrete arch—began to receive widespread usage among American engineers. Concrete arches relied on two ancient technologies—concrete construction and the arch form—to allow a material that ordinarily acts poorly in tension to carry loads over long spans. Used since ancient times, concrete consists of two parts—binder (i.e., cement) and filler (which for road work is usually crushed rock, sand or gravel. Essentially calcium oxide, cement is usually created by burning finely broken limestone. The resulting product is then mixed with water to form cement, which is either soluble in water (non-hydraulic) or, with the addition of silica and alumina, impervious to water (hydraulic). Obviously, only hydraulic cement was appropriate for use in road and bridge work.

If the silica and alumina occurred naturally in the limestone, "natural" cement was created. While sometimes used for bridge building, natural cement tended to be structurally unpredictable. It was supplanted in the United States in the 1880s by Portland cement, in which silica and alumina were artificially introduced to achieve consistent quality. The first use of Portland cement in America is attributed to David O. Saylor, who patented his own type of Portland cement and built the country's first cement manufacturing plant near Copely, Pennsylvania. The first documented use of concrete on an American bridge was the foundation of the Erie Railroad's Starrucca Viaduct, completed in 1848. John Goodrich was probably the first in this country to use concrete in a bridge superstructure in 1871. He was soon followed by others, so that by 1900 some 150 concrete arches had been built in America.

These early structures were built of unreinforced, or mass, concrete. In 1871 W.E. Ward was the first to embed steel bars in a concrete bridge to add tensile strength. By the early 1890s, this technology was being applied to bridge construction, resulting in the development of several proprietary reinforcement systems. The type chosen for a structure affected its appearance as well as its strength and bearing characteristics. Regardless of the structural type, quality control continued to be a problem until well into the 20th century, when aggregate was more carefully selected and washed. Ascertaining correct proportions of water, cement and aggregate was more of an art than a science during concrete's formative years, and mistakes caused structural failures. Around 1900 engineers began building ever longer reinforced concrete arch structures, reaching spans in excess of 250 feet by 1908. Both open- and filled-spandrel concrete arch bridges were ideally suited for the memorial bridges being erected by cities across the country to replace earlier iron trusses. As indicated by an article in *Engineering Record*, the truss was by then considered an eyesore on the urban landscape:

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> There is one feature of city (truss) bridge building that still remains in the dark ages, and engineers ought to give it more attention. The usual criticism of our public works is that they are needlessly utilitarian and consequently ugly. Now it must be admitted that an ordinary highway truss bridge is not so charming as a well proportioned masonry arch.[4]

Aesthetics thus became an important consideration in bridge design and detailing in the 1910s, particularly for urban structures. To conceal the stark concrete planes of their bridges, engineers often covered them with façades of real or imitation stone or formed and textured the concrete to resemble coursed masonry. Ernest Ransome had chosen to disguise the Alvord Lake Bridge, a structure at the forefront of technological innovation, with a veneer of imitation stone. "As often as not, the results were less pleasing than the structures they replaced," David Plowden states. "These bogus structures satisfied the aesthetic requirements of the turn of the century and cost much less to build than an all-stone bridge, despite the over ornamentation some of them received."[5]

As they gained experience with the material, bridge designers became more creative. "There is little excuse for building an ugly concrete bridge," Waddell insisted. While immediately appreciating the arch form in concrete, the public was initially unimpressed by the sparse look of concrete girder and beam spans. A contemporary wrote that "frequent objection has been made to the use of them for the reason that they are not susceptible to artistic treatment." While the writer maintained that this objection was diminishing, conventional wisdom held that if there had been a popularity contest for bridges in the early 20th century, concrete arches would have won hands down.

After 1905 concrete bridge construction experienced a marked increase, due largely to the efforts of one engineer, Daniel B. Luten of Indianapolis. Using a series of broadly stated patents for reinforced concrete arches, Luten largely controlled the concrete bridge industry in America. His lawsuits for patent infringement were routinely upheld in the courts, forcing many arch builders to pay royalties to Luten. Luten's arches were innovative. Featuring sometimes highly elliptical profiles, they were sophisticated in their dependence on steel reinforcing and allowed relatively thin concrete sections at midspan. Termed Luten arches—or horseshoe arches for their distinctive profile—they were built extensively from 1905 through the mid-1920s. Luten claimed to have built some 17,000 concrete arches, including several in Arizona.

Luten's stranglehold on the industry was finally broken in January 1918 when a Des Moines judge ruled that the broadly worded patents were invalid. The Iowa location was significant, for the suit challenging Luten's patents was initiated by America's other most significant bridge designer, James B. Marsh of Des Moines. The

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4 "City Bridges." *Engineering Record*, 3 June 1911.

5 Plowden, 298.

ruling opened up arch building in the country, and the concrete arch received increased use as a vehicular bridge type. Marsh himself had patented a reinforced concrete arch design in 1912, called the Marsh, or rainbow, arch. Marsh arches were essentially steel bridges sheathed in concrete, with the deck carried between two parallel arches. Costly to construct, they were built sparingly for highway use. None are known to have been built in Arizona.

The dull color of concrete bridges and the enormity of steel trusses sparked debate within the bridge profession on aesthetics and scale. To engineers interested in technological achievement, the monumental skeletal structures of steel illustrated perfectly the relationship of form and function. Moreover, those such as Thomas Clarke saw utility and not sculptural art as of primary importance. "Where so many bridges had to be built in a short period of time, aesthetic considerations are little regarded," he stated. "Utility alone governs their design. So long as they are strong enough, few care about how they look."[6]

On the other side were those that held the arch to be the highest form of bridge design. Concrete arches provided the opportunity for applied ornamentation in the form of incised panels or classical balustrades that starkly functional trusses did not. Moreover, proponents argued that the arch was structurally superior, more rigid under traffic and more resistant to flooding. Ultimately, however, the decision to build a concrete or steel bridge was often an economic one, and in most applications concrete cost more than steel.

A common thread that ran through all the major metal bridge types was the method of their construction. With the rise of industrialization, the settlement of the West and the resultant proliferation of overland transportation networks, a new industry—bridge fabrication—sprang up in 19th century America. A number of companies formed after 1850 to fill the demand for roadway and railroad truss bridges. After the Civil War, their numbers jumped from a total of just five to 75 in 1870, 137 in 1890 and almost 200 by 1900. Few civil engineers at the time fully understood stress analysis and truss design, allowing national firms such as the King Bridge Company and the Wrought Iron Bridge Company to accrue power in a rapidly expanding market.

These firms often published catalogues of standard structural types and bid competitively on construction contracts let by the counties and municipalities. Several firms in the Midwest and the Ohio River Valley specialized in bridge fabrication and erection. Constantly on the road, their salesmen contacted counties where rapid population growth produced a demand for large numbers of bridges. When an order for a bridge was received, its components were assembled at the fabrication plant, using iron or steel members rolled in the immense forges of Pennsylvania or Illinois. Bridge fabricators sometimes erected the parts at the site as well. Other firms received bridge contracts but were responsible for erection only, purchasing steel superstructures from fabricators such as the Minneapolis Steel & Machinery Company or the Omaha Structural Steel Works.

[6] As quoted in Plowden, 166.

In 1900 the complexion of the industry changed radically. That year financier J.P. Morgan created the enormous American Bridge Company by consolidating two dozen smaller firms, including the Wrought Iron Bridge Company (Canton, OH), the Edge Moor Bridge Works (Wilmington, DE), the Milwaukee Bridge & Iron Works (Milwaukee, WI), the Groton Bridge & Manufacturing Company (New York, NY) and the Youngstown Bridge Company (Youngstown, OH). This effectively molded most of the competing firms into one gargantuan company, which then fabricated and erected thousands of railroad and vehicular bridges across the country. Against this giant of the industry several smaller firms still managed to compete, mostly from the West and Midwest. These included companies such as the Missouri Valley Bridge & Iron Works (Leavenworth, KS), the Midland Bridge Company (Kansas City, MO), and the Canton Bridge Company (Canton, OH).

After 1900 the bridge companies had two more decades of intense activity before the industry was again transformed. Following passage of the Federal Aid Highway Act in 1916, the responsibility for bridge design generally fell to the state highway departments or to the federal government. While bridge design thus became more centralized, bridge contracting became more localized. National bridge firms offering design/build services to the counties could no longer remain competitive in this changing market, and an entirely new group of bridge builders quickly developed. Additionally, the industry transformation marked a shift from the design of wagon bridges in the 1910s to those intended specifically for automobile use. These two trends amounted to what was essentially an evolution from 19^{th} century to 20^{th} century practice.

As recent as America is in terms of bridge development, Arizona is far younger still. In the 1840s, when most of the major truss types were invented, Arizona was not even a part of the United States territory. When the rest of the country was experiencing what was probably the greatest period of roadway bridge construction in the 1880s and 1890s, Arizona was not yet a member of the union. When Indiana engineer Daniel Luten patented his first horseshoe arch in 1900, Arizona Territory had built only a few permanent crossings. And by the time Arizona was admitted as a state in 1912, bridge technology was already well developed in America. Despite this, a number of outstanding bridges have been constructed on Arizona's roads and highways, principally by the state highway department. Fortunately, most of the best of these have survived.

3 Territorial Road and Bridge Construction in Arizona: 1880-1912

From 1848, when much of Arizona territory was acquired from Mexico by the Treaty of Guadalupe, until 1863, with the enactment of the Federal Organic Act that designated the Territory after its separation from New Mexico, Arizona was crossed by only two major overland routes. Both traversed the region from east to west and both had been developed by the military. The first wagon road through the area was built in 1846 as a route between Santa Fe and San Diego. This road, constructed hurriedly by Capt. Phillip Cooke and the Mormon Brigade during the war with Mexico, entered the territory in the southeast

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corner, extended north to the Gila River and then west to the Yuma Crossing of the Colorado River. Known as Cooke's Wagon Road or simply as the Gila Trail because it largely paralleled the Gila River, this southern route was later made popular by those traveling to California in search of gold.

The northern route followed Lieutenant Edward Beale's 1857 survey along the 35th parallel for a wagon road between Fort Smith, Arkansas, and the Colorado River. With camels as pack animals, Beale's troops traversed the region as they charted a wagon road between Fort Defiance in New Mexico Territory to the Colorado River. In 1859 Beale's expedition returned to construct a 10-foot-wide track, largely by clearing vegetation and loose rocks from the route they had scouted two years earlier. Called Beale's Road, this route was used by hunters, trappers and military troops before construction of a railroad along the route in 1883. Beale reflected the prevailing view of the area when he reported back to Congress in 1858: "The region is altogether valueless. After entering it, there is nothing to do but leave." Other secondary routes—no more than trails, really—developed across the region through intermittent use. Road maintenance, such as it was, was performed on these routes by travelers as the need occurred. Bridges were virtually nonexistent.

At the point where the Gila Trail crossed the Colorado River, John Gallatin built a toll ferry in 1849, supplanting earlier Indian-operated ferries at this point. Louis Jaeger started his own ferry service here a year later, after the Indians exacted their own toll on Gallatin by scalping him. A settlement called Jaegerville soon developed on the California side of the ferry. In December 1850 the U.S. Army established a small encampment, called Fort Yuma, a mile upriver. The town of Colorado City was platted on the Arizona side of the river four years later. This community changed names three times before its incorporation in 1871 as Yuma. In addition to its role as a port for riverboats that plied the Colorado River, Yuma served as a funnel for overland travelers between southern California and the East. Thousands of immigrants traveled westward on foot, wagons or horseback across the Gila Trail, and the Butterfield Overland Stage followed the trail through Yuma on its route between St. Louis and San Francisco. The arrival of the Southern Pacific to Yuma, with the construction of the new railroad bridge over the Colorado, further bolstered the small city's role as a Southwestern transportation nexus.

Meanwhile, in the Salt River Valley some 180 miles east, another colony was growing around an agriculturally based economy. The origins of Anglo settlement in central Arizona date from 1867. That year William John Swilling, flamboyant Confederate army officer, prospector, Indian fighter and entrepreneur, formed the Swilling Irrigation Canal Company with John Y.T. "Yours Truly" Smith, the post sutler at Fort McDowell. They opened the Swilling Ditch by clearing an ancient Hohokam Indian canal, supplying water to a growing number of farms that sprang up along the ditch's length. Three years after the inception of the Swilling Ditch, the townsite of Phoenix was platted. Phoenix grew steadily with the rest of the Central Valley through the 1870s and 1880s. The city's future as Arizona's central metropolis was guaranteed when in 1889 the Arizona Territorial Capital was moved to Phoenix from Prescott. Although not directly on the Gila Trail, Phoenix was close enough to connect it by a relatively short wagon road to the south. The Gila Trail thus served to link Phoenix with Yuma and points west, and eventually the northern swing through Phoenix became the main line through common use.

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VEHICULAR BRIDGES IN ARIZONA

After its formation in 1863, the Arizona Territorial Assembly immediately recognized the need for transportation routes to connect the widely scattered settlements and foster economic growth. Money for road construction was scarce, however. The First Territorial Assembly did what government bodies have traditionally done when short of funds themselves: it licensed others to build the roads and bridges for profit. Privately held toll companies were given exclusive rights to build and administer toll roads and collect fees based upon predetermined price rates. To raise capital for construction, they were allowed to issue stock. To protect their investments, the companies were granted franchises for specified periods of time. In return for these exclusive rights, the territorial auditor collected a part of the gross proceeds from each road, to be applied to the school fund. During the first legislative session, six toll road ventures, such as the Santa Maria Toll Road Company and the Arizona-Central Toll Road Company, were thus chartered, most of which extended from the territorial capital at Prescott.

Toll rates were generally set on a per-mile basis, depending on the mode of transportation. As a free-market function, the tolls varied from road to road, but usually reflected the road's use, location and difficulty of construction. The acts of incorporation were similarly structured for all toll companies, containing the same general provisions: Roads were to be completed and improved within a designated period. Water wells were to be dug and maintained and facilities provided for use by both people and animals. The roads were to be kept safe and passable. Finally, exclusive rights to maintain the roads and collect tolls would be granted as long as they did not encroach on other existing toll roads.

The law did little to encourage excellence in road construction, however, and the toll road operators tried to avoid bridge construction as an unnecessary expense. The bridges that were built rarely lasted beyond the statutory limits of the franchises. Poorly constructed and unevenly maintained, these rudimentary timber or masonry structures typically washed out in floods or collapsed under load. Only two such structures from the territorial period are known to exist still. Both were built in 1907 in Graham (now Greenlee) County on the Clifton-Solomonville Road [*see Figure 1*]. The Solomonville Road Overpasses [**8150** and **8151**] are unusual in that they were built to carry wagon traffic over railroads (the earliest datable grade separations in Arizona), they used concrete arch construction, and they were built relatively late in the toll road milieu.

In a region in which government revenues were minimal, toll roads were generally regarded as a necessary evil, a costly but temporary way to develop a much-needed road system. But the First Territorial Assembly was also aware of the need for free highways to promote transportation and settlement. The Assembly tried to legislate a balance between roads built by private capital and supported by tolls and those over which no tolls could be extracted. To prevent toll operators from monopolizing travel by incorporating every road in the territory, the lawmakers designated several existing roads—developed solely by prior use—as free routes. This formed the basis for a free-highway network in Arizona, which subsequent legislatures would expand by incorporating toll road companies and simultaneously declaring other roads as toll-free.

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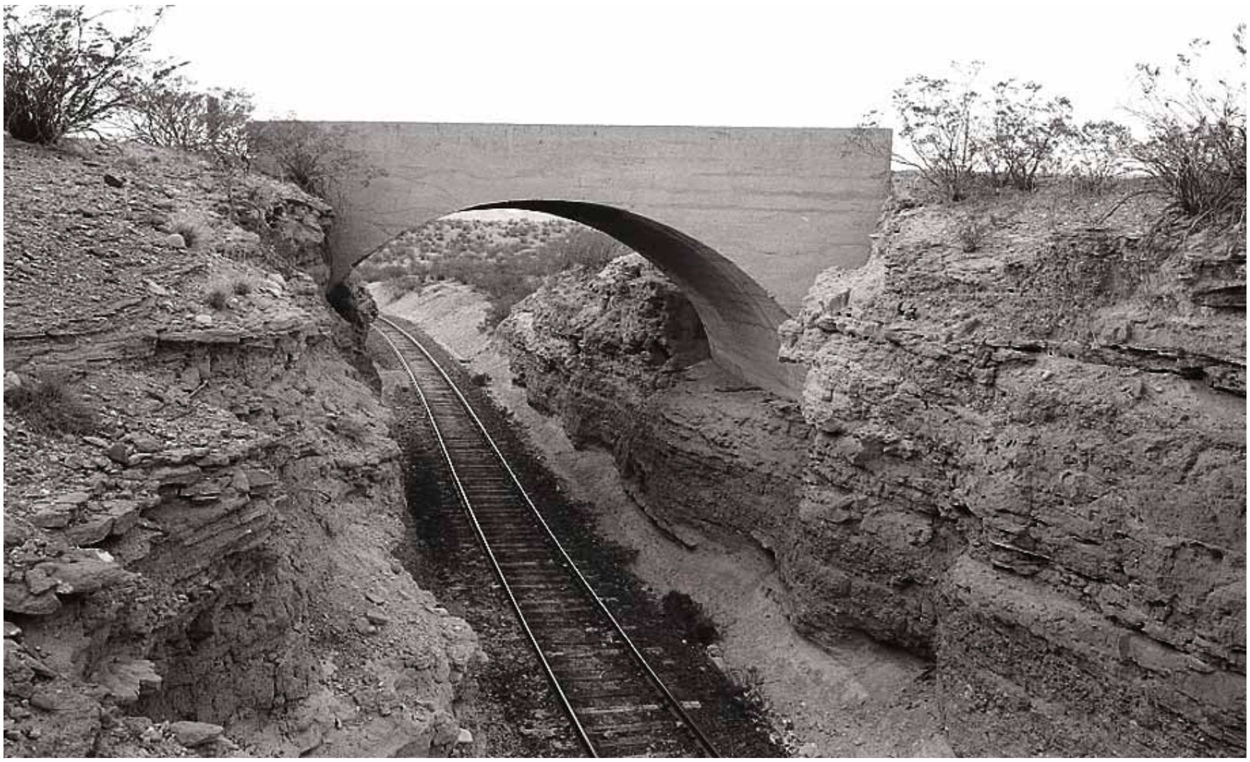

Figure 1. Solomonville Road Overpass, 2003.

Arizona's territory-level management soon proved burdensome, however. In 1866 the Assembly began transferring responsibility for building roads to the individual counties by authorizing the counties to establish road districts and appoint overseers to supervise roads and bridges within each district. To fund construction and maintenance, the county boards of supervisors were empowered to issue bonds of indebtedness. Additionally, they could assess a yearly road tax of $6 on every able-bodied man, which could be defrayed by labor on the roads. In 1871 the Assembly transferred even more autonomy to the counties, giving them the right to incorporate toll road proprietors themselves.

The conditions for incorporation were generally the same as those for the territory, and the counties retained the option to purchase the privately built roads after five years. With this, the county administrators possessed all the tools needed to pursue active road and bridge programs. They rarely used them well. Seldom following a premeditated plan, county supervisors authorized the surveying and clearing of roads and construction of bridges as needed, usually in response to urgent local petitions. Arizona State Engineer Lamar Cobb later characterized the situation:

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> Every two years the personnel of the various boards of supervisors is almost completely changed. They go in imbued with the idea that their predecessors squandered the county road funds and go out with the public equally confident that they have. With both more or less correct in their opinions, but it has not been the fault of the supervisors. With county road funds of limited proportions to repair hundreds of miles of road, and with every man in the county clamoring for work in his locality, it has been next to impossible for them to set aside a sum, in any amount, for permanent work.[7]

Maricopa County could afford a degree of road improvement and bridge construction, and in 1877 the Territorial Assembly authorized the county to issue $15,000 in bonds to finance construction of four wagon roads. In the sparsely populated areas outside of the major cities, however, few vehicular bridges were erected before the turn of the century. Many of these earliest county-built bridges, like those on the toll roads, tended more to the flimsy than the substantial. Some consisted of little more than two parallel boards laid across a streambed to carry the vehicles' tires. Often made up of wood stringer spans on timber piles or crude concrete abutments and piers, these questionable structures failed with distressing regularity. Only a handful proved more permanent. For longer spans, the counties erected simple kingpost or queenpost pony trusses, with timber compression members and wrought iron tension rods. None is known to have survived.

During the 1870s and 1880s, the Territorial Legislature seemed content to leave road and bridge construction to the individual counties. Between 1877 and 1881 the territory issued bonds totaling only $70,000 to fund road construction. In an uncharacteristic act of largesse, however, the Thirteenth General Assembly in 1885 appropriated $15,000 toward construction of a bridge over the Gila River at Florence in Pinal County. This, along with a $12,000 appropriation for a wagon road, prompted Territorial Governor Conrad Zulick to comment that the expenditure of funds on road and bridge work represented a "wanton misappropriation of public funds."[8] The bridge was constructed that year; in 1905 the legislature authorized a $19,000 bond issue to fund repairs to the Florence Bridge. But other than these tentative steps, the territorial government made only minimal impact on overland transportation in Arizona. Indeed, no territorial organization or staff had even been established to administer roads and bridges.

Construction of the Florence Bridge marked a watershed event in Arizona bridge history. Not only was it the first wagon bridge undertaken wholly by the territory, it was probably the earliest all-metal wagon truss in Arizona. The structure consisted of two 180-foot Pratt spans, with an extensive timber trestle over an island and slough. Consuming 30 tons of iron and 174,000 feet of lumber, the Florence Bridge was soon followed by other wagon trusses. Apache County built a pinned Pratt truss over Clear Creek south of Winslow. After

[7] Arizona State Engineer, *Report of the State Engineer of the State of Arizona: July 1, 1909, to June 30, 1914* (Phoenix: Arizona State Press, 1914), 72.

[8] As quoted by Jay J. Wagoner, *Arizona Territory 1863-1912: A Political History* (Tucson: University of Arizona Press, 1970), 239.

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its separation from Apache County in 1895, Navajo County built a Pratt through truss to carry the Winslow-Holbrook road over Chevelon Creek and another truss over the Little Colorado River. Similarly, Greenlee County built a four-span Pratt through truss over the Gila River at Duncan to replace an earlier wooden structure. Virtually all of the early metal trusses built by the counties featured relatively modest dimensions, standard Pratt configurations and prefabricated, pin-connected detailing. None is known to have survived.

One surviving bridge from the territorial period was constructed, not by the territorial government or by a county road district, but by the federal government—specifically the U.S. Reclamation Service (USRS, predecessor to the Bureau of Reclamation). In 1902 the USRS began planning a dam over the Salt River, one of the first dams authorized by Congress under the Newlands Act. The site for what would become the Theodore Roosevelt Dam was located in the mountains east of Phoenix. Before construction could begin on the immense structure, an access road had to be graded from the railhead at Mesa to the damsite. Routed along the ancient Apache Trail, the road wound its way through the rugged mountain range. Near its top, on a switchback curve in Alchesay Canyon, the USRS constructed a modestly scaled concrete arch structure in 1905. The Alchesay Canyon Bridge [**1532**] is today Arizona's oldest dateable vehicular bridge [*see Figure 2*].

Figure 2. Alchesay Canyon Bridge, 2003.

After the turn of the century, it became apparent that many major road and bridge projects were beyond the capacity of the individual counties. Further, the counties were building roads on a piecemeal basis, without regard to the roads in adjacent counties. This tended to create an uneven patchwork of dissimilar routes, making travel difficult for all but a few destinations. To fund the development of regional highways, the Territorial Assembly in March 1909 levied a property tax varying from 5 to 25 mills. (A mill is .001 or 1/1,000th of a dollar; a five mill tax is equivalent to five dollars per one thousand dollars.) The 5 mill tax was fixed in counties in which no highway work was contemplated, and the higher rates were applied proportionately to counties in which work was to be undertaken. In force until June 1912, this tax raised about $519,000.

The Assembly also created the office of the territorial engineer to administer the design and construction of territorial roads. Appointed by the governor, the position carried a two-year term. J.B. Girand was Arizona's first (and only) Territorial Engineer. His staff consisted of a clerk and a draftsman. Soon after his appointment, Girand began the planning and construction of several territorial highways in Arizona. The strategy was to link the county seats and more populous towns through a network of graded roads that would vary in width from 16 to 24 feet according to terrain and traffic. "Inadequate and crude as the law is," Girand stated in 1911, "much progress has been made in establishing a system of highways, which, if continued, will result in this department being the most important of all, from the standpoint of revenue."[9] In connection with this highway construction, Girand supervised construction of a handful of bridges over key crossings on the territorial network. Curiously, none of these bridges resembled each other even remotely.

One of the first territorial bridges was a replacement structure for the trusses at Florence, built in 1885 and then rebuilt in 1905. In November 1909 Girand designed a multiple-span, concrete girder structure, submitted the plans and specifications to the Board of Control and advertised for competitive bids. Five contractors responded, with proposals ranging from $48,000 to $62,000. Girand then rejected all bids and convinced the board to build the Florence Bridge using convict labor. With a territorial prison in nearby Florence, the idea had merit. In March a small force of prisoners began excavating for the foundations. The crew was increased to 36 men in April, when full-scale construction began, and averaged 55 men as the work continued on the bridge throughout the rest of the year.

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[9] J.B. Girand, "Arizona Roads," *Arizona*, July 1911, 2. Girand continued:

> Nearly one thousand miles of roads have been surveyed and mapped, running through various counties, as follows: Cochise, Gila, Graham, Maricopa, Pima, Pinal, Yavapai and Yuma, and nearly one hundred miles of road have been actually built and in use, and in addition thereto, three bridges have been or are being constructed, across the more important streams of the territory. Already scores of letters of praise have been received, commending the good work being done, and while as usual, public enterprises of this character meet with opposition, still, as a whole, the better element is body and soul with this work and it will be crowned with success.

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The Florence Bridge was completed in December 1910. In observing the prison laborers, W.A. Crossland of the Bureau of Public Roads commented:

> The convicts are comfortably sheltered, well fed and well treated. Guarded prisoners are kept in barbed wire stockades, under guard when not at work. Work performed by guarded convicts costs probably more than it could be done by contract, but that prison labor could compete with day labor or force account work. The fact that prison labor under guard cannot as a rule compete with contract work is due to many reasons. The work must be such as to require the employment of at least one hundred men to keep the overhead and subsistence charges to a reasonable minimum...
>
> To sum it all up, the cost of prison labor in small numbers is prohibitive. In forces of approximately one hundred, the cost (considering efficiency) per working man per day is very nearly the same as is actually paid to the hired laborer, taking into consideration contractors' profit from boarding house and commissary. Under favorable conditions, including continuous employment for long periods at or near the same place, prison labor under guard can compete with contract work. Under other conditions it is extremely doubtful if it can do so.[10]

This seemed borne out by the experience on the Florence Bridge. The total construction cost using prison labor turned out to be only $2,500 less than the lowest contractor's bid. Girand's first reinforced concrete arch was a more modest structure, built in 1911. The year before he had designed the territorial highway between Bisbee and Douglas, and in June 1911 Girand completed the drawings for a 60-foot arch over Mule Gulch east of Bisbee. Contractors R. Toohey and Son completed the Lowell Arch Bridge [**0130**] that December. The arch still carries traffic on U.S. Highway 80, but in greatly altered form.

What was perhaps the most unusual territorial bridge was not located on a territorial highway at all, but was built at the request of the U.S. Army on a remote military road. In 1911 the Territorial Assembly funded construction of a wagon bridge over the Black River to replace an existing ford near Fort Apache. For the Black River Bridge [**3128**] , Girand built two timber/iron Howe deck trusses carried high above the river on tapered concrete piers [*see Figure 3*].

During this time Girand surveyed the site for the Fairbank bridge and built three other major structures—a three-span pinned truss with concrete abutments over the Verde River at Camp Verde, an 80-foot timber trestle at Hassayampa and a 100-foot timber trestle over Forest Wash—as well as several short-span concrete slabs built from standard plans. Without doubt the most spectacular, expensive and important bridge built by the territorial government, however, was the concrete structure over the Salt River in Tempe. Made up of eleven open spandrel arch spans, the Tempe Bridge was built by convict labor between 1911 and 1913 [*see Figure 4*].

[10] As quoted in *Report of the State Engineer of the State of Arizona*, 8-9.

Figure 3. Black River Bridge, 2002 (note: trusses shown are replacement spans, erected in 1929 over original concrete piers).

By the time Arizona was admitted to the Union on February 14, 1912, the territorial government had built over 243 miles of highway at an average cost of $2,500 per mile. Additionally, 1,812 linear feet of bridges over 100 feet in length were constructed (not including the Tempe Bridge), totaling $144,000 in value. Girand estimated that an additional 740 miles of trails and graded county roads would soon be improved to form highways, "completing the great east and west and the north and south roads."[11] Thus, surveys and construction had been undertaken on almost a thousand miles of roads in the three years since the territory had taken an active role in highway construction.

[11]The east-west territorial highway largely followed the Gila Trail through southern Arizona, beginning at the Colorado River in Yuma and extending eastward through Phoenix, Globe, San Carlos and Clifton. The north-south road began at Douglas and extended northward to the Grand Canyon through Tucson, Florence, Phoenix, Prescott and Flagstaff.

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Figure 4. Tempe Bridge, 1982 (the bridge has since been demolished).

4 Early State Bridge Construction and Transcontinental Highways: 1912-1920

With statehood, the territorial engineer was retitled state engineer and Girand was replaced by Lamar Cobb. Little else changed, as road construction continued using the same basic administrative process. In fact, several road and bridge projects begun under Girand's administration, including the Tempe Bridge, were taken over by Cobb without interruption. The major difference lay in the level of activity. Less than $200,000 were spent on road and bridge construction throughout the territory in the year that Girand took office. Six years later in 1915, over $500,000 were spent by the counties alone. Despite this progress, the state's roads were in dismal condition under the county administration. Arizona ranked last in the nation in terms of its public road system. Cobb despaired in his first report to the state legislature:

> I have been over a great many roads in every county in the state except two, and I have not found a foot of properly graded and protected mountain road or road in a rolling county that was not constructed under the direction of the (territorial) engineer department. There are a few miles of graveled road in Graham, about ½ mile in Yuma and several miles of caliche road in Maricopa. I know of no other improved roads in the state, outside of the cities, towns or special road districts, though I may have missed a half mile or so elsewhere.[12]

[12] *Report of the State Engineer of the State of Arizona*, 72.

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In June 1912 the new state legislature passed enabling legislation for the state engineer's office. Like the territorial law, the state act funded the road and bridge programs through property taxes. The levy was sufficient to raise $250,000 annually—25 percent to be expended by the state engineer on state highways and the remaining 75 percent to be distributed to the counties proportionately to collections. This tax would remain in effect until the start of federal aid in 1917.

To augment these revenues, the legislature passed the first of a series of acts providing for the licensing and governing of motor vehicles the following year. The legislature directed Cobb to delineate a network of state highways encompassing some 1,500 miles of route that would link the major towns [*see Figure 5*]. Cobb was cognizant of the need for continuity between his office and the office of the territorial engineer that had preceded him. In 1914 he wrote:

> When this administration assumed office, a tentative State Highway System had been adopted, consisting of a road from Yuma to Clifton and one from Douglas to the Grand Canyon. The routes selected had become fixed to a certain extent by the construction of several units of their length and, though not meeting with entire approval, they had also become fixed in the public mind as the State Highways. It was, therefore, thought best not to make any changes in their location as it would undoubtedly lead to others by succeeding administrations, resulting in State Highways "that would start nowhere and end nowhere," thus defeating one object of the State Road appropriation – a State system of roads composed of coordinating county units connecting every county seat in the State. The mileage of roads improved with the State Road Fund is small considering the total mileage of the proposed system and their completion with the present annual Road Fund is far removed; however, the worst places between counties and those bearing the greatest amount of traffic are gradually being improved by permanent construction, so, even without additional means, they will be put in much better condition year by year and some day be completed.
>
> The value of this department to the taxpayers of the State cannot be measured by the roads that have been built under its administration, for the examples of proper road construction it furnishes in every county is of greatest value to officials charged with the expenditure of county road funds. The Boards of Supervisors in eight of the fourteen counties have called upon this office for advice relative to road and bridge construction, four for plans and specifications, and four for our engineers to locate or superintend county road construction covering expenditures of approximately $100,000. Since the creation of this department, there has been a marked improvement in the type of road work in every county in the State which is largely attributable to the demonstration work done by this office.[13]

"This improvement is shown both in location and construction," Cobb continued, "however, the former, which is of the greatest importance, has not received the consideration it should have. Few county roads are now located in natural water courses, grades exceeding 10% are rare and more attention is being given to protecting ditches and other drainage; However, their drainage openings are as a rule entirely too small, as for instance a 36 inch culvert to carry the water necessitating a 50 foot railroad bridge."[14]

[13] *Report of the State Engineer*, 5-6.

[14] *Ibid.*, 6.

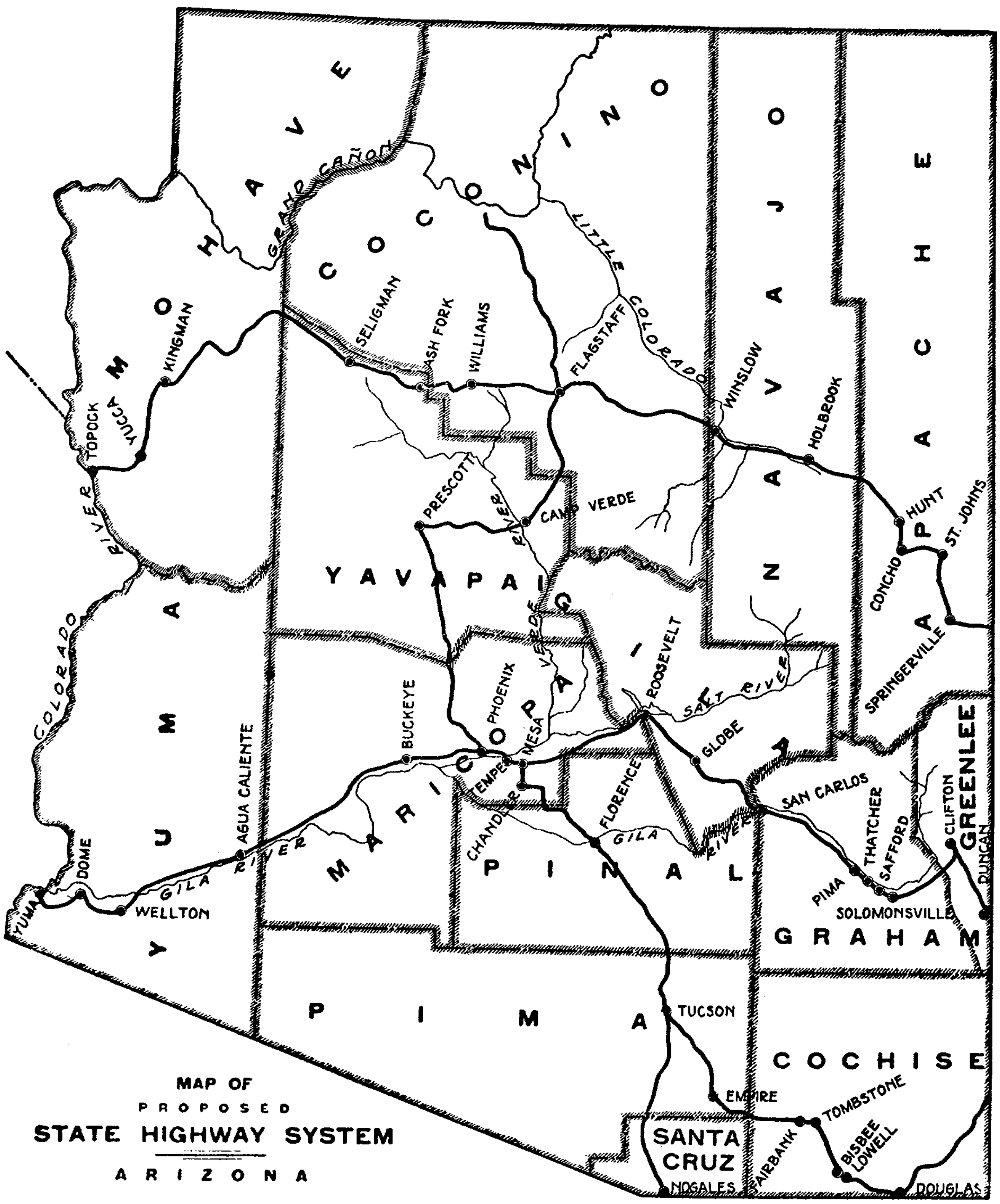

Figure 5. Map of proposed state highway system of Arizona, 1912.

During his first two years in office, Cobb undertook several important road and bridge construction projects. Without question the largest of these was the Tempe Bridge, under construction when Arizona became a state. Built using prison labor and opened to traffic in September 1913, it had originally been designed as a nine-span filled spandrel structure, but the design was changed during the course of construction to eleven open spandrel arches. Its total cost was almost $119,000. Built over the Salt River at the state's most heavily trafficked river crossing, the Tempe Bridge was unquestionably Arizona's most historically important bridge.[15] During this biennium Cobb was also responsible for a number of smaller structures totaling 1,608 linear feet for an aggregate cost of $101,000.

In 1913 the Arizona Good Roads Association published the state's first book of road maps and travel information. "At this time, trips to every part of the state are made by automobiles," the guide stated optimistically, "and while some difficulties are encountered in the remote sections, principally owing to lack of travel, these are rapidly being eliminated."[16] During the 1914-1916 biennium, Cobb continued work on the state's road and bridge system. As delineated by his office in 1916, the state highway system remained essentially unchanged [see *Figure* 6]. With the state and the individual counties undertaking the construction, improvements to the roads were made incrementally in relatively small segments. The principal difference between the entities lay in the amount of money spent. As funds allocated by the state for road and bridge work increased steadily—from $294,000 in 1912 to $487,000 in 1916—the amount of construction administered by the counties almost quadrupled from $309,000 to $1.5 million over the same four-year period.

The state engineer's office was responsible for construction of numerous small-scale drainage structures on state highways, and for these engineers began developing standard designs for short-span concrete slabs and box culverts. Cobb undertook more ambitious multiple-span structures as well, concrete girder structures similar in scale to the Florence and Tempe bridges. The largest bridge built during this period was a structure over the Gila River on the Phoenix-Yuma Highway in Yuma County. In 1912 Cobb had first surveyed sites at Antelope Hill and the nearby town of Dome and selected the former for a bridge. The next year his office designed a multiple-span concrete structure comprised of 15 girder spans supported by massive bullnosed concrete piers. The longest of these spans extended 65 feet; the bridge's overall length was almost 1,000 feet, not including the timber trestle approaches on the ends.

[15]The Tempe Bridge, later called the Ash Avenue Bridge, carried traffic until completion of the parallel Mill Avenue Bridge in 1931. Included in the first statewide historic bridge inventory in 1987, it stood abandoned in place until it was demolished in 1990. Today only the southern abutment of the bridge stands.

[16]Arizona Good Roads Association, *Illustrated Road Maps and Tour Book* (Prescott: Arizona Good Roads Association, 1913 (Reprint Phoenix: Arizona Highways Magazine, 1978)), 6. The guide continued:

> A system of State Highways is now under construction: the counties of Yavapai, Mohave and Coconino are about to construct good roads within their boundaries with money from county bond issues and cash taxes; and in many parts of Arizona new roads are being located and old highways improved. Therefore, it will be but a short time until the whole State is gridironed with travelable roads, giving easy and comfortable access to the scenic, agricultural and industrial sections of this rich commonwealth.

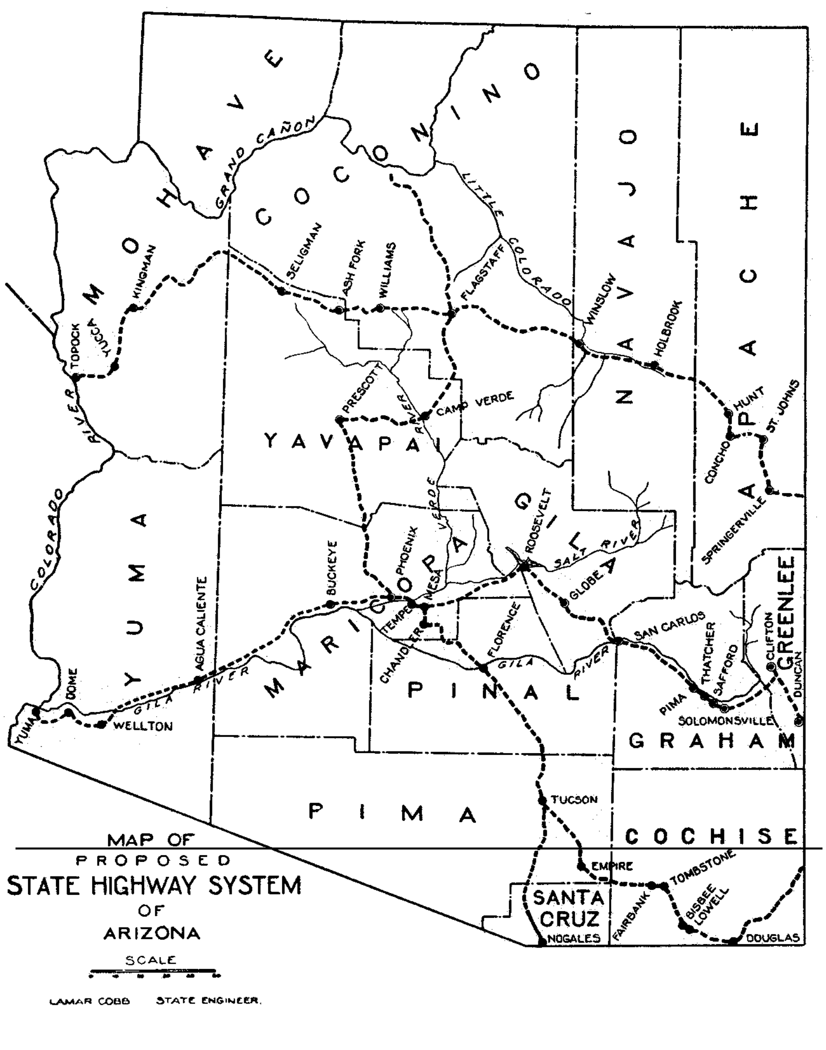

Figure 6. Map of proposed state highways of Arizona, 1916.

In December Cobb advertised for competitive bids to build the immense structure. Opting instead to use prison labor, the state rejected all bids. Cobb then redesigned and rebid the project when it became apparent that not enough prison manpower would be available. In May 1914 Perry Borchers was hired to build the bridge. But Borchers was in over his head. He began construction in June but soon defaulted, and after floods damaged the partially completed structure that winter, the state once again undertook the project with prison laborers. The Antelope Hill Bridge [**abd.**] was finally opened to traffic on August 18, 1915, with a gala picnic attended by thousands of well-wishers.

This star-crossed structure began to fail almost immediately, revealing a dangerous and expensive weakness of the state's large concrete spans. These structures were demonstrably stronger and more stable under load than their steel truss counterparts. Their poured-in-place superstructures could carry traffic well enough, but their substructures proved woefully inadequate to withstand the changeable desert rivers. As a result, the bridges collapsed in whole or in part when the piers toppled over in flood. In January 1916 floods washed away almost two miles of approach grading and widened the river's channel at the north end of the Antelope Hill Bridge by approximately 300 feet. To correct this, the State Legislature in March 1917 appropriated $50,000 to build an extension onto the north end. The new construction consisted of five additional concrete girder spans and an extensive timber trestle approach. Completed in autumn 1918, the bridge carried traffic more-or-less as intended until a flood a week after Thanksgiving, 1919, destroyed some 500 feet of the north approach and shifted some of the concrete piers on the extension.

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Further flooding three months later dropped about 300 more feet of trestle, the north abutment and the northernmost girder. Worse, the floodwaters caused several of the piers on the extension, already damaged by the previous flood, to further shift downstream. "The Antelope Hill Bridge is located at a point where it is impossible to control the river and keep it under the bridge at any reasonable cost," complained State Bridge Engineer Merrill Butler in 1921. "Foundation conditions are bad and a permanent extension would necessarily be long and costly with the strong possibility that the same situation would again develop in a few years." Butler concluded prophetically, "The foregoing, together with the apparent need for expensive repairs to two of the existing piers, should mitigate against anything except some form of temporary construction."[17] [See *Figure 7*.]

Figure 7. Ruin of Antelope Hill Bridge, 2003.

[17]State of Arizona, State Engineer, *Fourth Biennial Report of the State Engineer to the Governor of the State of Arizona: 1918-1920* (Phoenix: Republican Print Shop, 1921), 66-67. Within two years, AHD had rerouted the road to bypass the Antelope Hill Bridge entirely. The bridge was replaced in 1929 with the Dome Bridge [**abd.**]. It now stands in ruins, with several of its concrete piers and girder spans washed away.

Actually, the Antelope Hill Bridge suffered from at least three major engineering shortcomings, which combined to make it a maintenance nightmare. First, the bridge was poorly situated on a sweep of the river that was prone to extensive flooding. Second, the piers were poorly founded on spread footings instead of driven piles and were provided with insufficient scour protection. Finally, without shore rectification works to constrict and guide the river, the Gila was allowed to shift channels unchecked, putting unbearable pressure on the bridge's north spans and approaches. All these problems could have been addressed properly during initial construction. Engineers had learned to cope with similar problems of far greater magnitude on the Missouri River 40 years earlier. But the deceptively placid nature of the Gila River at normal stage did not prepare the engineers for its radical character change in flood.

Another perennial problem for the state was the Agua Fria River Bridge at Coldwater, built about the same time as the Antelope Hill Bridge. In 1915 Cobb designed the bridge with 37 concrete girder spans, supported by concrete column bents. Construction began in December. Three months later, heavy flooding forged a new channel on the opposite side of an island about 1,000 feet upriver from the bridge site. Rather than re-design the bridge to accommodate the shift in channel, the engineers continued building it as drawn, now only over a dry streambed, and attempted to re-divert the river back into its earlier bed by filling the new channel. When the bridge's west approach washed out the first winter, the legislature appropriated funds for reconstruction and channel work. This lasted until the Thanksgiving flood of 1919, when seven spans and both approaches collapsed. Subsequent floods carried away five additional spans. As the state tried to keep up with the repairs, the approaches washed away with every flood. "The location and foundation conditions are both extraordinarily poor," stated Merrill Butler, "but the bridge is on a main highway, a road of great economic importance, and in a section where no better site can be found within a reasonable distance."[18]

Cobb and his successors, Thomas Maddock and B.M. Atwood, experienced significant problems with other multiple-span concrete structures, including the Tempe Bridge and the Florence Bridge. But not all of the state's major early spans were structurally suspect. The Santa Cruz Bridge in southern Arizona was comparatively trouble-free. In 1915 the Arizona State Legislature appropriated $12,500 from the state's General Fund for construction of a major bridge over the Santa Cruz River on the Nogales-Patagonia Highway. Atwood located the site for this bridge some 5½ miles northwest of Nogales and, because its construction was contingent on an equal contribution from Santa Cruz County, waited until the county appropriated its share early in 1916. Atwood then surveyed the site and engineered this concrete deck girder bridge.

With a design similar to the Antelope Hill Bridge, the structure consisted of three 65-foot two-girder spans, with eight shallower 32-foot spans over the flood plain east of main river channel. The spans were supported by massive concrete piers built with bullnosed ends to withstand flooding on the Santa Cruz. The bridge featured a concrete deck poured integrally with the girders. This was flanked on both sides by steel pipe guardrails. Rather than let the bridge's construction out for competitive bid or bring in prison laborers, Atwood instead opted to build it using day laborers under state supervision. In May a state work force be-

[18] *Fourth Biennial Report of the State Engineer*, 68. Like the Antelope Hill Bridge, the Coldwater Bridge was eventually abandoned by the highway department as unsalvageable.

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gan construction of the bridge under the direction of General Foreman F.W. Haynes. The crew completed the Santa Cruz Bridge [**8166**] early the next year for a total cost of about $38,000 [*see Figure 8*].[19]

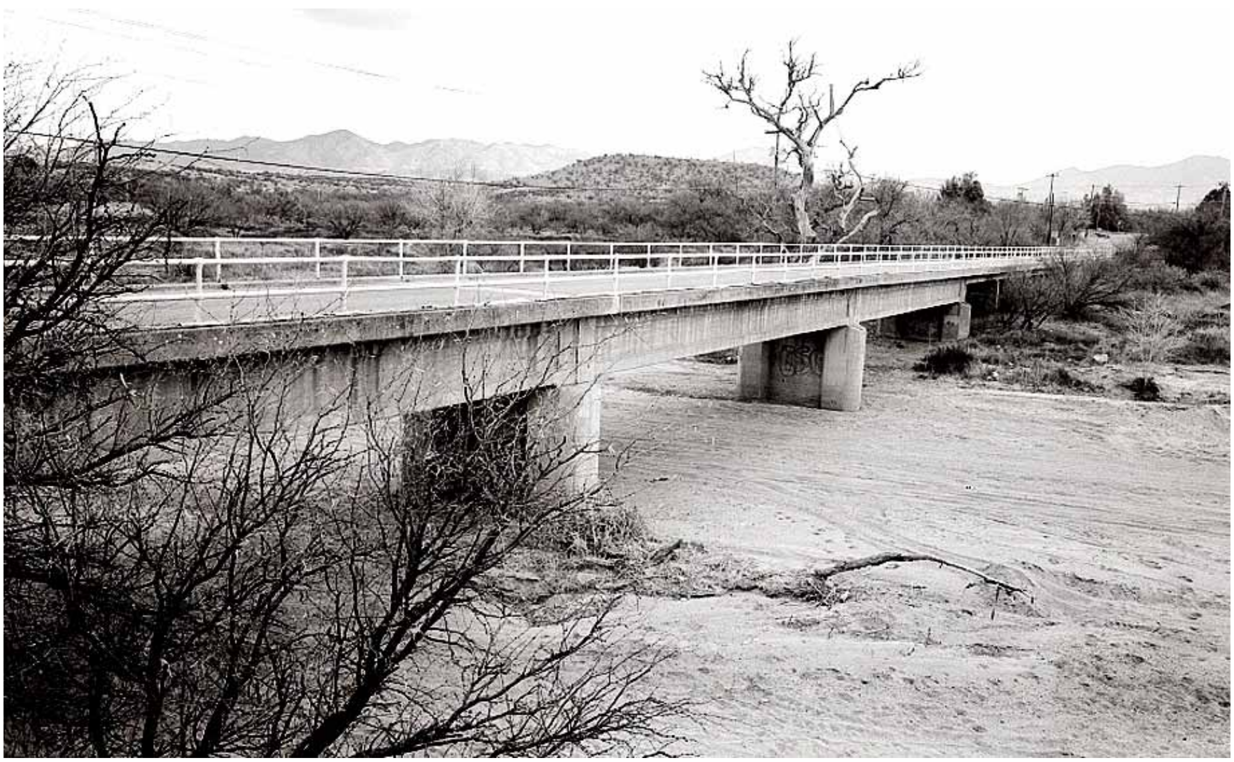

Figure 8. Santa Cruz River Bridge, 2002.

When the automobile was introduced in the United States from Europe, it was generally believed that its widespread adoption would be delayed by the relatively poor condition of the country's roads. "Because motor vehicles for common roads are practicable in France and England, it does not follow that they would be in America," *Scientific American* stated in 1895. "The roads in those countries are almost perfection; but in this country a fairly good road is the exception. . . The roads in America are not good enough except in certain localities yet to permit of a very rapid development of the automobile carriage, but their use in great cities is likely to be rapid."[20]

[19] The Santa Cruz Bridge carried mainline highway traffic until a route realignment in 1927. It has since functioned as a county bridge in unaltered condition.

[20] "New Prizes for Motor Carriage Competitions," *Scientific American* 73:40 (20 July 1895).

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The first inventory of American roads, conducted in 1904, revealed that of some 2.1 million miles of roads in the country only 7 percent had any surfacing at all. Those that had any applied surface were almost all gravel, and virtually none of America's roads were sufficient to carry steady motorized traffic. The best roads were located, naturally enough, in the heavily populated New England and Middle Atlantic states. The worst were in the South and Midwest, where rain turned the roads into bottomless gumbo. The West, with its long distances between settlements that required almost universal use of horse-powered travel, offered numerous dirt roads but few that could accommodate automobiles.

Like much of the West, Arizona was slow to embrace the automobile in the early 20th century, largely due to the wretched condition of its roads. The first auto in the state was reportedly brought into Tucson by Dr. Hiram Fenner around the turn of the century. This was soon followed by cars in Phoenix; by 1913 some 646 vehicles were registered in Maricopa County. As in other states, Good Roads Associations took root in Arizona in the early 1900s, largely driven by recreational bicycle riders. The bicyclists formed clubs, which collectively organized the national League of American Wheelmen [LAW] in 1880.

As one of the leading proponents for good roads in the late 19th century, the league began publishing *Good Roads* magazine in 1892 with the slogan"Lifting Our People Out of the Mud." That year another group, the National League for Good Roads [NLGR], formed to give voice to rural farmers and ranchers weary of the deplorable condition of the nation's farm-to-market roads. These were joined by the National Good Roads Association [NGRA] at the turn of the century. Collectively known as good roaders, these groups had organized to promote better roads in cities, where they were bad enough, and in rural areas, where they were virtually impassible.

More than any other group in America, the good roaders were responsible— both directly through "Good Road Days" volunteer construction efforts and indirectly through political lobbying among local and state officials—for the improvements made in the country's highways during the formative years. "The good roads agitation is now on a footing such as it never had in the past," stated Colonel Albert A. Pope in 1903. "For this, no doubt, much credit should be given to the various automobile clubs and associations scattered throughout the country. It was none the less creditable to these bodies that their share in the movement has been so unobtrusive that now, for the first time, the demand for better highways may be said to be in every sense a popular one."[21]

The Good Roads Movement was from its inception politically oriented. Good roaders recognized that the only way to effect wholesale improvements on the nation's roads was through the government. Partially in response to their hectoring, the federal government in 1893 established the U.S. Office of Road Inquiry [ORI] to assess the lamentable condition of the nation's highways and consider the best strategies for road

[21]Colonel Albert A. Pope, "Automobiles and Good Roads," *Munsey's Magazine* 29:168 (May 1903). Pope, a Connecticut coach and bicycle manufacturer, had a vested interest in promoting good roads. He favored electrical power for autos over internal combustion, stating emphatically, "You can't get people to sit over an explosion!"

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management. Location of the ORI in the Agriculture Department indicated the rural thrust of the government's response to the good roaders. Though the Office did little more than study the issue of good roads, its formation marked the first acknowledgment by the federal government of the coming importance of automobile travel. Gen. Roy Stone, who headed the Office, estimated that the cost to transport goods over the roads was three times more than it should have been, had the roads been improved. He arrived at this estimate based on the additional time required to travel the poor roads and the additional wear and tear on automobiles, wagons and livestock.

President William McKinley referred to the Office in a message to Congress in 1901, when he stated: "There is a wide-spread interest in the improvement of our public highways at the present time, and the Department of Agriculture is co-operating with the people in each locality in making the best possible roads."[22] In 1903 his successor, Theodore Roosevelt, along with Roosevelt's opponent in the 1904 election, William Jennings Bryant, attended the National Good Roads Convention in St. Louis. That year the organization managed to get highway legislation before Congress. The Brownlow-Latimer Federal Good Roads Bill would have involved the federal government in road construction for the first time, had it not been defeated. In subsequent years the Automobile Club of America and the American Motor League were instrumental in undertaking ambitious programs to install signboards to warn of dangers along the highways, both through their own efforts and through lobbying state legislatures.

In 1904 the Office of Road Inquiry initiated what it called its "object-lesson" program, building relatively short segments of improved roads to demonstrate their utility. ORI representatives would travel to good roads meetings on "Good Roads Trains", construct demonstration roads and proselytize for the cause of road improvement. By 1905 the ORI, renamed the Office of Public Roads, had built almost 40 miles of object lesson roads in 100 separate projects.

The Good Roaders in Arizona were responsible for the promotion of road improvement throughout the state, though they tended to concentrate their efforts more in the urban areas, particularly Phoenix and Tucson. The group's efforts began to show results in the 1910s with the bitulithic paving and construction of a major multiple-span concrete girder bridge over the Salt River on Central Avenue in Phoenix. This was followed by smaller-scale paving projects in Tucson, Bisbee and Flagstaff. "The lesson to be drawn is manifest," a writer in *Arizona* magazine stated in 1916. "Good roads do not 'grow' in Arizona, nor elsewhere, and the fact that Arizona is getting them is license to regard them as one of our best and most promising 'manufactures,' even though they are not made in a big mill building and sent out on freight cars. Besides all their virtues in highways there is an economic consideration in the pay rolls they maintain and the attendant business they develop during construction—home money, paid to home people, and kept chiefly in home circulation."[23]

[22]Quoted in John L. Butler, *First Highways of America* (Iola: Krause Publications, 1994), 59.

[23]"Good Roads in Arizona." *Arizona*, April 1916, 10.

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Outside of the major cities, however, the roads and bridges were noticeably less developed. Even the major routes in the state were little more than wagon tracks, troubled by steep, rocky grades in the mountains and shifting sand in the desert. In its appropriations for road and bridge construction, the state legislature was responding not only to requests from its Arizona constituency but to pressure from out-of-state tourists as well. The Petrified Forest near Holbrook was designated a national monument by President Theodore Roosevelt in 1906. Grand Canyon National Park was established in 1919 and quickly became one of the county's premier scenic attractions. These and a profusion of other sites drew tourists from all directions. In the late 19th century, visitors had generally arrived aboard trains or stagecoaches. The time and expense of this type of travel limited it generally to only the most well-heeled tourists. This began to change with the advent of the motorcar, however. Tourism was now within the reach of the middle class. As people gained more mobility between towns that had previously been isolated, and, perhaps more importantly, as merchants began to gauge the value of the tourists that were taking to the Western roads in cars or motor coaches, the need for better roads became more urgent.

Added to this was the movement for transcontinental highways. In the absence of federal participation in road building, several quasi-public organizations formed to promote specific transcontinental or transregional routes in the 1910s. Capitalizing on the incipient demand for long-distance auto travel, these groups sponsored auto reliability contests and focused attention on the poor shape of the nation's roads. The most famous of these early proto-highways was the Lincoln Highway, established in 1912 as America's first coast-to-coast road between New York and San Francisco. Formed at about the same time was the National Old Trails Road between Baltimore and Los Angeles. Several other privately designated highways also took root during this formative period.

By 1922 a myriad of transcontinental highways had been routed across America. Among these were the Theodore Roosevelt International Highway between Portland, Maine, and Portland, Oregon; the Midland Trail between Washington, D.C., and Los Angeles; the Old Spanish Trail between Tallahassee and Los Angeles; and the Dixie Overland Highway between Savannah and San Diego. Additionally, there were numerous shorter routes, such as the Blue Pole Highway between Fremont and Chadron, Nebraska; the Mohawk Trail between Greenfield, Massachusetts, and Schenectady, New York; and the Custer Battlefield Hiway [their spelling] between Des Moines and Glacier National Park. Most extended east-west, but a few—the Evergreen Highway between Portland and El Paso; the King of Trails Highway between Winnipeg and Brownsville, Texas; the Jackson Highway between Chicago and New Orleans and the Jefferson Highway between Winnipeg and New Orleans—ran south-north.

These roads were designated, promoted and maintained by local commercial and governmental organizations along their routes. Their sponsoring associations often published trail guides and newsletters extolling the virtues of their particular routes. The trail associations typically marked their routes by painting insignias on posts, rocks, telephone poles, barns or any other roadside object that would stand still. Highways in name only, these early routes typically followed existing roads, with the level of road maintenance varying

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widely from route to route and even from mile to mile on the same route. The named highways often overlapped confusedly as they zigzagged across the country. This was especially true in the West, where there were often several named routes but relatively few route choices available due to the daunting terrain.

Two of these early booster-sponsored highways crossed Arizona [*see Figure* 9]. The first of these, the National Old Trails Highway (also called the Santa Fe Highway), followed the Atchison, Topeka & Santa Fe Railroad—which itself generally followed Beale's Road—over the width of the state. Followed by the National Park to Park Highway and later incorporated into Route 66 between Chicago and Los Angeles, this highway formed the major east-west route across northern Arizona in the 1910s and 1920s. Despite its importance to interstate commerce, the route was "just dirt all through Arizona," according to Valentine, Arizona, resident Robert Goldenstein. "A [50-mile] trip to Kingman might take two days if the washes was running."[24] The highway entered Arizona from the east at Lupton on the Navajo Indian Reservation, paralleled the Rio Puerco to Holbrook, and then extended west through Winslow, Flagstaff and Kingman before crossing the Colorado River at Topock.

Similarly, the old Gila Trail—designated as the east-west territorial road and later the primary east-west state highway—was incorporated into the Pikes Peak Ocean-to-Ocean Highway. All or part of this route was overlaid in Arizona by other named highways such as the Borderland Route, the Dixie Overland Highway, the Old Spanish Trail, the Bankhead Highway, the Lee Highway and the Atlantic Pacific Highway. This road, portions of which were the most heavily trafficked in the state, touched Douglas, Benson, Tucson, Florence, Phoenix and Yuma on its way across southern Arizona. Towns along the route that had been established to serve the railroad eventually transformed themselves into highway towns, sprouting motor courts, diners and service stations to ply the car-bourne trade. Dome, Wellton, Agua Caliente and Buckeye straddled the road between Yuma and Phoenix. The Plank Road west of Yuma was part of the highway. Comprised of boards lashed together by cable, this eight-foot-wide road crossed the desert between Yuma and Holtville, California. The road was built in 12-foot sections to permit quick disassembly and relocation around the shifting sand dunes. A well-known local landmark, the Plank Road was a latter-day equivalent to the 19th century corduroy roads built in the upper Midwest.

The Ocean-to-Ocean Highway suffered from the same poor maintenance as the Old Trails Route. Upkeep of the road from Phoenix to Yuma had been shared by Maricopa and Yuma Counties over the years, with predictably uneven results. Territorial Engineer James Girand had surveyed a 202-mile route between the two cities, with the counties sharing the engineering cost, but had not undertaken any substantial construction on the route. Little changed during the first two years of Lamar Cobb's

[24]Quoted by Susan Croce Kelly, *Route 66: The Highway and Its People* (Norman: University of Oklahoma Press, 1988), 60-61.

Figure 9. Clason's Guide Map of Arizona, 1918.

tenure as state engineer. In 1914-1915 Yuma County undertook repairs of the highway east of Yuma. At this time the state undertook construction of the Antelope Hill Bridge. At the same time the Office of Indian Affairs erected a long-span steel truss that carried the highway over the Colorado River at Yuma. The major river crossings on the route's western end had thus been addressed, but the state had yet to make improvements to the eastern section of the Phoenix-Yuma Highway. In 1914 Cobb commenced work on the section between Arlington and Agua Caliente, "on account of this section being the worst part of the road."[25] Highway engineers were faced with a choice of courses to take: the southern route through Woolsey Park and Point of Rocks (which was then in common use), or the northern route by way of Fourth of July Butte and Yellow Medicine Wash. According to Cobb:

> It was found that both routes presented many difficulties and disadvantages. The southern route would have required a great deal of heavy rock work to get through Woolsey Wash and past the Point of Rocks. It also ran for many miles through the silt bottom land of Cottonwood Wash and the Gila River—the poorest kind of material for road purposes— and the outlook for obtaining anything better for surfacing was very discouraging, as there was nothing suitable that would give a shorter average haul than about ten miles. There were also many large and unconfined washes to cross. The northern route ran through a somewhat rougher country and was a few miles longer, but the material was, in the main, of a suitable character for surfacing, and there was a great deal less drainage to be looked after. For these reasons it was decided upon as being the one that would prove most economic eventually.[26]

Most of the roadwork in this area involved the rugged stretch of the highway between Lowdermilk and Yellow Medicine Washes. In this three-mile section the crew graded the road and built two small steel bridges. The highway followed the north side of the Gila River all the way from Antelope Hill to Phoenix, thus avoiding the need to build another costly bridge over the river. In 1915-1916 the highway department built a multiple-span concrete girder bridge on the highway over the Agua Fria River at Coldwater, and a timber-pile bridge over the Hassayampa River at the town of Hassayampa. But it became increasingly evident that, rather than follow north of the Gila, the better route to take would be south of the river, along the original Gila Trail. "The greater portion of the [northern] route followed the bottom lands along the Gila River and was on light, silty soil which would have required expensive surfacing," stated Thomas Maddock in 1920. "The floods of Thanksgiving, 1919, and those of the latter part of February, 1920, submerged a large portion of the located line and demonstrated beyond question that this location was not feasible."[27] Flooding along the Gila River had washed out a large portion of the highway between Wellton and Agua Calinete. Moreover, both the Antelope Hill and the Coldwater Bridges had become an embarrassment to the department, washing out with almost every major flood.

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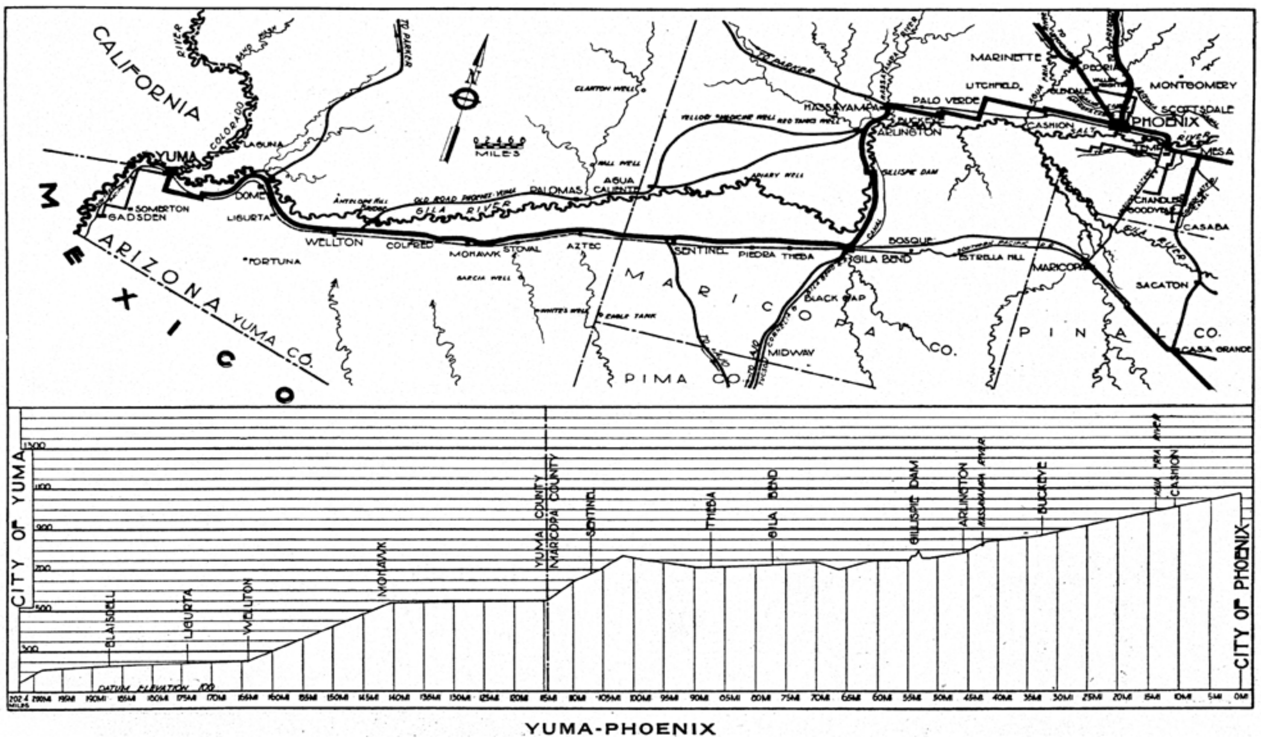
[25]**State of Arizona, State Engineer, *Second Report of the State Engineer to the State Highway Commission: 1914-15 and 1915-16 .* (Phoenix: The McNeil Company, 1916), 395.**

[26]***Ibid.***

[27]State of Arizona, State Engineer, *Fourth Biennial Report of the State Engineer to the Governor of the State of Arizona: 1918-1920* (Phoenix: Republican Print Shop, 1921), 56.

By 1920 the highway department had decided to re-route the road [*see Figure 10*]. According to Maddock, "The survey for a complete highway from Phoenix to Yuma has been made. In view of the floods in the winter of 1919-1920 and the desire of the Yuma Highway Commission to connect with both Phoenix and Ajo, also in realization of the necessity for a highway from the Capital of the State to Ajo, this survey was run on the south side of the Gila River from Yuma to Gila Bend, thence in a northerly direction through the area proposed to be irrigated from the Gillespie Dam, now under construction, and thence to Arlington."[28]



■ Figure 10. Map of proposed Phoenix-Yuma Highway, 1920

Adoption of the southern route meant that the highway would have to cross the Gila River at some point west of Phoenix. The solution for a Gila River crossing came from an unlikely source—agriculturalist Frank A. Gillespie. A native of Oklahoma, Gillespie had established the Gillespie Land and Irrigation Company to acquire thousands of acres of agricultural land between the Gila River and the town of Gila Bend. The lifeblood of his ranching and farming domain flowed through a system of irrigation canals branching from the Enterprise Canal, built in 1886. The canal's headgate was situated on

[28]*Ibid.*, 78.

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the Gila River about 45 miles southwest of Phoenix, at a narrow pass between the Buckeye Hills and the Gila Bend Mountains. Here earlier irrigators had built a diversion dam of earth, rocks and brush to impound water on the Gila River and divert its flow into the canal. Built in 1894, the Peoria Dam had washed out in 1900 and was replaced in 1906. In place of this latter structure, Gillespie proposed building a substantial concrete dam. To design the immense structure, he hired former Arizona Territorial Engineer James Girand. Girand delineated a multiple-arch structure, 1,768 feet in length and 56 feet tall that would span the river at the existing masonry intake for the canal. Construction commenced in 1919; the Gillespie Dam was completed in 1921 for a cost of about $3 million.

Situated as it was in a relatively constricted stretch of the river, this crossing had long been in use on the old Gila Trail before the road was rerouted north of the Gila River in the early 1910s. Before the advent of automobiles, stagecoaches had used the ford south of the present-day dam. In a setup worthy of a bar joke, the *WPA Guide* described one perilous crossing at high water:

> On one occasion two nuns, a gambler, and a soldier hung on the outside and upstream side of the coach in order to counterbalance the flood current. As the story goes, this stratagem, plus the driver's goading of his struggling horses, the nuns' praying, the gambler's cursing, and the soldier's shouted encouragement, brought the coach safely to the opposite shore.[29]

The Arizona Highway Department [AHD] could not rely on the historic ford for use on a major transcontinental route, so engineers had to devise another means to cross the Gila here. A bridge would have been prohibitively expensive. "We doubt that any bridge crossing of the Gila River," stated Maddock, "from its junction with the Salt to its confluence with the Colorado, can be secured for less than between three and four hundred thousand dollars."[30] As early as the summer of 1919, Maricopa County had proposed building a vehicular bridge across the dam, using the arch piers to support the bridge superstructure. The county offered to pay $3,300 (later increased to $4,842) to defray the cost of extra foundation piles under the piers of the dam. The cost of the bridge itself would apparently be borne by the state. The offer was so insignificant that it received little serious consideration, however, either from the dam company or from the highway department. It was quickly shelved.

AHD instead opted to build a concrete apron onto the downstream toe of the Gillespie Dam, the construction of which would cost some $125,000. The apron was built soon thereafter, and autos began driving behind the dam sometime in 1922. Automobiles could drive over the apron unassisted during low water, but when the Gila was in full flow, several cars would be chained together in a makeshift train and pulled across the dam by a truck [*see Figure 11*]. When the Gila was flooded, traffic across the apron stopped altogether.

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[29]*The WPA Guide to 1930s Arizona* (reprint ed., Tucson: University of Arizona Press, 1989), 218. The *Guide* relates another story about the killing here of a bandit named, ironically, Innocente Valenzuela. Valenzuela and two accomplices had murdered and robbed the superintendent of the Vulture Mine, who was on his way to Phoenix. The posse caught the robbers at the Gila River ford and killed Valenzuela.

[30]*Fourth Biennial Report of the State Engineer*, 78.

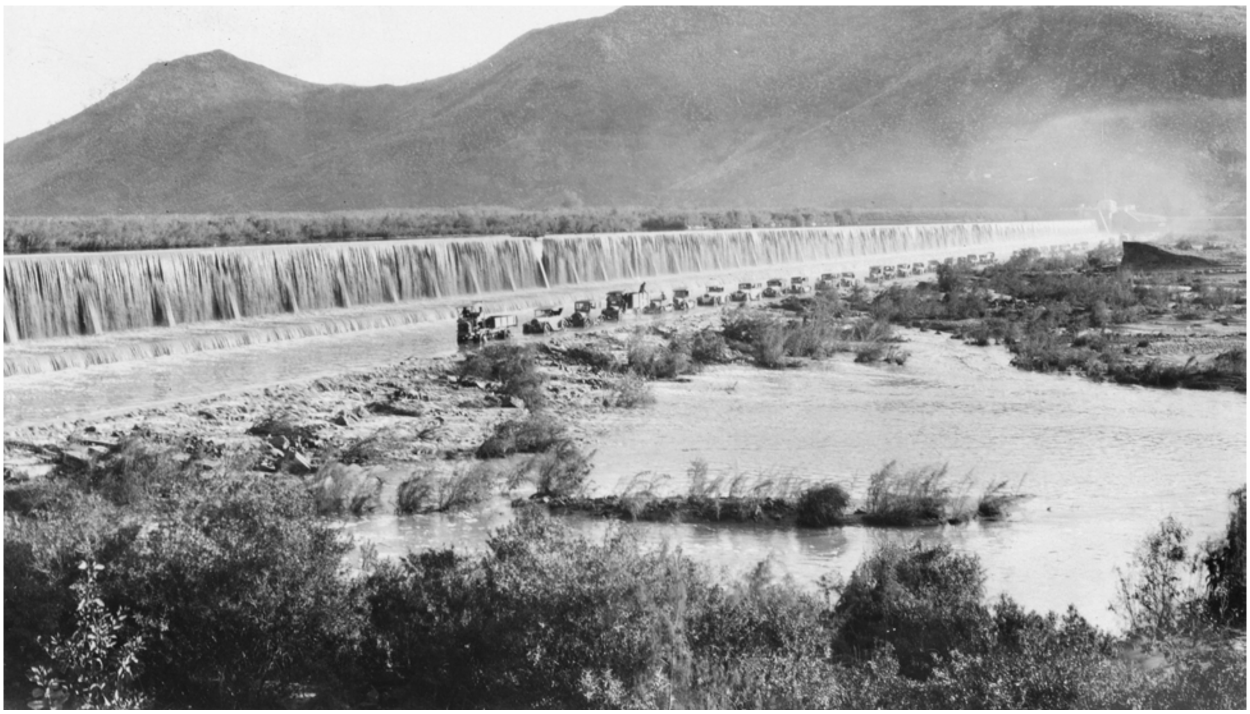

Figure 11. Truck pulling train of cars across Gillespie Dam apron, circa 1926.

Despite their active promotion for their highways, none of the early highway organizations had the financial wherewithal to undertake actual large-scale construction. Road and bridge construction in Arizona was still the responsibility of the state and the counties in the 1910s. As one of the counties through which the Old Trails Highway passed, Navajo County was responsible for maintenance of the road under its jurisdiction. The highway entered the county on the east at the Petrified Forest National Monument and extended westward to Holbrook. From there the route angled northwestward along the old Beale's Road past St. Joseph to Winslow. By keeping south of the Little Colorado River, the road missed the region's major watercourse, but steep-walled chasms at Clear Creek, Chevelon Creek and Jacks Canyon southeast of Winslow could not be avoided.

As one of the few existing wagon bridges in the area, the existing Clear Creek Bridge formed a pivotal point for the highway. The road was routed over the truss erected by Apache County in the 1880s. At Chevelon Creek, J.B. Girand first surveyed the highway crossing in 1911, at the request of the county. A year later, at Lamar Cobb's recommendation, the newly formed state legislature appropriated $5,500 from the state road fund for construction of a substantial structure there. Cobb delineated a long-span pony truss for the cros-

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sing, and in October 1912 the state contracted with the Missouri Valley Bridge & Iron Works for the bridge. A Missouri Valley crew began construction late in 1912, pouring concrete abutments onto the solid rock rim of the canyon. For this crossing, the company engineered a 100-foot-long Warren truss, with rigid connections and polygonal upper chords. In January Cobb approved the truss's design. In July the bridge was opened to traffic [*see Figure 12*].

Figure 12. Chevelon Creek Bridge, 2003.

As the Chevelon Creek Bridge was nearing completion, Navajo County contacted Cobb with a request for another vehicular bridge over Jacks Canyon about 4½ miles southeast of Winslow. After visiting the site, Cobb designed a small reinforced concrete slab to span the narrow canyon. That year force account laborers on the state payroll constructed the bridge for a cost of $1,163 [*see Figure 13*]. The plank formwork was crude, the design simple and unarticulated, and the guardrails were threaded steel pipes—indicative of the early construction by an unskilled work crew.

Figure 13. Jacks Canyon Bridge, 2002 (note: bridge is presently abandoned, with its steel guardrails removed).

During the 1913-1914 biennium, Navajo County undertook the construction of 3¾ miles of the Old Trails Highway between the Clear Creek and Chevelon Creek bridges. The following biennium the county graded and drained another four-mile segment of the road between Winslow and Holbrook. Work on the route progressed in this manner over the next few years, as the county made incremental improvements to the route using state road funds. Navajo, like other Arizona counties, often put off building bridges at river and stream crossings as long as possible, instead pouring concrete fords in the streambeds, even on major highways. "That's where tourists would get into trouble," stated Holbrook mayor Dick Mester of the Old Trails Highway. "They would see water in the dip, and when they tried to go around the water they would get into quicksand. As long as the water wasn't rushing or too deep, they could stay in the concrete and do just fine."[31]

Navajo County's experience typified road and bridge construction in Arizona. Using their share of the State Road Fund and adding considerable amounts of money from county road funds, the counties were still

[31]Quoted by Susan Kelly, 30.

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undertaking most of the road work during this period. Many of the bridges in use today on secondary roads in Arizona were funded and contracted for by the counties as part of their bridge construction programs. Unlike the state engineer, the counties rarely had the in-house facilities to design major bridges and could not tap the sizable labor pool in the state's prisons. Despite their lack of expertise, they rarely relied on the state for engineering assistance. "Counties do not avail themselves to any great extent of the services of the State Engineer, AHD engineer W.A. Crossland stated in 1914. "This is due to no disinclination on their part, but to the fact that the engineer's organization is limited and he cannot always furnish the assistance requested of him."[32] Counties, therefore, tended to hire bridge companies or contractors for all but the smallest spans.

These firms marketed prefabricated steel structures, built from standard designs and purchased by the counties through competitive bidding. The steel was produced in the major foundries (Carnegie, Cambria, Lackawanna, Inland) in Illinois and Pennsylvania. The foundries supplied rolled steel parts to fabricators such as the American Bridge Company of Chicago, the Omaha Structural Steel Works on Nebraska, the Midwest Steel and Iron Works of Denver or the Phoenix-based Allison Steel Company. These firms in turn marketed complete, prefabricated trusses to bridge contractors who assembled the superstructures on the sites. Because the government entities of Arizona contracted for so few steel bridges, no indigenous steel bridge company of note ever developed. Those few local firms such as S.T. Clark of Bisbee that occasionally built steel trusses were far more dependent on other forms of contracting. The counties relied heavily upon out-of-state contractors for both design and construction of their bridges, and most of the major steel spans in the state were fabricated and built by out-of-state firms.

The same bridge contractors' names cropped up at almost every county bid letting, as a relatively small coterie of firms competed for a limited number of commissions. Among the out-of-state bridge companies active in Arizona during the 1910s and 1920s were the El Paso Bridge and Iron Company (Walnut Grove Bridge [**8227**]); the Midland Bridge Company of Kansas City (Allentown Bridge [**3073**], Cameron Bridge [**abd.**]); the Monarch Engineering Company of Denver (Sanders Bridge [**3074**], Little Hell Canyon Bridge [**abd.**]); Missouri Valley Bridge and Iron Works of Leavenworth, Kansas (Chevelon Creek Bridge [**8158**], Fish Creek Bridge [**0027**], Lewis and Pranty Creek Bridge [**0028**]); Levy Construction Company (Dome Bridge [**abd.**]); Kansas City Structural Steel Company (Navajo Bridge [**0051**], Topock Bridge [**abd.**]); and the Omaha Structural Steel Works of Nebraska (Saint Joseph Bridge [**8157**], Woodruff Bridge [**8156**], Yuma Bridge [**8533**; [*see Figure 14*]]).

Given Arizona's proximity to southern California, it is surprising that almost all of the contract work went to bridge companies from the South and Midwest. Although California firms submitted proposals, only one major bridge, the Winslow Bridge, built in 1916 by Los Angeles-based Mesmer and Rice, was constructed by a California-based firm. And it was composed of trusses manufactured in Chicago by the American Bridge Company.

[32] *Report of the State Engineer*, 13.

Figure 14. Letterhead of Omaha Structural Steel Bridge Company, 1919.

Each government entity had structural configurations upon which it relied principally. Counties tended to erect steel trusses and stringers because they could obtain the engineering as part of the bridge solicitation process. The state engineer, like the territorial engineer before, employed reinforced concrete for a wide range of bridge applications. Concrete has a number of advantages in Arizona. First, a properly constructed concrete bridge was considered more substantial than a steel or wooden structure. Concrete was more flood-resistant and more stable under load. Short-span concrete structures could be built using standard specifications. This allowed a limited staff of engineers to design a disproportionately large number of drainage structures, badly needed on a rapidly growing road network. Unlike steel, which had a centralized system of manufacturing and marketing, concrete could be manufactured using locally procured materials. Finally, mass concrete technology was more rudimentary than steel, allowing the state to undertake bridge projects using small-scale contractors or unskilled crews of convicts or day laborers.

Structures such as the Tempe, Florence, Antelope Hill, Coldwater and Santa Cruz Bridges represented major technological accomplishments. Most of the earliest concrete bridges in Arizona, however, consisted of relatively modest spans, either simple slab or girder, used singly or in multiple-span iterations. These served well for minor washes or for rivers with wide flood plains. When the state engineer began planning bridges for intermediate watercourses and canyons, it became evident that long-span structures would be needed. Long spans in concrete at that time meant arches. For these earliest structures, Lamar Cobb turned to the engineering of America's pre-eminent arch builder of the time, Daniel B. Luten. An Indianapolis engineer, Luten patented a reinforced concrete arch design in 1900. His distinctively shaped design was so popular that in the first ten years he built some 4,000 Luten, or horseshoe, arches across America.

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Arizona first associated with Luten in 1913. That year one of Cobb's assistants surveyed a bridge site over Canyon Padre, a rock-walled chasm on the Old Trails Highway. Cobb contracted with the Topeka Bridge and Iron Company, western representative of Luten's National Bridge Company, for design and construction of the bridge. Completed in April 1914, the Canyon Padre Bridge [**abd.**] was a 140-foot arch with a cantilevered roadway [*see Figure 15*]. A few months after it was completed, Cobb contracted with Topeka B&I for design of a second arch span, over Canyon Diablo, also on the Old Trails Highway. Although the drawings were submitted by Topeka, Luten himself engineered the 128-foot arch. Like the Canyon Padre Bridge, the Canyon Diablo arch featured a cantilevered roadway with reinforced concrete brackets and parapet walls. The Canyon Diablo Bridge [**abd.**] was completed in March 1915 by a local contractor, Thomas Maddock of Williams. Cobb designed the third arch himself, in consultation with Luten. Intended as a replacement for an earlier steel truss that had washed away, the Holbrook Bridge [**abd**.] in Navajo County featured an extraordinarily long 174-foot span length. It was completed in March 1916. The next year Maddock succeeded Cobb as state engineer.

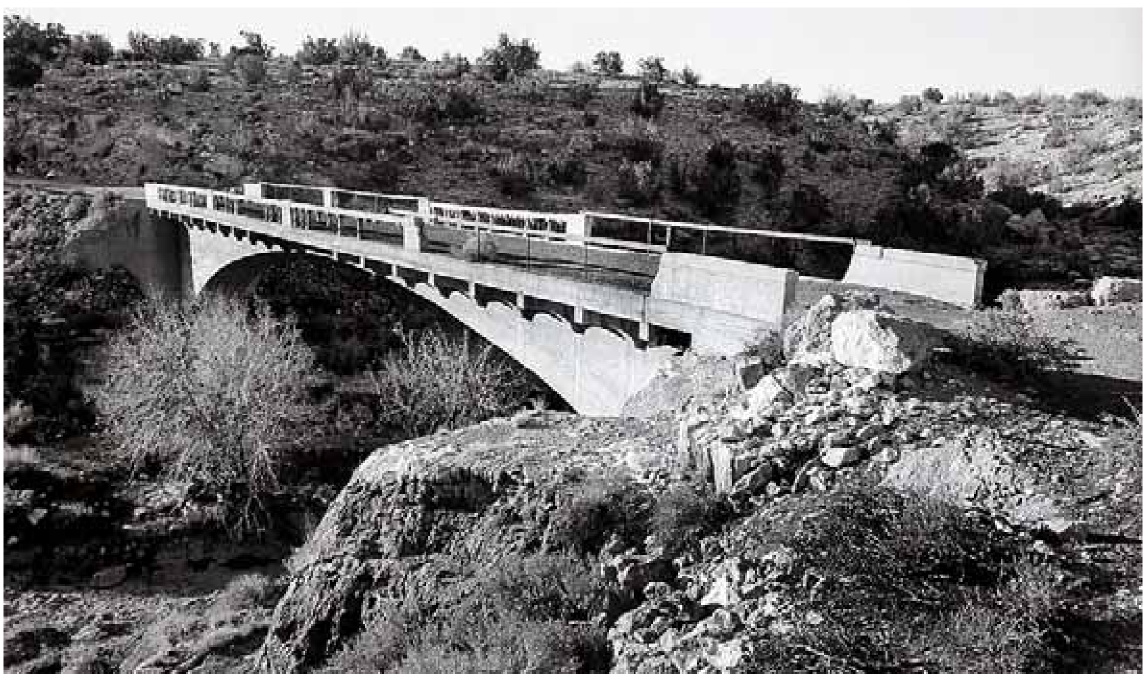

Figure 15. Canyon Padre Bridge, 2003.

Like Cobb, Maddock soon enlisted the assistance of Topeka B&I for a major highway span, but the circumstances this time were quite different. One of the unfinished projects that Maddock inherited from Cobb involved a crossing of the Gila River near Clifton. Maddock designed a steel bridge, but he did not remain state engineer long enough to see this design executed. Steel shortages caused by World War I drove the price

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of the arch well beyond the budget, however, and the design was scrapped. So was the design for a single long-span concrete arch. Eventually, the state hired R.V. Leeson, engineer for Topeka Bridge, to design a two-span Luten arch. The Gila River Bridge [**8152**] was built by convict labor that year [*see Figure 16*].

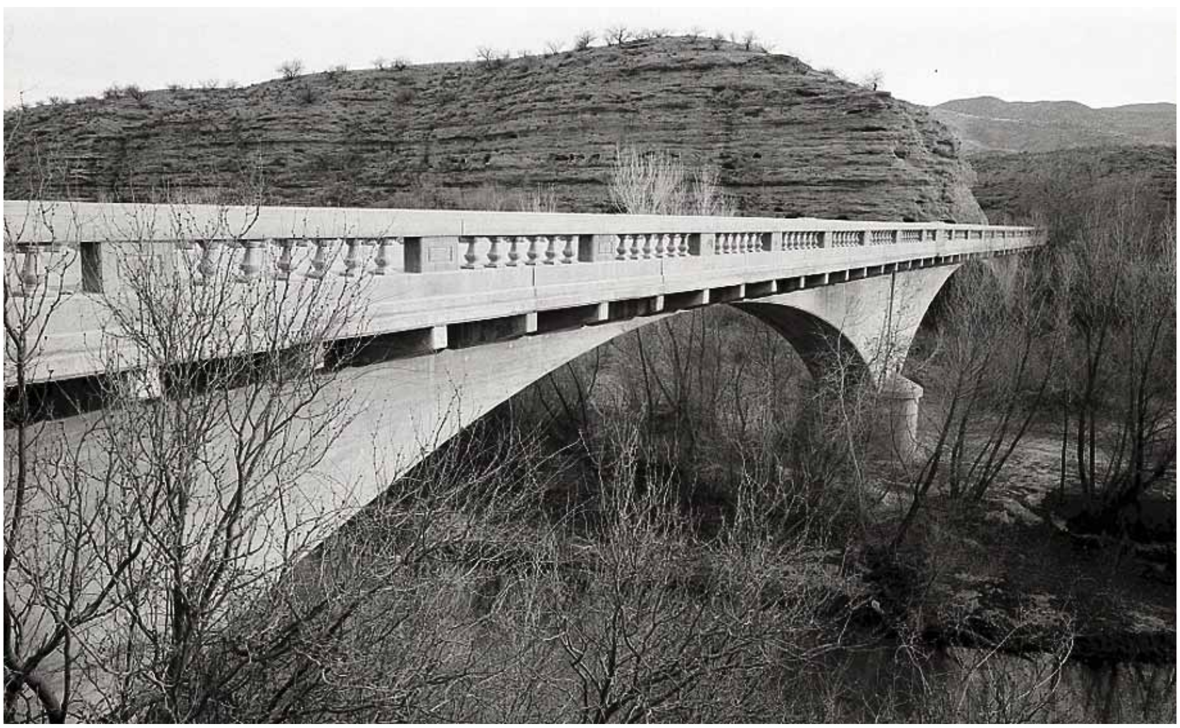

Figure 16. Gila River Bridge, 2003.

Maddock's successors B.M. Atwood and W.C. Lefebvre, contracted for a handful of other Luten arches in the state. One four-arch bridge spanned the Verde River at Camp Verde in Yavapai County. Another crossed the Agua Fria River in Maricopa County. A 100-foot arch spanned Willow Creek in Yavapai County, another spanned Silver Creek in Cochise County, and a 120-foot arch spanned Queen Creek in Pinal County. All but the Queen Creek Bridge [**8440**] have since been razed. Because Luten arches used a proprietary design, which was protected vigorously by Daniel Luten and his attorneys, they were perceived as more expensive than other highway bridge types. For this reason, they were rarely built by Arizona's individual counties or municipalities. Two notable exceptions were the Kelvin [**8441**] and Winkelman [**8442**] bridges, built under contract with Pinal County in 1916-1917 [*see Figure 17*].

Actually, given their scale and technology, the Winkelman and Kelvin structures proved to be bargains, compared with other, similarly scaled spans. Costing almost $22,000, the 419-foot, four-span Winkelman

Bridge cost almost a third as the two-span Gila River Bridge and only slightly more than the single-span Holbrook Bridge. These figures are even more remarkable given that the Winkelman Bridge was founded on driven timber piles, more expensive to build than the spread footings of the Holbrook Bridge. The Winkelman and Kelvin bridges cost about as much as a four-span through truss built near Winslow by Navajo County in 1916-1917 and almost half as much as the Santa Cruz Bridge near Nogales. Some of the last Luten arches built in Arizona were five short-span structures [**8585**, **8586**, **8587**, **8588** and **8589**] on city streets in Miami, completed in 1920-1921.

Figure 17. Kelvin Bridge, 2002.

Several of Arizona's most significant vehicular bridges date from this formative period of state history. The Chevelon Creek Bridge [**8158**], a long-span steel truss, and the Jack's Canyon Bridge [**abd.**], a rail-top concrete slab, were two of the earliest state structures. The Black Gap Bridge [**8534;** *see Figure 18*] and the Gila River Bridge [**8152**] are both early convict-built structures. The Santa Cruz Bridge [**8166**] was an outstanding multiple-span concrete girder structure. Built in 1915 and 1917 respectively, the Broad Street Bridge [**8603**] in Globe and the Broadway Bridge [**8488;** ***see Figure 19***] in Clarkdale are among the state's oldest dateable concrete slab structures.

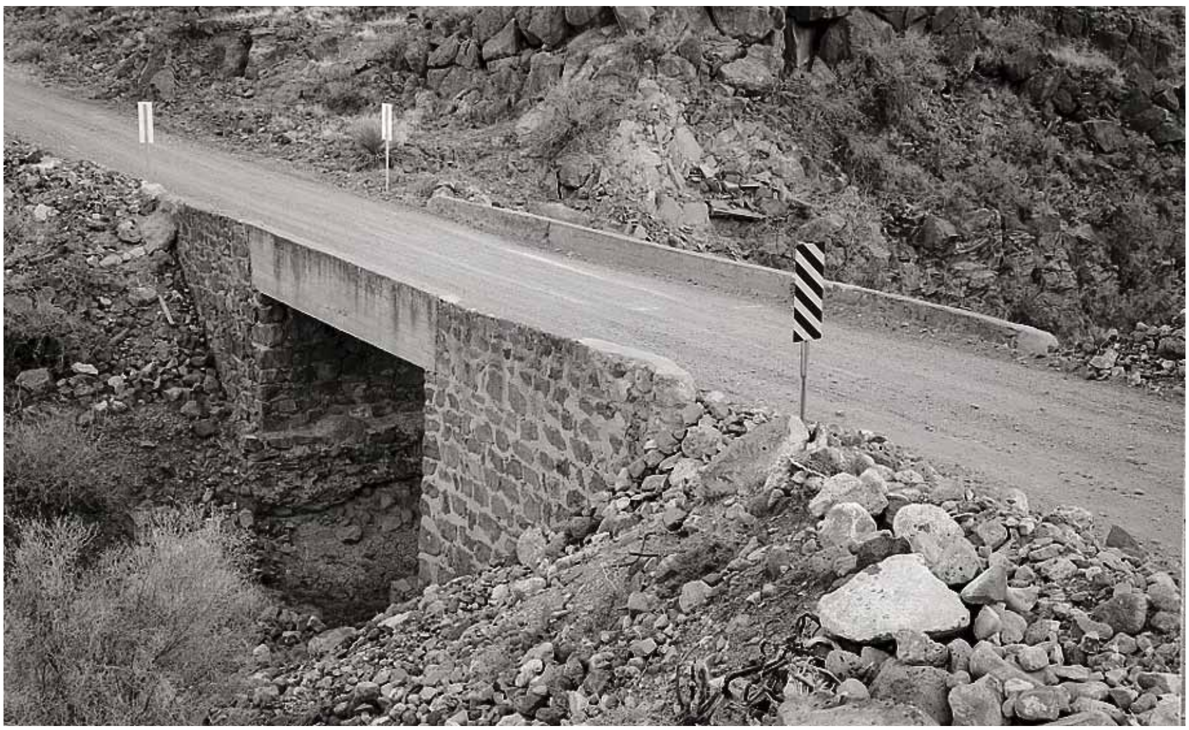

Figure 18. Black Gap Bridge, 2002.

The state engineer and the individual counties and municipalities accounted for virtually all of the vehicular bridges in Arizona, but a third entity—or group of entities, actually—was active in bridge construction as well. The federal government, through the Interior Department, built several vehicular spans associated with government highway programs. Coming from a variety of bureaucratic sources and circumstances, these bridges displayed a wide range of technological expression, some of which were as esoteric as they were dramatic. The bridges themselves were remarkable enough, but what was perhaps even more remarkable was the fact that they were built at all. Virtually every major bridge built by the federal government in Arizona before 1916 required individual Congressional approval.

The federal agency most active in territorial and early state road and bridge construction was the Office of Indian Affairs [OIA, predecessor to today's Bureau of Indian Affairs] in the Department of the Interior. With thousands of square miles of land on 19 separate reservations, the OIA was responsible for the infrastructure of a large part of Arizona. OIA's first major structure spanned the Little Colorado River at the western edge of the Navajo Indian Reservation. Located about 50 miles north of Flagstaff, the long-span wagon bridge would link the sprawling Navajo and Hopi reservations with Flagstaff. OIA contracted with the Midland Bridge Company of Kansas City, Missouri, in 1910 to design and build the structure.

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Figure 19. Broadway Bridge, 2002.

Completed the next year, the Cameron Bridge [**priv.**] featured a 660-foot suspension span with steel wire cables and a stiffening truss [*see Figure 20*]. The Cameron Bridge had a profound impact on the commerce and transportation of a rugged, remote and isolated section of Arizona. It soon spawned a trading post and small settlement on its south side and facilitated travel to and from the Navajo Reservation. Perhaps more important commercially, it carried virtually all freight traffic between Flagstaff and Arizona's northern border.

Inducing the federal government to pay for the territory's internal improvements in the name of Indian advancement had been the idea of Ralph H. Cameron, Arizona's Territorial Delegate to Congress.[33] As his namesake bridge over the Little Colorado was under construction in April 1911, Cameron introduced legis-

[33]Directing funds that had been appropriated for Indian support to serve Anglo needs was hardly novel. The Office of Indian Affairs had been prey to pork barrel politics since its inception in 1824. Despite occasional efforts by reformers to clean it up, the Indian Office remained the archetype of government corruption and inefficiency throughout the 19th and early 20th centuries. Although bridge construction did indeed benefit Native Americans, it undoubtedly profited the commerce and transportation of Anglos far more. Several exhaustive studies of the Indian Office have been produced, including Robert M. Utley, *The Indian Frontier of the American West: 1846-1890* (Albuquerque: University of New Mexico Press, 1984); Francis Paul Pruscha, *The Great Father: The United States Government and the American Indians* (Lincoln, Nebraska: University of Nebraska Press, 1984); and Paul Stuart, *The Indian Office: Growth and Development of an American Institution, 1865-1900* (Ann Arbor, Michigan: UMI Press, 1978).

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lation in Congress to build two other wagon bridges on the San Carlos Indian Reservation. His bill allotted $100,000 to pay for steel or concrete structures over the San Carlos and Gila Rivers near the town of San Carlos, in southeastern Arizona.

Figure 20. Cameron Suspension Bridge, 2002.

Ostensibly, the spans would benefit the Apache Indians by providing all-weather access from the reservation to the Solomonville-San Carlos Highway, the principal route through the region. But they would also form a strategic crossing of the Gila River for Anglo travelers along the territorial east-west route. The San Carlos Bridge, as planned, would combine with the Tempe Bridge under construction over the Salt River and the proposed Antelope Hill Bridge over the Gila in western Arizona to span the route's three most problematic crossings. Moreover, it would form the only point between Florence and Duncan at which Anglo freight wagons could traverse the Gila River on their way to the booming mining district around Globe.

Cameron's bill failed, and he re-introduced it on January 29, 1912, without the appropriation. This too failed. When Arizona was admitted into the United States two weeks later, Cameron was replaced in Congress by Carl T. Hayden. Hayden almost immediately resumed his predecessor's quest for bridges. On March 30, 1912, he introduced a bill again directing the Secretary of the Interior to examine suitable sites for the San

Carlos bridges, as well as a steel span over the Colorado River at the Yuma Indian Reservation. This time, without the commitment to fund actual construction, the legislation passed. The proposed San Carlos and Yuma bridges were surveyed late in 1912; the next year Congress approved funds for their construction.

Responsibility for locating and designing the San Carlos Bridge had been delegated to the Indian Office in Washington, D.C. Rather than place the structure at San Carlos, as had been envisioned in the initial legislation, the agency proposed a location more than twenty miles upriver, at the Naches Siding of the Arizona & Eastern Railroad near Calva. OIA engineers sited the bridge over a meandering stretch of river bounded on both sides by earthen banks. The Solomonville-San Carlos Highway paralleled the river on its south side, as did the tracks of the Arizona & Eastern Railroad. As delineated by OIA in July 1913, the bridge was comprised of seven Pratt through truss spans, each extending 138 feet in eight equal-length panels, for an overall structure length of 980 feet. To fabricate and erect the San Carlos Bridge, OIA contracted with the Midland Bridge Company, the contractor for the Cameron Bridge. It is unclear whether OIA engineered the trusses for the San Carlos Bridge or whether Midland was responsible for their design. Based on the generalized drawings produced by OIA, the agency probably delineated the overall layout and configuration of the bridge and left the specific truss design and detailing to the bridge company.

Midland riveted the members of the San Carlos Bridge in its Kansas City shops, using steel pieces rolled in the Pittsburgh mills of the Cambria Iron Works. During the fall of 1913, the firm shipped several carloads of steel to the site by rail and stored the steel components beside the construction site. Steelworkers then used a wooden traveler to erect the trusses over traditional timber falseworks. The San Carlos Bridge was reported complete by the end of the year.

Building the San Carlos Bridge proved far easier than keeping it open to traffic, however. As OIA soon discovered, the Gila River—once called the muddiest river in the world—had few rivals in the West for its sheer destructiveness. Variously known as the Rio del Nombre de Jesus (river in the name of Jesus), Rio de los Santos Apostoles (river of the sainted Apostles), Rio de las Balsas (river of the rafts), Rio del Coral (red river), Brazo de Mirafloras and Gila River (from the Spanish "a steady going to or from a place"), this storied watercourse had its headwaters in the mountains of western New Mexico. The Gila entered Arizona from the east at Duncan and disgorged itself from its mountainous canyon before meandering through Greenlee and Graham Counties. It flowed beneath the San Carlos and Florence Bridges and snaked its way westward through Pinal, Maricopa and Yuma Counties, where it emptied into the Colorado River immediately upriver from Yuma.

The Gila River was notorious for its radical shifts in character. It could range from barely perceptible trickle to violent flood and back within a day's time. The river's relatively shallow descent, wide flood plain and sandy bed permitted fording during low-water stage throughout much of Arizona. But during floods, all traffic across the Gila virtually stopped. The river flooded to some extent almost every year. Monumental floods, cresting far higher than usual, were logged in 1862, 1869, 1884, 1891 and 1905. Parts of the wagon bridge at Florence—both the territorial and the state versions—were carried away with almost every flood.

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This prompted Arizona Senator Marcus Smith in 1916 to call the hapless structure "a monument to the treachery of the river." During the downpour just before Christmas 1914, the river actually washed away approaches on both sides of the concrete structure, isolating it in the middle of the roaring channel.

The Christmas flood of 1914 marked the first major test of the San Carlos Bridge since its completion. The steel structure itself withstood the high waters, but the river shifted its channel dramatically immediately upstream, cutting a 500-foot-wide swath through the south embankment. "The bridge proper was uninjured but left isolated by lack of facilities to confine the stream," Merrill Butler reported, "permitting the Gila to change its course and wash around the approach."[34] With the south approach destroyed, the bridge was rendered worthless, only a year after its completion.

Owned and maintained by the state, the Florence Bridge was soon repaired. The San Carlos Bridge, on the other hand, was federal property. Money had been appropriated for the bridge's construction but not its maintenance and not for rectification works on the Gila. A little more than a year after the flood, Frank Olmsted, a Los Angles-based engineer under contract with the Department of the Interior, investigated the site and recommended that the riverbank be rebuilt to restore the bridge's south approach. But without funds, the Indian Office could do little to repair the structure. It thus stood abandoned, as the river cut progressively deeper into the south embankment at each flood. "The usefulness of this particular bridge has been lost to the community for a period of something over five years because of erratic stream action," Butler wrote in 1920. "Necessity for stream control is, therefore, emphasized in conjunction with bridge construction and maintenance."[35]

The proposed bridge over the Colorado River at Yuma had exactly the opposite problem than the San Carlos Bridge: it proved durable enough once completed but its construction was plagued with woe. Ostensibly to provide a crossing for the Yuma Indian Reservation across the river in California, the bridge would also carry the Ocean-to-Ocean Highway as the only bridged crossing of the Colorado for some 600 miles. In a classic instance of bureaucratic bumbling, Office of Indian Affairs engineers designed the bridge in Washington, DC, without benefit of an on-site visit at Yuma. They delineated a

[34] *Fourth Biennial Report of the State Engineer*, p. 65.

[35] Ibid. Instead of re-channeling the river under the bridge, the Indian Office eventually opted to extend the bridge over the new channel. OIA reportedly added four 126-foot trusses to the structure's south end to reach the new embankment. The San Carlos Bridge was thus put back into service in February 1921. In the mid-1920s, it was made part of U.S. Highway 180 (later U.S. 70) and placed under the aegis of the state highway department. As traffic along the highway increased, the narrow trusses eventually formed a bottleneck. By the mid-1930s the highway department began planning a new, wider structure to replace the San Carlos Bridge. In 1935 the original bridge was replaced by the Arizona Highway Department, and four of its truss spans were moved by relief workers and re-erected in the Prescott and Tonto National Forests. The Whispering Pines Bridge in the Tonto National Forest has since been removed. The two-span Perkinsville Bridge [**9474**] and the single-span Walnut Creek Bridge [**8741**] in the Prescott National Forest continue to carry vehicular traffic.

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long-span, simply supported truss, to be erected using traditional falseworks. What they had not counted on was the unpredictable nature of the Colorado. After the falsework washed away twice in flash floods, the contractor devised an alternate erection system. In March 1915 the Ocean-to-Ocean Bridge [**8533**; *see Figure 21*]] at Yuma was prefabricated on a barge upriver from the crossing site, floated to the site and lowered onto the abutments in one breathtaking operation.

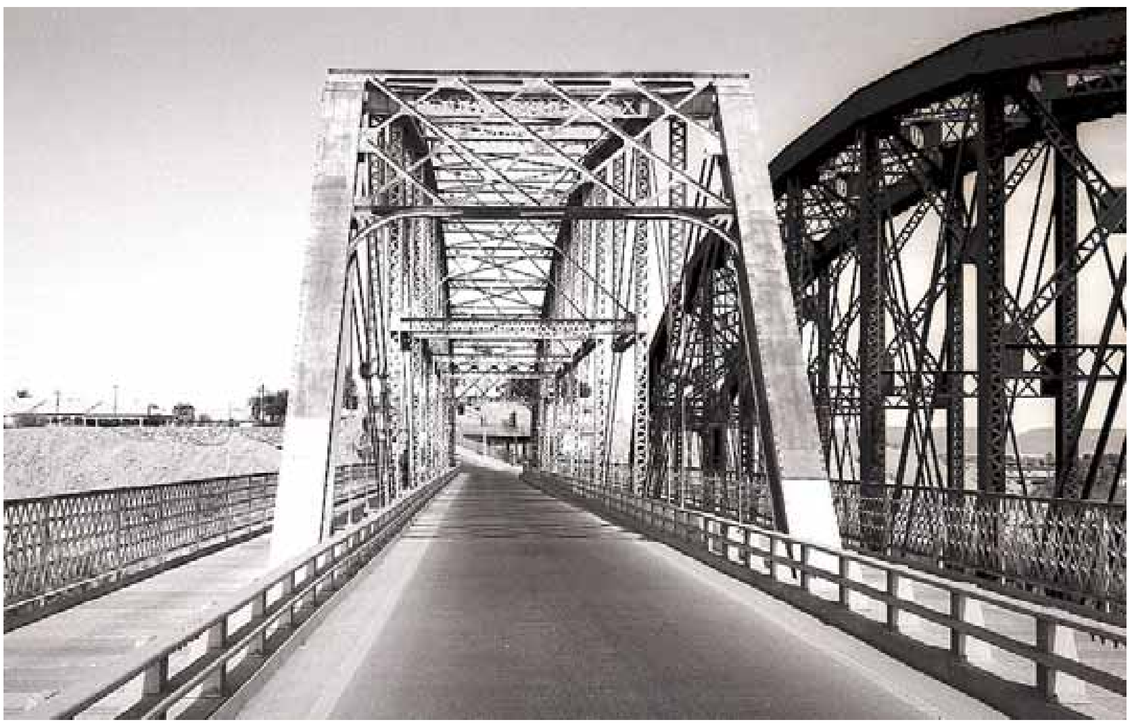

Figure 21. Yuma Bridge, 2003.

As the contractor was struggling to build the Yuma Bridge in 1914, the Indian Office solicited help from Arizona and California to erect another major span over the Colorado at Topock. This bridge would carry the Old Trails Highway, Arizona's other transcontinental route. An extraordinarily graceful span that bears more than passing resemblance to the 1905 Bellows Falls Bridge in Vermont, the Topock Bridge [**priv.**] in Mohave County was at the time of its completion in 1916 the lightest and longest three-hinged steel arch in America [*see Figure 22*]. Another outstanding bridge built by the Indian Office was notable for its multiplicity of spans rather than its technological daring. The Sacaton Dam Bridge [**3165**] in Pinal County, completed over the Gila River in 1925, consisted of 25 concrete girder spans. It was at that time exceeded in overall length by only two other vehicular bridges in Arizona.

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