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United States Department of the Interior
National Park Service

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Cover

National Register of Historic Places Multiple Property Documentation Form

This form is used for documenting property groups relating to one or several historic contexts. See instructions in National Register Bulletin *How to Complete the Multiple Property Documentation Form* (formerly 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

X New Submission _____ Amended Submission

A. Name of Multiple Property Listing

Historic Bridges of Delaware Township, Hunterdon County, New Jersey

B. Associated Historic Contexts

Stone Arch Bridges built in Delaware Township before 1882

Metal Truss Bridges built in Delaware Township before 1945

C. Form Prepared by

name/title Caroline Charlese Scott; Carla Cielo, Historic Preservation Consultant, Ringoes, NJ
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D. Certification

As the designated authority under the National Historic Preservation Act of 1966, 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 60 and the Secretary of the Interior's Standards and Guidelines for Archeology and Historic Preservation.
(_____ See continuation sheet for additional comments.)

Ass't Commissioner 7/28/16

Rick Boas

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 the Keeper

10/4/16

Date of Action

Table of Contents for Written Narrative

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

E. Statement of Historic Contexts

(if more than one historic context is documented, present them in sequential order.)

Stone Arch Bridges built in Delaware Township before 1882

Metal Truss Bridges built in Delaware Township before 1945

F. Associated Property Types

(Provide description, significance, and registration requirements.)

G. Geographical Data

H. Summary of Identification and Evaluation Methods

(Discuss the methods used in developing the multiple property listing.)

I. Major Bibliographical References

(List major written works and primary location of additional documentation: State Historic Preservation Office, other State agency, Federal agency, local government, university, or other, specifying repository.)

E. Statements of Historic Context

I. *Introduction*

Two types of roadway bridges are associated with this nomination: stone arch bridges and metal (cast or wrought iron or steel) truss bridges. Although Hunterdon County and Delaware Township contain historically significant railroad bridges, the context for their evaluation differs from from those of road or highway bridges, and is not presented in this nomination. [The structure inventories used by engineers and transportation agencies classify structures with a clear span between abutments less than twenty (20) feet as "culverts" and structures with a clear span 20 feet or larger as "bridges." For ease of understanding, however, *all* structures, regardless of length, whether using trusses or stringers or arches, are called *bridges* in this Multiple Property Documentation Form (MPDF).]

The historic bridges described by this MPDF are significant under National Register of Historic Places Criteria A and C. The Criterion A significances arise from the bridges' association with the development of the transportation network that was the foundation of the dispersed agricultural economy of Hunterdon County during the 19th and early 20th centuries. Criterion A significance also arises from the association of metal truss bridges with the evolution and advancement of the profession of civil and structural engineering, "bridge engineering as a profession came of age with the truss bridge."[1] Criterion C is applicable because both bridge types embody the distinctive characteristics of the types, periods, and methods of construction that pertain to them and that were important in shaping the built environment of Hunterdon County and Delaware Township. Whereas stone bridge building represents the continuity of carpentry and masonry craftsmanship, metal truss bridges represent the evolution and maturation of iron and steel metallurgy and its distinctive application to the structural engineering and construction of bridges. These structures also possess integrity of location, design, setting, materials, workmanship, feeling, and/or association.

Hunterdon County is significant for its large number of stone arch bridges. "With over 100 surviving stone arch bridges, Hunterdon County, New Jersey, represents the largest concentration of stone bridges in North America."[2] Delaware Township's 13 remaining stone arch bridges (11 on active roads and 2 on abandoned sections of road) represent a significant collection of this bridge type. Among these 13 surveyed bridges, construction dates range from 1829 to circa 1882. Hunterdon County is also noted for its large concentration of metal truss bridges. "The glory of Hunterdon County is its assemblage of metal truss bridges, which ranks as not only the most impressive in the state, but one of the finest in the country."[3] Delaware Township has ten metal truss bridges, six of which are clustered within the hilly northeastern quadrant and represent a significant grouping of this bridge type. The Township's collection of metal truss bridges shows the evolution of truss design between 1872 and circa 1920, and includes

[1] Harshbarger, Patrick. "Project Planning for Metal Truss Bridges." Presentation at the Pennsylvania By-Ways Conference, May 2008.
[2] Boothby, Thomas E. "Stone Arch Bridge Inventory, Phase II, Hunterdon County, New Jersey." The Pennsylvania State University, November 1998, p. Executive Summary.
[3] Lichtenstein, A. G. and Associates, Inc. *New Jersey Historic Bridge Survey*, 1992. p.HUN-3.

excellent examples of the Pratt, Warren, and Howe truss designs. Several bridges, including D300[4] over the Lockatong Creek, are associated with a noted builder and/or manufacturer or represent advancements in engineering and metals technology. The Peck's Ferry Bridge over Plum Brook is individually listed in the National Register of Historic Places. (Although not included in this MPDF document, Delaware Township's Green Sergeant's covered bridge (bridge D304) is also individually listed in the National Register and is the last remaining, publicly-owned, historic covered bridge in New Jersey.)

Delaware Township's current landscape is approximately 40% agricultural, 33% woodland/forest, 11% water and wetlands, and only 14% residential, commercial, and transportation corridors.[55] Consequently, the rural historic landscape of Delaware Township maintains a high degree of integrity and provides the appropriate historic setting for stone-arch bridges and metal truss bridges. These humble bridges are unassuming: built as utilitarian structures, but with a pride of craftsmanship. Their unpretentious character complements the ambiance of the 18th- and 19th-century farmhouses and farm outbuildings that remain throughout Delaware Township. These small, bridges are one of the character-defining features of the Delaware Township landscape, past and present.

Geographic Area

Delaware Township occupies a 37 square-mile corner of southwestern Hunterdon County along the Delaware River. It is bordered by Raritan Township to the northeast, East Amwell Township to the east, West Amwell Township, Stockton Borough, and Lambertville City to the south, Kingwood and Franklin Townships to the northwest, and the Delaware River to the west. The northern and northwestern parts of the township are hilly and have a rocky, predominantly wooded terrain. Most of the truss bridges are located in this section of the township.

Delaware Township's southeastern 2.8 square miles drain to the Raritan River and the remaining area of the township drains to the Delaware River. Seventy six (76) miles of rivers, streams, tributaries, and the Delaware and Raritan Canal flow through and within Delaware Township (* includes tributaries):[6]

Delaware and Raritan Canal * Lockatong Creek*	5.10 miles 5.64
Plum Brook*	6.82
Alexauken Creek*	10.17
Neshanic River*	19.78
Wickecheoke Creek*	27.51

The majestic Wickecheoke Creek is the focus of a wooded greenway (now preserved) that traverses the township and travels southwesterly to enter the Delaware River at Prallsville. Three metal truss bridges

[4] This number represents the Hunterdon County structure number for this bridge (D being for Delaware Township).

[5] Delaware Township Natural Resource Inventory, 2004, p.7.

[6] Ibid. p.8.

(D325, D337, and D468) and the Green Sergeants Covered Bridge (D304) cross the Wichecheoke. Plum Brook and Shopprons Run, which are also primarily wooded, feed the Wickecheoke as do other small tributaries. Four truss bridges cross Plum Brook (D363, D368, D390, and D424). The Lockatong Creek crosses the northwestern corner of the township and enters the Delaware River between Prallsville and Raven Rock. Today, much of the Lockatong passes though publicly-preserved land and is the focus of numerous hiking trails. Two through-truss bridges (D300 and D481) cross the Lockatong.

The southeastern and southwestern parts of Delaware Township are much flatter with fertile farmland and smaller creeks. Hunterdon County historian James P. Snell described this section of the township in 1881 as "one of the most fertile farming sections in Hunterdon County."[77] About half of the stone bridges are located in this part of the township. There are a few small streams and tributaries in the southeastern section that flow east, ultimately into the Raritan Bay. The Alexauken Creek forms part of the southern boundary with West Amwell and empties into the Delaware River at the southwest corner of the township. One truss bridge (WD120) crosses the Alexauken. The southern section of the township has small creeks that either feed into the Alexauken or the Delaware River. This quadrant of the township is primarily served by small pipe culverts not included in this nomination.

Geographic factors and topographic constraints influenced the construction of bridges in Delaware Township. Truss bridges cross the major water courses and are primarily concentrated in the northwestern portion of the township. Stone-arch bridges are dispersed throughout the township and cross smaller streams and tributaries. This choice of bridge type was generally dependent on the required span length. The stone-arch bridges, as well as timber-stringer spans on stone abutments, were generally used for shorter spans. While the stone abutments of several timber stringer bridges remain in Delaware Township, all of the timber decks have been replaced with steel or concrete. Metal truss bridges were generally reserved for longer spans and likely replaced earlier timber and, in some cases, stone-arch bridges. The span of the surviving stone-arch bridges range from 4'-6" to 21-feet with the exception of DQ321, which is the only double-barrel stone arch bridge in Delaware Township. It was built in 1838 and has a combined span of 45 feet. The metal truss bridges in Delaware Township range in span length from 29 to 129 feet.

Geological Background

Hunterdon County historian James Snell described Delaware Township as having a diversity of soils - such as red shale, gravelly loam, sandy loam, and some clay loam.[8] The bedrock, however, is primarily sedimentary stone that includes brown and gray sandstone and blue argillite, known locally as "blue jingler." Argillite is mainly found in the northern part of the township. Both types of stone were used to build the fieldstone houses which characterize Delaware Township's 18th -and 19th-century building stock. All of the township's remaining stone bridges and abutments were built with local stone (from within Delaware Township or western Hunterdon County), which was primarily undressed sandstone. One stone arch bridge (D334) is argillite.

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[7] Snell, James P. (ed.) *History of Sussex and Warren Counties, New Jersey*. Philadelphia: Everts and Peck, 1881.

[8] Ibid.

Delaware Township is located within a belt of sandstone that extends diagonally through New Jersey from the Delaware River to the Hudson River. By the 1870s, there were at least eight active quarries in the township that were located either along the Delaware River or within a few miles of it (between Brookville and Raven Rock).[9] In 1832, the 23-mile Delaware and Raritan Feeder Canal was built between Trenton and Bulls Island, through Delaware Township. The feeder canal allowed for the commercial-ization of the sandstone quarries, which, prior to its opening, existed on a smaller scale and mainly supplied local building stone. By 1854, the Belvidere Delaware Railroad (the "Bel-Del," later a branch of the Pennsylvania Railroad), which paralleled the feeder canal between Trenton and Raven Rock and continued north along the Delaware River to Phillipsburg and Belvidere in Warren County, furthered the development of the sandstone industry.

During the 18th century (primarily the second half), quarried sandstone was used to build and/or decorate (in the form of keystone lintels and quoins) the most important homes in Delaware Township - those few homes that exhibited high style and prestige. Cut sandstone trim faced the high-style Georgian homes of the more prosperous property owners. But few homeowners in Delaware Township could afford cut stone, and the quarried stone was primarily shipped throughout New Jersey for railroad bridge abutments and occasionally for the construction of important commercial buildings. Cut sandstone, however, was used for the arch ring of every stone-arch bridge remaining today in Delaware Township. It was also used for all of the datestones and occasionally for the bearing seats of timber stringer bridges. The abutments and wing walls of the Pratt through-truss bridge on Raven Rock Road over the Lockatong Creek (D300) consist entirely of cut sandstone of a massive scale, comparable to that which was used for railroad abutments. The abutments and wing walls of the Strimples Mill Road truss bridge over the Lockatong Creek (D481) include blocks of argillite that appear to have been quarried near the bridge.

Historical Background

Delaware Township was once part of Amwell Township, a 200 square-mile area that extended from the Delaware River east to Hillsborough Township in Somerset County. This area exists today as Delaware Township, Raritan Township, Readington Township, East Amwell Township, West Amwell Township, Flemington Borough, Lambertville City, and Stockton Borough. The former Amwell Township also included parts of today's Clinton Township, Lebanon Township, and Tewksbury Township. Amwell Township was established in 1708 in what was then part of Burlington County. Hunterdon County was formed from a part of Burlington County in 1714, and, in 1838, Mercer County was formed from a part of Hunterdon County, establishing the modern-day county boundaries.

The earliest permanent Euro-American settlers in the area that would become Delaware Township arrived in the first quarter of the 18th century. They were primarily of English descent, and, to a lesser extent, Dutch and German. When they arrived, the region was virtually a wilderness. The earliest permanent settler in what would become Delaware Township is believed to have been John Reading, who purchased

[9] Cook, George H. *Annual Report of the State Geologist for the Year 1873*. Trenton, NJ: State Gazette, Murphy & Bechtel, 1873.

land along the Wickecheoke in 1702.[10] Reading, a Quaker, arrived in the colony in 1684. He was an influential member of the Council of Proprietors of West Jersey and a captain of the county Militia.[11]

The population of Hunterdon County in 1737 was 5,570 and seven years later (1745), it had grown to 9,151.[12] Early industries reflected the area's rapid growth. The presence of a grist mill in a neighborhood indicated that milled grain was needed by a population sizable enough to support its construction. The earliest grist and saw mills in the area that became Delaware Township were constructed by John Reading in or about 1710 for his daughter, Mary, and her husband, Daniel Howell. These mills were located on the Wickecheoke Creek near its confluence with the Delaware River at what would become Prallsville. The mills were rebuilt several times, but milling operations continued at this site until 1968.[13]

Mill construction inland from the Delaware River began a few decades later. The earliest inland mill is believed to have been built by John Opdyke at Headquarters in 1735.[14] Before a mill could be built, roads (with or without bridges) had to be present for transportation to and from the mill. Opdyke's operations soon grew to include "a grist mill, a saw mill and a distillery." The distillery was said to have "supplied swill enough for a thousand hogs and refuse enough to feed 500 steers."[15] Distilleries provided an excellent market for maize and rye – millers paid higher prices for the grain and converted it to whiskey which was "being drunk by everybody."[16] Opdyke also built a mill on the Wickecheoke near the [Sergeantsville] covered bridge in 1745.[17]

By 1830, the population of the still undivided Amwell Township had reached 7,385 and, by this time, an expanding network of roads had been established. In 1832, Amwell had "4 stores, 8 fisheries, 15 saw mills, 21 grist mills, 3 oil mills, 2 ferries and toll bridges…"[18] Mills were located at a reliable waterpower source and often became the centers of small hamlets. Small secondary roads were designed to connect mill sites and/or to serve the area farmers. Major roads or "highways" had been charted, often through larger hamlets to established Delaware River crossings, and to larger town and city centers including Philadelphia and New York.

The northwestern portion of Amwell Township became Delaware Township in 1838, with the village of Sergeantsville emerging as the municipal center. This region included a large portion of the fertile Amwell Valley, which from the time of the initial Euro-American settlement into the middle of the 20th

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[10] Hammond, D. Stanton. "Hunterdon County, New Jersey," Sheet F, Map Series #4. Genealogical Society of New Jersey, 1965.
[11] Strunk, Keith. *Images of America: Prallsville Mills and Stockton.* Arcadia Publishing, 2008.
[12] Gordon, Thomas F. *Gazetteer of the State of New Jersey*. Trenton: Daniel Fenton, 1834. (Reprint: Polyanthus, 1973).
[13] Strunk. 2008, pp.7-9, 11.
[14] Goodspeed, 2006; also the building datestone.
[15] Larison, C. W. *The Ancient Village of Amwell.* Flemington, NJ: 1916 (Pamphlet).
[16] Ibid.
[17] Goodspeed, 2006.
[18] Gordon, 1973, p.94.

century fostered and sustained a primarily agricultural economy. Headquarters, Rosemont, Saxtonville (later called Raven Rock), Sand Brook, Locktown, Croton, Prallsville, and Brookville grew as the principal hamlets that supported the township's dispersed agricultural population.

The remaining 18th and early 19th century architecture displays modest English tastes of the times, and there are some remaining traces of Dutch architecture as well. The heavy German influence seen in the architecture of the northern sections of Hunterdon County is less evident here. The traditional house type that remains most prevalent today is known by cultural geographers as the vernacular "I" house; these were built from the first quarter of the 18th century through the second quarter of the 19th century. These two-story dwellings (both stuccoed fieldstone and frame) are one room deep and two rooms wide, typically with "hall and parlor" floor plans. The "hall" was the kitchen; the "parlor" was reserved for special occasions. The earliest house in Delaware Township with this plan has a 1711 datestone.[19] The dominance of this plan type indicates the importance of separating formal parlor functions from informal kitchen functions. This unpretentious house type best represents the middle, property owning class of Delaware Township families. Houses with a single-room plan (hall-kitchen on the first floor with an attic or chambers above) also remain, but less frequently and were often enlarged not long after their initial construction.

High-style Georgian and Federal homes also exist and are typically associated with mill owners and other prominent families. The 1758 stone Georgian house at Headquarters Farm has a formal five-bay facade clad in ashlar sandstone with quoined corners, a projecting watercourse, and keystones above window openings. Homes with a Georgian or Federal side-entry plan are also present. These higher-style houses are distinguished from middle-class vernacular homes by their proportions and more sophisticated architectural details.

According to Snell, there were 366 farms in Delaware Township in 1880 (having been separated from East Amwell in 1838) and the population was 3,092. Farmers grew a variety of crops, including much of their own food which would be used seasonally or canned, preserved, and stored for winter use. Flax was an important late 18th century and early 19th century cash crop used for making linseed oil, but this industry had declined by the 1850s. Apples, pears, corn, wheat, oats, rye, buckwheat, barley, hay, white potatoes, and sweet potatoes were commonly grown, and each farm had pigs, a few cows, horses and/or oxen. However, by the 1880s, farming activities in Hunterdon County were in a state of decline. "The peak of [Hunterdon County's] population of 40,758 in 1865 was not matched again until well into the 1940s."[20] Peach farming brought a rapid though temporary appeal in the late 19th century, but was curtailed by the peach tree blight in the early 20th century. In 1931 there were 14 abandoned farms (1089 acres) in Delaware Township.[21] Chicken and egg farms were seen as the answer to the farming problems in the 1930s, but soon this market was flooded. Finally, large-scale dairy farming was attempted from the 1940s through the 1970s. Today, Delaware Township largely serves as a bedroom community with some

[19] Holcombe-Jimison House, located on NJ Route 29 outside Lambertville.

[20] Litchtenstein, 1992. p.171.

[21] State of New Jersey, Department of Agriculture. *Idle Farms in Hunterdon County, New Jersey.* Trenton, NJ: June 1932. p.41, 44.

families engaged in farming activities as a side interest or hobby, however, the trend toward organic and locally grown produce has ushered in new interests in local farming. According to the United States Census, the township population in 2010 was 4,563, a slight increase from the 4,512 residents counted in the 1990 census.

Transportation Development

Native Americans navigated a complex system of footpaths long before European arrival. These footpaths gave access to all parts of the county and the region. The early settlers adopted and widened these paths for wagon travel.[22] As the population increased, supplemental roads were added. Despite this effort, travel was frequently impeded by the natural topography. Hunterdon County experienced the same difficulties as much of the eastern United States:

> It is a notorious fact that there is no country of the world which is more in need of good and permanent Bridges than the United States of America. Extended along an immense line of coast on which abound rivers, creeks, and swamps, it is impossible that any physical union of the country can really take place until the labours of the architect and mechanic shall have more perfectly done away the inconvenience arising from the intervention of the waters.[23]

In Hunterdon County, "in general, fords were more common than bridges during the whole of the Colonial period. This meant that all travel except that by horseback was stopped by freshets [floods]."[24] Hunterdon County resident Thomas Capner, arriving from England in 1787, commented that there were "practically no bridges."[25]

New public roads and changes to an existing road's alignment were initiated by property owners who petitioned for surveyors of the highway to meet as a jury, examine the ground, then prepare, in a road book, a map and schedule (known as a "road return") to be recorded by the court clerk of the "Common Pleas." The construction and repair of the roads, as surveyed, was a township responsibility. Each township appointed overseers of the highways who were responsible for the condition of the roads.[26] In 1832, greater Amwell Township (which at that time still included the future Delaware Township) raised $2,500 in road tax which, compared to the amount other townships generated, was quite high.[27]

Public roads were maintained by "labor" or by "hire" (where permitted) in the 18th century. If maintained by labor, the township committee divided the road into districts and assigned local inhabitants, using their livestock, to work them for three years. Inhabitants who neglected to perform their quota of work were fined. The road tax could be paid in labor, and it was the responsibility of the mill owner to repair roads

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[22] Schmidt, Herbert G. *Rural Hunterdon, An Agricultural History*. New Brunswick: Rutgers University Press,1946. p.162; Litchtenstein, 2005, p.168.

[23] Pope, Thomas. *A Treatise on Bridge Architecture*. New York: Alexander Niven 1811, p.127

[24] Goodspeed, Pecks Ferry Bridge NRHP Nomination

[25] Ibid.

[26] Gordon, 1973, p.61.

[27] Gordon, 1973, p. 94; Tewksbury Township raised $600 for road tax in 1832 (Gordon, p.249); Lebanon Township raised $800 for road tax (Gordon, p.168); Alexandria Township raised $800 for road tax (Gordon p.93).

over their own mill dams. If the township voted to maintain a road by hire, they paid for its maintenance from a "road tax" fund paid from taxes.[28]

The importance of roads to agricultural Hunterdon County was acknowledged in 1860, when at the annual meeting of New Jersey Agricultural Society, one speaker's presentation quoted W.M. Gillespie, author in 1847 of *A Manual of the Principles and Practice of Road Building*:

> Roads are the veins and arteries of the body politic, for through them flow the agricultural productions and commercial supplies which are the lifeblood of the state. Upon the sufficiency of their number, the propriety of their directions, and the unobstructedness of their courses, depend the ease and rapidity with which the more distant portions of the system receive their nutriment… Agriculture is thus directly, and likewise indirectly, dependent in a great degree upon good roads for its success and rewards. Directly, these roads carry the productions of the fields to the markets, and bring to them in return their bulky and weighty materials of fertilization… Indirectly, the cities and towns, whose dense population and manufacturing industry make them the best markets for farming produce, are enabled to grow and extend themselves…[29]

There were several early roads of significance in Delaware Township. The Easton-Trenton Turnpike, although it bears the name turnpike, was a highway that began as a native path and provided access to two large agricultural product markets – Easton, Pennsylvania and Trenton, New Jersey. Now known as County Route 579, the road delineates a section of the eastern border that Delaware Township shares with Raritan Township. Three of the Township's earliest remaining stone-arch bridges are located on this road: DQ313 (1829) is a single-barrel stone-arch bridge; DQ320 (1837) is also a single-barrel stone-arch bridge; and DQ321 (1838) is a double-barrel stone-arch bridge.

The second major road through Delaware Township (now Route 523) led from Flemington to a Delaware River crossing at Prallsville. In 1785, Flemington was chosen to be the county seat, and throughout the 19th century was the principal agricultural market in Hunterdon County.[30] This ten-mile long road terminated at "Reading Landing" (now Stockton) where a ferry connected New Jersey with Pennsylvania. John Reading obtained the rights for this crossing in 1693.[31] The ferry was replaced in 1814 by a covered timber-truss bridge that was built on stone abutments.[32] This bridge was replaced by a six-span Warren truss structure in 1926 after the covered timber-truss bridge burned in 1923.[33] No historic bridges remain along Route 523 today. The third major road of significant historical importance (today's County Route 604) linked Headquarters, Sergeantsville, Rosemont, and Delaware Township's second Delaware River crossing at Saxtonville (Raven Rock) with Ringoes in what is now East Amwell Township. A bridge

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[28] Gordon, 1973, p.62.

[29] New Jersey Agricultural Society "Annual Report of the N.J. Agricultural Society for the Year 1860" Appendix to the Minutes of the Eighty-Fifth General Assembly of the State of New Jersey. John H. Lyon & Co. Printers, 1861.

[30] Gordon, 1973, p.142.

[31] Website of the "Delaware River Mill Society" http://home2.netcarrier.com/~drms/ (See also - Dale, Frank T. *Bridges over the Delaware River: A History of Crossings.* (New Brunswick, NJ: Rutgers University Press, 2003).

[32] Strunk, 2008, p.51.

[33] Delaware River Joint Toll Bridge Commission website http://www.drjtbc.org/default.aspx?pageid=734 – accessed 8/29/12

crossing the Wickecheoke Creek along this route is thought to have been in existence from the 1750s. This bridge was repaired in 1787, and according to the Freeholders' meeting minutes of that year, was to be maintained for "50 years" by Samuel Opdyke, the local miller, at his own expense. The last remaining covered bridge (D304) in New Jersey is on the site of this early bridge. Ringoes had been settled circa 1720 by John Ringo and became an important crossroads community that grew at the junction of "York" Road and the Easton-Trenton Turnpike. York Road was a major route connecting Philadelphia and New York. A ferry was located north of Saxtonville's Tavern to provide service to Lumberville, Pennsylvania. A covered bridge replaced the ferry in 1856.[34]

A road following the Delaware River (modern day NJ Route 29) was improved in the 19th century. A petition to improve the "old road as now used on the bank of the Delaware" between the lands of John Hoffman (below Saxtonville) and the lands of John Reading (near Prallsville) is dated 1827.[35] This was an important road that joined Delaware River hamlets and facilitated river trade. In the early days, the Delaware River provided a means for intrepid boatmen to transport goods. Rafts were floated down the river from Pennsylvania and New York State, supplying local saw mills with building materials. The Durham boat was used to haul wheat, corn, barreled pork, limestone, etc. and the "coal ark," a large box mounted on a flat boat, transported coal and building stone.[36]

In Delaware Township, a network of small farm roads that supplemented the major roadways was primarily laid out by 1850, but additional connector roads were added through the 1880s. Cornell's 1851 *Map of Hunterdon County*, New Jersey shows roughly 80 percent of the roads that were present on the Beer's 1873 *Atlas of Hunterdon County*, New Jersey. The Beers Atlas shows that the great majority of the old roads that remain in the township today were present then. Reading Road, however, was not opened until 1878[37] and Worman Road was opened in 1882-83.[38] In the 20th century, a few connector roads were abandoned that have returned to farm or woodlands.

Delaware Township's transportation network was also impacted by the introduction of canal and railroad lines that bordered the township. With the opening of the Delaware and Raritan Feeder Canal, Saxtonville changed from an agricultural support village to one that supported trade. Constructed in 1832, the feeder canal began at Bulls Island and ran 23 miles along the Delaware River to meet the main canal in Trenton. The canal was a "public highway" with fees charged per mile to ship merchandise and to transport people. It replaced most river trade and shortened the distance needed for overland carting of goods. Instead of taking commodities directly into distant city markets, goods were brought to and from the canal at Lambertville, Stockton, and Raven Rock.[39]

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[34] Clark, Kathleen Zingaro. *Images of America - Bucks County. Arcadia Press*, 2006. p. 40. (See also Dale p.13-20)

[35] *Hunterdon County Road Returns, Vol. 2*, Hunterdon County Hall of Records, Flemington, NJ. p. 263, November 15, 1827.

[36] Schmidt, 1946, pp.179-181.

[37] Bertland Dennis N. "Covered Bridge Historic District." National Register of Historic Places Nomination. January19, 1999. (Copy at New Jersey Historic Preservation Office, Trenton, NJ.) Section 8, p.7.

[38] Hunterdon County Road Returns.

[39] Schmidt, 1946, p.183.

The Belvidere-Delaware (or "Bel-Del" (later a division of the "Pennsylvania")) Railroad was the second transportation achievement that facilitated economic trade in Delaware Township. The railroad (completed to Lambertville in 1851 and to Phillipsburg in Warren County in 1854) was built along the Delaware River with two station stops in Delaware Township - Stockton and Raven Rock/Bulls Island.[40] Many of the township's industries – particularly the sandstone quarries – grew because of easy access to canal and rail transportation. Between 1872 and 1929, Delaware Township was also serviced by what has become known in the 20th century as the Black River & Western Railroad, originally a Pennsylvania Railroad branch from Lambertville to Flemington along the southeastern border of the township shared with West Amwell. Both railroads carried passengers and freight, such as peaches, milk, burnt lime, lumber and coal. Meanwhile, on the national level, "the rapid growth of the railroad industry influenced the art of bridge building and resulted in the development of new bridge types, new construction techniques, and the shift to new building materials."[41]

In the last decade of the 19th century and the early 20th century, road building in New Jersey was influenced by the 'Good Roads Movement,' which began with bicycle enthusiasts and continued with the popularity of automobiles. In 1891, New Jersey became the first state to appropriate money to county governments for road improvement. Surfacing roads with macadam began under this program. New legislation permitted county takeover of certain main roads, and beginning in 1916, state aid became available to help townships macadamize roads not taken over by the county.[42] Efforts to widen and pave the road along the Delaware River (Route 29) began in the 1930s, but were not completed until the 1950s. The former Easton-Trenton Turnpike was widened in 1937-38, as were the three remaining stone bridges along its route. Today, about 10% of the roads in Delaware Township remain unpaved.

Early Bridge Construction and Design in Delaware Township

A bridge is a structure that spans and provides passage over a physical obstacle, such as a river, stream, valley, road, etc. A bridge consists not only of the horizontal span built across the physical obstacle (frequently referred to as the superstructure), but also its vertical abutments, which support the ends of the superstructure, and, at the same time, support the embankment into which it is anchored. In addition, longer, multi-span bridges have piers, which support the ends of each span between the abutments. The abutments and piers are frequently referred to as the substructure. Abutments were frequently constructed with wing walls, which are low walls extending from the abutments to provide additional lateral support for the abutments and the embankments that form their approaches. They also add stability to the bridge substructure.

Wing walls can be U-shaped (making a 90-degree angle with the face of the abutment) or splayed (placed at an angle larger than 90 degrees) to suit conditions.[43] The splay configuration is the most common type

[40] Treese, Lorett. *Railroads of New Jersey-Fragments of the Past in the Garden State.* Mechanicsburg, PA,: Stackpole Books, 2006, p.11.

[41] Historic Highway Bridges in Pennsylvania. p.4.

[42] Schmidt,1946, pp.166-67.

[43] Ketchum, Milo S. *Structural Engineer's Handbook Data for the Design and Construction of Steel Bridges and Building.* New York: McGraw-Hill Book Company, p.245.

associated with Delaware Township. One of the wings of a U-shaped abutment may be omitted and replaced with an extension of the abutment forming an L shape. This design was used to divert a stream under a bridge at a natural bend and was occasionally used in Delaware Township. Site limitations often affected the geometry of the wing walls.

Typically, the abutments of a bridge are perpendicular to the direction of the roadway. In a "skewed" bridge, however, the abutments are placed off axis to compensate for the natural course of the stream or creek. Skewed stone arch bridges involve complicated geometry. Five of the thirteen stone arch bridges in Delaware Township are skewed.

Arches are defined by their geometry and the contour of the arch ring. The semicircular or "full-centered" arch is the "most stable arch configuration." [44] Segmental or elliptical arches have a flatter configuration. These arches have a "lower rise-to-span ratio" and require "heavier abutments to resist their thrust."[45] A voussoir or barrel vault arch has a continuous ring across the width of the arch. The "voussoirs" are "the wedge-shaped stones of which an arch or vault is built."[46] Commonly, voussoir or barrel vault arch bridges have closed (solid) spandrel walls that contain the fill (dirt, rubble, or stone) that covers the arch and retains the base of the roadway surface.

In stone arch bridges, abutments (and piers) "absorb the thrust placed on the arch and transfer it to the ground" and wing-walls are "extensions of the abutments designed to retain side slope material from the approaches." Spandrels are the "exterior walls that surround the arch barrel and act as retaining walls for the fill material, which carries the roadway." [47] Parapets are the spandrel walls that rise above the roadway and are often capped by coping stones. Stone is classified as either rubble, squared, or ashlar. All of the small stone arch bridges in Delaware Township are voussoir-closed spandrel arches.

The experience of Hunterdon County and Delaware Township mirrored the experience of the eastern United States. United States Secretary of the Treasury Albert Gallatin, in his 1807 *Report on Roads and Canals*, noted:

> In the Eastern States…wooden bridges, uniting boldness to elegance, and having no defect but want of durability, have been erected over the broadest and deepest rivers. In the lower counties of Pennsylvania, stone bridges are generally found across the small streams. Both in that State and at some distance eastwardly, bridges with stone piers and abutments, and a wooden superstructure, are common over wide rivers.[48]

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[44] Miller, Ann B., Kenneth M. Clark, Matthew C. Grimes. *Final Report: A Survey of Masonry and Concrete Arch Bridges in Virginia*. Charlottesville, VA: Virginia Transportation Research Council, 2000. p.16.

[45] Ibid.

[46] Ibid.

[47] Ibid.

[48] Gallatin, Albert. *Roads and Canals Letter from the Secretary of the Treasury, Transmitting A Report Prepared in Obedience to the Resolution of the Senate of March 2, 1807, Respecting Roads and Canals* (Reprint from State Paper No. 250, Tenth Congress, First Session). United States Senate, 61st Congress 2nd Session Document No. 499 Washington, Government Printing Office 1910. p.35.

Nineteenth-century abutments were typically constructed of stone masonry and occasionally timber. Both pile and crib wood abutments could have been used for light bridges. Timber pile abutments made use of closely- spaced logs driven into the ground. Crib abutments used stacked horizontal logs.[49] Timber pile abutments remain at canal crossings in Lambertville and Delaware Township; however, the availability of suitable building stone throughout Hunterdon County made stone the ideal choice for the construction of bridge abutments. Abutments are referred to as "butments" or "buttments" in the Hunterdon County Freeholder minutes, and all of those reviewed referenced stone construction. In the twentieth century, concrete became the preferred material for constructing bridge abutments.

The earliest roads often crossed rivers and streams in shallow places where they could be forded.[50] But fording streams soon proved unsatisfactory and bridges were deemed necessary.

> In Hunterdon County, it was the minor roads that helped tie the agricultural communities and rural enterprises together with the larger commercial communities. The ability to move crops, livestock, and other products was essential to the economic viability of individuals and for the community's growth. The County's great number and length of watercourses, from small rivulets to streams and rivers, presented problems of passage along roadways of every size.[51]

Laws adopted by New Jersey since 1704 gave counties the authority to maintain roads and bridges, but Hunterdon County did not impose a bridge building tax until 1795. Bridge construction and repair was a county expense paid from a "county tax." A few earlier bridges were built in what was at the time Hunterdon County, including a 1764 "Stone Bridge over Assunpink at Trenton," a multiple-span stone arch bridge carrying what is now South Broad Street, which is referenced in the Hunterdon County Freeholders' minutes, but few other freeholder references to bridges exist before 1800. More attention was given to bridge construction in the 19th century.[52] In 1830, the county's budget for building and repairing bridges was $6446.52. By the Civil War, the budget had increased to $25,000 a year.[53]

An act of the legislature was necessary to authorize the construction of a bridge over a navigable stream, and the first bridges across the Delaware River were toll bridges built by private companies. For smaller township bridges over non-navigable streams, the management of bridge building, repair, and replacement was the responsibility of the "overseer of the highways" and the township freeholders. For bridges that cost less than $50 to build (including the materials), the "overseer of the highways" and two chosen freeholders of the township were permitted to direct the construction, repair, or rebuilding of such bridges. For bridges costing more than $50 and less than $500, written notification for a scheduled meeting of the chosen freeholders of the township and the two adjacent townships was required. The decision to build, rebuild, or repair a bridge was by majority vote. The requirements were more stringent for bridges

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[49] Harger, Wilson G. and Bonney, Edmond A. *Handbook for Highway Engineers.* New York: McGraw-Hill Book Company, 1919. p.100.

[50] Lichtenstein, 1992, p.168.

[51] Boothy, p.42

[52] Ibid, p.168.

[53] Schmidt, 1946, p.168.

exceeding $500 in cost.[54]

After the chosen freeholders decided on the type of bridge to be built, the freeholder board appointed a supervisor(s) to attend construction. The freeholders also "appointed an inspector to audit the accounts and inspect the bridge to determine that it was constructed of quality materials and in a workmanlike manner." The freeholders decided the method of payment and were required to post a public notice. By the mid-19th century, an auction to "sell the opportunity to construct the bridge" was held.[55]

The Freeholders' minutes provide records of bridge construction in Hunterdon County beginning in the late 18th century. It is difficult to use the minutes to date individual bridges, but the minutes can be used to determine the period of use for each bridge type, the types of materials used, the relative costs involved, and possibly to confirm builders and datestones. The earliest mention of a bridge in what would become Delaware Township is the 1787 repair of a bridge crossing the Wichecheoke on the site of the current Green Sergeants covered bridge.[56] Because Delaware Township was not founded until 1838, the meeting notes for bridges built in Delaware Township before 1838 are found with those of Amwell Township.

The choice of span type – stone arch, timber stringer, timber truss, metal truss – depended on location, size of the stream, anticipated road traffic, and period of construction. In the 20th century, as trucking grew in favor, heavier bridges were required; therefore, the steel stringer bridges, which were stronger, were the most commonly-built bridges in Delaware Township after *circa* 1920.

II. ***Stone Arch Bridges Built in Delaware Township Before 1882***

The colonists brought stone arch technology from Europe and textbooks such as William Pain's *Carpenter's Pocket Directory*, published in 1792, and *The Practical Builder,* published in 1797, provided detailed descriptions and drawings of the carpentry needed to build the form or "falsework" that was required to build a stone arch.[57] Despite the availability of this knowledge, the relative rarity of stone arch bridges during the 1700s can be surmised by some of the attention that they received. For example, Dr. Robert Honyman, in his published journal *Colonial Panorama 1775*, specifically noted the presence of stone arch bridges in the Delaware Valley, commenting: "Between Philadelphia & Bristol there are 2 or 3 pretty small stone bridges over some pleasant little rivers."[58]

The stone arch bridges of Delaware Township have been described as uniquely American structures that stand as a cohesive group depicting regional characteristics specific to southern Hunterdon County. These characteristics were influenced by the materials available and the skill level of the local masons and

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[54] Nixon, John T. *A Digest of the Laws of New Jersey.* Newark, NJ: Martin R. Dennis & Co., 1868. p.87.
[55]. Lichtenstein, 1992, p 4.
[56] Hunterdon County Freeholders Minutes, Vol.1, p.133
[57] Pain, William. *The Carpenters Pocket Directory*. London: I. and J. Taylor, 1792; Pain, William. *The Practical Builder or the Workman's General Assistant*. London: I. and J. Taylor, 1797.
[58] Padelford, Philip, Ed. *Colonial Panorama 1775: Dr. Robert Honyman's Journal for March and April.* San Marino, CA: The Huntington Library, 1939. p.23.

carpenters who built them. Thomas Boothby, an engineer and stone bridge historian who has surveyed and extensively evaluated Hunterdon County's stone arch bridges, has concluded:[59]

> Stone bridges represent many important parts of the history of transportation in North America, the importance of safe and reliable transportation for farm products, the development of turnpikes, which, along with canals and railroads supplied the transportation needs of North American communities during the early nineteenth century, the pressure from bicycling, and later automobile interest groups for better roads, and the technological achievements of the emerging engineering profession in North America. The stone bridges of Hunterdon County, however, almost exclusively arose from the response of a local agricultural community to the need for better roads for the support of agriculture. The bridges are built in a native craft tradition, showing only minor refinements and untouched by the technological improvements of stone bridges of the late nineteenth century.

Boothby's physical examination of approximately 100 stone arch bridges in Hunterdon County has identified some distinctive features that are pertinent to fully understanding the history and significance of the stone arch bridges found in Delaware Township:[60]

> … A fundamental stylistic difference can be discerned, roughly divided between the northern and southern townships [of Hunterdon County]. In general, the bridges in the Northern Townships appear to be more hastily and expediently constructed and to reflect less intervention of the builder either on the shape of the stones used in the bridge or on the shape of the bridge within the landscape …
>
> A distinctly different style of bridge construction prevails in the southern townships of West Amwell, Delaware, Kingwood, and Franklin. Structures in these areas, although still clearly of rustic craftsman construction, show refinements of style and execution that are not present in the northern portions of the county. Softer and more easily shaped stones are used in general and more care is used in dressing and shaping the stones, especially the stones of the arch ring. Joints in the arch ring follow a radial alignment, and the stones are shaped on the intrados and extrados to conform to the curve of the arch ring.
>
> Particular additional refinements can also be seen. Many of the bridges in Delaware and East Amwell Township have the plane of the arch ring and the spandrel slightly inset from the parapet and wing walls. In bridges such as D-368 located on Sandbrook-Headquarters Road at the intersection with Lambert Road [in Delaware Township], this treatment is combined with careful craftsmanship in the arch ring to produce a structure reflective of simple elegant craftsmanship. The construction method is the same as the northern township bridges; the approach to the slight skew is identical, as is the construction method of the arch barrel, but the external appearance is strikingly different.
>
> The inset style, in which the arch ring and spandrel wall lie in a slightly different plane from the

[59] Boothby, Thomas E. "Stone Arch Bridge Inventory, Phase II, Hunterdon County, New Jersey." The Pennsylvania State University, November 1998, (Executive Summary).
[60] Ibid. pp.21-31.

> wingwalls and parapet, appears to evolve from the combination of buttresses and string courses observable in bridges in the Eastern US. The preponderance of slightly skewed bridges is also noteworthy, especially because of the unsophisticated methods of achieving a skew alignment used by the local builders…

Boothby's survey of Hunterdon County's stone arch bridges included six within Delaware Township. Stone-arch bridges with a span over 20-feet (surveyed in 1992 by Lichtenstein Associates for the New Jersey Department of Transportation) were not considered in his analysis, nor were the stone-arch bridges that remain on abandoned segments of roadway. However, when all 13 of Delaware Township's stone-arch bridges are compared, a striking similarity is conveyed. All 13 stone-arch bridges are ornamented with cut sandstone voussoirs – some with keystones, most without – that are strikingly distinctive from the coursed stonework of the spandrels and wing walls, which have a handmade, unsophisticated appearance. In 11 of the 13 stone-arch bridges, the arch rings and spandrels are within an inset panel.[61] The use of the inset panel appears to be concentrated in this region of Hunterdon County and can be considered a regional subset. Interestingly, the two bridges that do not have inset panels are the earliest bridge (DQ 313 – 1829 on the Easton-Trenton Turnpike) and the last stone-arch bridge to be built (D449 – c. 1882 on Worman Road).

The stone-arch bridges surviving today in Delaware Township were built between 1829 and c. 1882. Six bridges have datestones with the following dates: 1829, 1837, 1838, 1849, 1872, and 1873. The Route 579 bridge (DQ-313), with a 1829 date stone, is believed to be the oldest documented bridge in Hunterdon County. The Freeholder minutes frequently mention the construction of new stone bridges after 1800, but no reference to new stone bridges appears after 1882 for Delaware Township locations. However, in other parts of Hunterdon County stone-arch bridges continued to be built up to 1900.

Based on the evidence offered by the surviving population of stone arch structures in the county and limited primary source documentation, the heyday of the stone arch bridge and culvert appears to have been the first three quarters of the 19th century. This was especially true of the middle quarters of the 19th century when secondary roads and their related stream crossings were improved as farm-to-market roads. The local infrastructure took on added importance as part of a multi-modal transportation network that included the railroad beginning in the 1840s.[62]

Eight of the stone arch bridges have a "low rise" – meaning they are not semicircular and have a height-to-width correspondence of .25 to .33. Arches built with a perfect semicircle have a height-to-width correspondence of .5. The Buchanan Road Bridge (D-441) and the Worman Road Bridge (D449) both have a perfect semicircular arch. Bridges classified as having a "high rise" have height-to-width correspondence of .45 to .5. Five of the stone arch bridges are classified as having a high rise.

> The span and rise of a semi-circular arch is equal, meaning that as the semi-circular arch increases in span it's rise increases in direct proportion…segmental arches occur vary rarely in culvert

[61] See Photo of Bridge D379 or D448 for representative examples of this design element.
[62] Lichtenstein, Hunterdon County Stone Arch Culvert Survey Phase I, p.3.

spans less than ten feet, but are fairly commonly found in spans between ten and twenty feet where their use is typically associated with the need for a wide waterway opening in a low embankment.[63]

In six of the stone arch bridges, the point at which the arch rises from its supports (spring line) begins at a very low position to that of the stream. The arches of seven of the bridges are raised on bearing seats. In most cases, arches with a high rise are founded on raised bearing seats and arches with a low rise begin at a low position. Four bridges, however, break this general rule: three low-rise arches are founded on raised seats and one high- rise arch is founded on low seats. The use of a low-rise arch and the omission of raised bearing seats were, as Boothby described, used to prevent or reduce a hump in the road and were a result of the mason's decisions in the field. Where the terrain allowed a greater height between the stream and the roadbed, a higher arch and/or raised bearing seats were used; such was case with the Worman Road Bridge (D449).

The typical Delaware Township stone-arch bridge has a flat parapet above the inset panel and tapering parapets above the wing walls. The edges of the inset panels align with the wing walls. Asymmetrical wing walls that splay at different angles on each side of the bridge in response to the topography are characteristic. No attempt was made to create perfectly symmetrical wing walls; this contrasts with the precision of the arch rings.

Bridge D449 is located on Worman Road which was partitioned for construction in 1882 and the bridge[6470] likely accompanied the construction of the road. It is believed to be the last stone-arch bridge built in Delaware Township. This bridge has a small (4'-6") span and a high arch built on raised seats. Its appearance is similar to several small stone-arch railroad bridges on the Black River & Western Line which was constructed through Delaware Township in 1872. This bridge differs from the other stone-arch bridges in Delaware Township with the omission of the inset panel, high arch rise, and a substantially raised arch on bearing seats. The method used to lay out and build the parapets and wing walls is the same, but the flat parapet section was omitted.

The stone arch bridges of Delaware Township highlight the "fact that the form and methods of constructing stone arches changed little during the 19th century. … Up until the mid-19th century the majority of … arches continued to be designed and built by the rule-of-thumb practice established by masons rather than in accordance with mathematical theory."[65]

Despite this continuity in the "art" of stone-arch building, great advances were made during the latter half of the 19th century in understanding and explaining the science of stone-arch design, for example, *The Theory of Voussoir Arches,* written by mathematics and engineering professor William Cain and published 1893[66]. During the period 1850 to 1890 the fundamental literature of modern structural mechanics

[63] Stone Highway Culverts in New Hampshire 1750-1930 NRHP MPDF August 2008. p E9
[64] Hunterdon County Road Returns.
[65] Stone Highway Culverts in New Hampshire 1750-1930 NRHP MPDF August 2008. p.E9
[66] Cain, William. *Theory of Voussoir Arches.* New York: D. Van Nostrand Co., 1893.

appeared. Railroads, and the engineering that they required, "upset the old world" and bridge engineering produced, in both stone and iron and in steel, the "best of constructive art and science."[67] The stone bridges that are most often described, illustrated, and celebrated are those massive structures built by the railroads:

The largest body of literature on the design and engineering of stone culverts pertains to those built by the railroads and was published in the last quarter of the 19th century. Prior to this time, stone culvert design and construction was based on traditional knowledge of the component elements such as the strength of the local stone and characteristics of a particular water course and drainage area. Stone culverts designed and constructed by bridge builders or masons can be called "vernacular in design" and the majority of stone highway culverts undoubtedly fall into this category. It is important to note that while a bridge is a structure that spans a physical natural hurdle or obstruction like a river or valley, a culvert is an embedded structure with a shorter span , which may be bridge-like in function, that allows for passage of water through a physical obstruction such as a hill, roadway, passage, or walkway. With the exception of the military works, canals, hydropower, and a few great water supply and sewerage projects, civil engineering in America during the 19th century was dominated by railroad work. The majority of knowledge of the engineering of bridges, culverts, and land drainage resulted from the building of what became the world's greatest railroad system.[68]

By the mid-19th century the use of the stone arch was in rapid decline due to the advent of truss bridges of wood and iron, all iron, and finally all steel construction. This was essentially true in the United States where the railroads – during their initial building and period of expansion – demanded cheap and rapidly constructed bridges, characteristics stone arches did not possess.[69]

The large number of stone-arch bridges that remain in Delaware Township and elsewhere across Hunterdon County is, in part, a tribute to "the inherent soundness and simplicity" of this structural configuration especially when applied to small scale bridges. Stone, especially when configured into an arch, is able to sustain a great deal of compression, support exceptional loads, and resist environmental threats like the rust and rot that plague other materials. Additionally, "an arch generally fails slowly and [visually] telegraphs problems when it is overstressed."[70]

The stone arch bridges of Hunterdon County and Delaware Township are tangible counterpoints to the interpretation that late-19th century bridge building, dominated by metal truss and, subsequently, concrete bridges, was exclusively the province of advancing structural engineering and materials technology. The stone- arch bridges of Delaware Township document the persistence of the carpentry and masonry skills needed to build them for at least a generation after metal truss bridges began to make their local appearance.

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[67] Benvenuto, Eduardo "1850-1880: Bridge-Building and Modern Structural Mechanics" in *Arch Bridges History, Analysis, Assessment, Maintenance and Repair*. Rotterdam/Brookfield: A.A.Balkeman, 1998. p.4.
[68] Stone Highway Culverts in New Hampshire 1750-1930 NRHP MPDF August 2008. p.E9
[69] Ibid. p.E10.
[70] Lichtenstein, Phase 1, p.3.

III. ***Metal Truss Bridges Built in Delaware Township Before 1945***

Whereas stone-arch bridges typically crossed small waterways, truss bridges were desirable for longer crossings. The earliest wooden truss bridges - including the 1792 Essex-Merrimac Bridge in Newburyport, Massachusetts - were not covered. It was soon found to be advantageous to enclose and protect the bridge from the weather.[71] However, covering the trusses did not necessarily mean enclosing the entire span. In Hunterdon County, small truss bridges were built throughout the early-to-mid 19th century with the trusses capped and the deck open – none of these, however, have survived in Delaware Township. The Hunterdon County Freeholder minutes usually do not distinguish between an uncovered timber-truss bridge and a timber-stringer bridge.

Covered wooden truss bridges were built in England in the 18th century. The first covered bridge in America was built in 1804 across the Schuylkill River in Philadelphia. Other early spans include Delaware River crossings at Trenton in 1806 and between Lambertville and New Hope, and Stockton and Center Bridge in 1814.[72] The presence of wooden truss bridges in Burlington and Somerset counties was acknowledged by a New Jersey Statute of 1834 that prohibited traveling across such bridges at a pace faster than walking.[73]

A truss is "composed of an assemblage of triangles."[74] The top and bottom "chord" [the portion of the truss that is designed to resist bending][75] holds the triangles together and two (or more) parallel trusses connected and braced laterally form the superstructure of a truss bridge. Truss bridges are classified as either deck truss, where the roadway is atop the trusses; through truss, with lateral cross bracing at the upper and lower connections of the trusses; or "pony-truss" where the roadway is between parallel trusses that have lower but not upper (overhead) lateral cross bracing (sometimes called a "half-through truss").

Pony-truss bridges are a lighter structure used for shorter crossings; they have shallower truss depths and no bracing between the top chords. They were typically called "low truss" bridges by the Hunterdon County Freeholders. Through-truss bridges are designed for longer spans and heavier loads, for example railroad bridges. Through-trusses are substantially higher than a pony truss, and the top chords are laterally braced. The trusses must be high enough to drive under the bracing. Two trusses, joined by the road deck (and by the road deck and cross members in a through-truss), create one bridge span. As a load traverses each span, opposing forces of compression and tension are at work within the trusses. Early trusses were all wood, or combined wood and iron. The earliest all metal trusses used cast iron. Later metal trusses used both wrought and cast iron components in the same structure, cast iron for compression members and wrought iron for tension members, and by the 20th-century truss bridges were built with steel.

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[71] Marburg, 1911, pp.310-311.
[72] Goodspeed, 1995.
[73] State of New Jersey, "An Act Relating to Bridges," 1833.
[74] Marburg, 1911, p.309.
[75] Waddell, John Alexander Low. *Bridge Engineering (Volume 2).* New York: John Wiley and Sons, 1916. p.1929.

In the early 19th century, the principles of stresses began to be understood and a series of patented truss designs were developed for roadway and railroad bridge use. The patents were typically named for the designer. Between 1797 and 1872, 372 applications for truss bridge patents were sent to Washington.[76] Most were fanciful, and some were even dangerous. Only a dozen or so became widely used. Among the most well-known patents are: the Town lattice-truss patented in 1820 by Ithiel Town, the Howe Truss patented in 1840 by William Howe, and the Pratt Truss patented by Thomas. W. and Caleb Pratt in 1844.[77] The Howe Truss was most commonly used for wooden bridges and continued to be used into the early 20th century.[78] By 1870, books such as United States Corps of Engineers Colonel William E. Merrill's *Iron Truss Bridges for Railroads* offered "Methods of Calculating Strains" and "New Formulas for Bridge Computations."[79]

The overwhelming majority of truss bridges built during the late 19th and early 20th centuries were metal truss bridges. As a structural form, the truss was first built in timber. In the 1840s two truss types were patented as combination wood and iron structures. The truss members which acted in compression were made of wood, while the tension members were of iron. Combination trusses of this kind continued to be built through most of the nineteenth century, but the more progressive iron trusses surpassed them in popularity, largely as a result of innovations in bridge engineering developed for the nation's fast growing railroads. During the post-Civil War years, the American railroads grew rapidly, extending railroad lines and developing new metal truss types which could accommodate heavier trains and faster speeds, and the greater stresses that accompanied these developments. Each railroad had its own preferred type of truss and many railroad engineers patented the trusses they developed. While the railroads spurred the development of new metal truss types, the ease of construction and suitability for diverse site conditions made the metal truss bridge a favored choice for many local highway bridges. The metal truss bridge had several advantages for the railroad companies and the highway bridge designers alike. First, it was possible to analyze the structural behavior of the bridge through systematic engineering calculations. Second, bridge members became standardized and it became possible to physically test materials and members for their capacity and behavior under applied loads. Finally, the components of the truss were easily manufactured and shipped, and the entire bridge could be erected quickly on the substructure with a minimum of skilled labor.[80]

According to Norman F. Brydon's *Of Time, Fire, and the River; the Story of New Jersey's Covered Bridges*, "New Jersey could never boast a large number of covered bridges. A total count at any one time was about 35."[81] Fourteen of these crossed the Delaware River between Trenton and Dingmans Ferry.

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[76] Goodspeed, March 1999, section 8, p.4.
[77] Marburg, Edgar. *Framed Structures and Girders, Theory and Practice,* Volume 1, Part 1. New York:, McGraw-Hill Book Company, 1911. pp.310-313.
[78] Ibid, p.313.
[79] Merrill, Colonel William E., United States Army Corps of Engineers. *Iron Truss Bridges for Railroads*. New York: D. Van Nostrand, 1870.
[80] Historic Bridges in Pennsylvania, p.11.
[81] Brydon, Norman F. *The Story of New Jersey's Covered Bridges of Time, Fire and the River*. New Vernon, NJ: Business Services,

Hunterdon County had eight covered bridges, the largest number of any county: six crossing the Delaware River (Lambertville, Stockton, Raven Rock, Byram, Frenchtown and Milford) and two inland (a span crossing the South Branch of the Raritan River at Three Bridges and the span crossing the Wickecheoke Creek in Delaware Township - D304).[82] Today, the only surviving historic covered bridge in New Jersey is centrally located in Delaware Township.

In 1872, two timber truss covered bridges apparently were constructed in Hunterdon County. Specifications for one crossing the Neshanic at an unknown location follow:

> [The Board met] for the purpose of viewing a site on the Neshannock Creek (on a new road) and considering and deciding upon the necessity of a building a bridge over the same.
>
> A new bridge was granted on the site viewed today. A single-spanned wooden bridge with iron stringers, having a length of seventy five feet and a width of fourteen feet, was voted.
>
> On a motion passed at the last meeting of Sergeantsville in relation to inclosing the truss work of the bridge at this place. Adopted.
>
> On motion, it was agreed that said bridge be covered.[83]

In 1872, the Hunterdon County Freeholders examined a bridge that crossed the Wickecheoke at the site of an existing covered bridge (D304). They voted that "all piers be removed and a wooden bridge be erected with iron stringers." The motion was amended to include capping the truss work with pine boards. White or rock pine was specified for the timbers, and the bridge would be "as wide as the present abutments will permit," indicating that the new bridge was constructed on the earlier abutments. The construction was supervised by Joseph Smith, Freeholder, and the chief architect/builder was Charles Ogden Holcombe of Lambertville. Peter Sibley, a ship's carpenter, worked on the bridge, and masonry work was completed by Ely Everitt and his brother Charles.[84] The clear span of this surviving bridge is 73'-8". The bridge (D304) is named for Richard Green Sergeant (1795-1878), a farmer and miller who probably supplied the timbers used for its construction. The "Sergeant's Mill" and associated farm was purchased by Charles Sergeant in 1805 from the heirs of Samuel Opdyke. Upon Charles' death in 1833, the property was inherited by his son, Richard Green Sergeant.[85]

The Green Sergeant's Covered Bridge was originally constructed as a wooden Howe Pony Truss bridge with heavy timber top chords and diagonals, and vertical iron rods. According to Lichtenstein:

> Wood works well in compression, but it cannot accommodate tensile forces efficiently". This limitation was resolved by William Howe (1803-1852) who, in 1840, patented a truss bridge design that used wrought iron rods for the tension members (posts) and wood for the bulkier

1970.
[82] Ibid,p p.22, 32 and 95.
[83] Hunterdon County Freeholders Minutes, Vol. 4, p.157.
[84] Goodspeed, 1995.
[85] Goodspeed, 1995; Karschner, 1974.

> compression members, and top and bottom chords. His design with the iron tension rods, which is represented by the Sergeantsville bridge [D304], heralded the beginning of the switch from wood to metal truss bridge technology.[86]

The Green Sergeant's Covered Bridge is both individually listed on the National Register of Historic Places and noted as a contributing resource within the Covered Bridge Historic District. In 1937, it was documented by the Historic American Buildings Survey (HABS). In 1961, it was disassembled and rebuilt on steel girders. The trusses were reconditioned and erected in their former positions on steel brackets. Sixty percent of the original pine siding was reused, as was 90% of the original rafters. The abutments were repaired and reinforced with concrete and steel rods. The bridge was made one-way for west-bound traffic, and a new steel and concrete span with stone parapets was erected beside the old bridge for east-bound traffic.[87] Although no longer functioning as a truss bridge, its original visual aesthetics and character remain uncompromised.

Iron, both cast and wrought, was the material that bridge builders used during the transition between timber or stone bridges and bridges constructed of steel. One of the early uses of iron in a Hunterdon County roadway bridge was in July of 1863 when the Freeholders authorized the construction of a "wooden bridge to be built with iron stringers, 55 feet span."[88]

Although some of the earliest iron bridges used only cast iron (a brittle material with little tensile strength), engineers quickly transitioned to using "cast iron for compression members and wrought iron for tension members." Although wrought iron "cost twice as much as cast iron," it "resisted tension (stretch) so much better that it was worth the expense for certain parts of a bridge." "Iron was the modern wonder - strong, affordable, mass-producible, portable, fire-resistant, and capable of being shaped in the loveliest designs." Bridge historian Eric Delony has concluded: "The iron truss is the rarest and least recognized American bridge" but is also "the most technologically significant."[89]

Although the first truss bridge was patented in 1806, the construction of iron truss bridges began in about 1840[90] with two iron truss bridges constructed over the Erie Canal. Interest in the construction of iron truss bridges was stimulated by the development of railroads. The first iron truss railroad bridge in America was designed in 1845 by Richard B. Osborn and constructed by Philadelphia and Reading Railroad at a location near Manayunk, Pennsylvania.[91] However, several early disastrous failures fostered the continued use of wooden truss railroad bridges until the materials were better understood. The Chief Engineer for the Baltimore and Ohio Railroad, Benjamin Latrobe, chose to build iron bridges on the line between Cumberland, Maryland and Wheeling, West Virginia, and that led to the general adoption of iron for railroad bridges.[92] Working with Latrobe, Wendel Bollman and Albert Fink, designed "all-metal

[86] Lichtenstein, 1992, p.56.
[87] Bertland, 1999, section 7, p. 3; Goodspeed, 1995.
[88] *Hunterdon Republican*, July 31, 1863.
[89] Delony, Eric. "The Golden Age Of The Iron Bridge." *American Heritage of Invention and Technology*. 9,1 (Summer 1993).
[90] Marburg, 1911, p.315.
[91] Ibid, p.316.
[92] Ibid, p. 316.

trusses that could support more than one ton per lineal foot."[93] Bollman and Fink each subsequently developed a patented iron truss bridge, with a Fink Truss Bridge being constructed in Hunterdon County in 1858.

The use of iron truss bridges for roadways began in New Jersey in the late 1850s.[94] The earliest reference to an iron bridge in the Hunterdon County Freeholders minutes is 1858 – ten years earlier than in Somerset County. Meeting notes do not reference truss type or fabricator, but a Fink Suspension Truss Bridge was constructed in 1858 over the South Branch of the Raritan River in Hamden Township, Hunterdon County. The Fink Truss, patented in 1854 by former Baltimore and Ohio Railroad engineer Albert Fink, was listed on the New Jersey and National Registers of Historic Places in 1974 and survived as the oldest metal truss bridge in Hunterdon County until 1978 when it collapsed after being struck by a motor vehicle.[95] (Until that accident, it was one of the last Fink-type truss bridges in the United States.)

The impetus for the construction of this first metal truss bridge in Hunterdon County appears to have been the advocacy of iron bridges by Hunterdon County freeholders such as Samuel Lilly, MD, who served as Lambertville's first mayor beginning in 1849 and also, beginning in 1857, served as a Hunterdon County freeholder for 8 years. An obituary published in the *Transactions of the American Medical Association* noted that Lilly "…was director of the [Freeholder] Board, and very active in the introduction of iron bridges into the county."[96]

In 1868, Hunterdon County funded the construction of a Lowthorp Truss highway bridge over the Musconetcong River in New Hampton on the Hunterdon-Warren County border. The Lowthorp Truss, patented by Francis C. Lowthorp in 1857, used the web system of the Pratt Truss and added compression members of iron and tension members of wrought iron. Lowthorp, like Bollman and Fink, obtained bridge building experience during his employment as a railroad bridge engineer, completing an 11-span iron truss railroad bridge in 1856-1857. Hunterdon County's first Lowthorp truss bridge was fabricated in 1868 by the Charles Cowin foundry in Lambertville and installed across the Musconetcong River in New Hampton. Other metal truss bridges constructed in Hunterdon County prior to the 1876 construction of Delaware Township's first metal truss bridge (D300, Raven Rock-Rosemont Road) include a second Lowthorp Truss constructed in Clinton and a third Lowthorp Truss constructed in Glen Gardner, both in 1870. All three of these Lowthorp truss bridges survive.

In the decade of the 1870s, newspapers reported the construction of at least 10 other iron truss bridges, with spans between 40 and 150 feet. The transition from timber to iron truss was specifically noted in 1877 when the Freeholders announced their intent to sell a covered bridge and replace it with an iron bridge 150 feet in length and "proportioned to carry a distributive load of one hundred tons in addition to

[93] Delony.
[94] Lichtenstein, 1992, p.57.
[95] Lichtenstein A. G. and Associates Inc. and Kemp, Emory L. *A Plan for the Reconstruction of the Historic Hamden Fink Suspension Truss*. (Copy at New Jersey Historic Preservation Office, Trenton, NJ, 1979).
[96] American Medical Association, *Transactions of the American Medical Association*, 1880, p.1062.

its own weight."[97] The newspapers also reported examples of iron bridges being built to replace stone-arch bridges that were "not large enough to allow the passage of water during freshets."[98]

By the 1880s, metal truss bridges were preferred by the Hunterdon County Freeholders. According to Lichtenstein, "The last quarter of the 19th century was the halcyon era of the metal truss bridge in America." Wrought and cast iron was used for the construction of iron truss bridges until about 1895, after which steel was substituted.[99] The Pratt Truss was patented by Thomas and Caleb Pratt in 1844 and became the most popular truss configuration for iron bridges in the United States because of its "simplicity of design and economy of fabrication and erection."[100] The Pratt truss was originally constructed with wrought iron diagonals and wood verticals and top and bottom chords. It differed from the Howe truss in that the verticals were designed to act in compression and the diagonals in tension instead of the reverse. It was more expensive to build than the Howe, but when the same design was executed in iron and steel, "it came into wider use than any other type."[101] The Parker Truss, essentially a Pratt Truss with a curved top chord, was introduced in the late 19th century.

The Pratt truss was used for both through- and pony-truss bridges. The freeholders called a pony-truss bridge a "low truss" bridge to distinguish it from a through-truss or "high truss" bridge. Beginning in the 1880s, "low truss bridges" were preferred for their low maintenance on short-span crossings, and the freeholders regularly voted to replace timber spans – both timber stringer and early uncovered timber trusses – with "low truss bridges." Through-truss bridges were used to cross wider creeks and were sometimes used to combine several shorter timber spans into one long span, thus eliminating the need for piers. Prominent in a truss bridge are the top and bottom chords, which are the structural members that resist the forces induced by bending. These chords carry the major loads exerted on the bridge. The web members are categorized as verticals and diagonals, and are connected to the top and bottom chord at joints.

> It is the arrangement of the chords and web members that determines the specific truss type, as a wide variety of configurations is possible…other basic components of a truss bridge are the portal, stringers, floor beams, and deck. The portal is the space of a truss, which forms the entrance to the bridge. Stringers are the longitudinal members, set parallel to the direction of traffic, which are used to transmit loads to the floor beams. The floor beams are set transverse to the direction of traffic to transmit the deck loads to the trusses. The deck is the structural element providing direct support for vehicular loads. The truss rests on the top of the pier or abutment at a point called the bearing seat.[102]

According to Lichtenstein, "exceptionally fine early examples of Pratt through-truss bridges are scattered throughout the northern part of the state with Hunterdon and Somerset Counties having the greatest

[97] *Hunterdon Republican*, September 6, 1877.
[98] *Hunterdon Republican*, July 28, 1897.
[99] Lichtenstein, 1992, p.59.
[100] Ibid, p.59.
[101] Marburg, 1911, p.313.
[102] Historic Bridges in Pennsylvania, p.111.

numbers"[103] Delaware Township has two Pratt through-truss bridges and three Pratt pony-truss bridges. All of the Pratt truss bridges were built before circa 1901. The 1878 through-truss bridge across the Lockatong Creek on Raven Rock Road (D300) was built by the Lambertville Iron Works, and the 1897 through-truss bridge across the Lockatong Creek on Strimples Mill Road (D481) was built by the Wrought Iron Bridge Company of Canton, Ohio. Two of the Pratt pony-truss bridges were also built by the Wrought Iron Bridge Company – the 1889 (D488) span over the Wickecheoke Creek on Old Mill Road and the circa 1895 span (WD120) across the Alexauken Creek on Hamp Road. Lichtenstein credited the Hamp Road bridge as "having rare design details like cast bearings and connectors."[104]

Lambertville Ironworks was founded in 1849 as "Laver and Cowin" and was a partnership between John Laver and his nephew, William Cowin (1825-1874). The company fabricated railroad car wheels, axles, boilers, steam engines, and truss bridge members. The name was changed to Lambertville Iron Works in 1859 after the partnership dissolved shortly before Laver's death.[105] According to Lichtenstein, "Cowin was the fabricator of the most important 19th century bridges in the region." The Raven Rock Road Bridge (D300) was the last bridge built at this foundry, and it is said to be an "excellent representation of the skill of the 19th century iron worker."[106]

During the second half of the 19th century, companies such as the Wrought Iron Bridge Company, Berlin Bridge Company, King Iron Bridge Company, Keystone Bridge Company, Canton Bridge Company, Groton Bridge Company, and Champion Bridge Company emerged as prominent manufacturers and fabricators of metal truss bridges. The Wrought Iron Bridge Company, founded in Canton, Ohio in 1864 by David Hammon, was one of the most successful late-19th-century bridge manufacturers. Illustrated catalogs and traveling agents were used to promote their bridges to distant markets; their bridges were common throughout New Jersey.[107] The company mass-produced parts and shipped pieces by railroad. Local contractors were able to assemble a bridge quickly, like a model. By 1882, the company claimed to have erected "nearly 4,300 spans" in 26 states, Canada, and Mexico. In 1899, the company was consolidated along with 27 other companies into the American Bridge Company.[108] A number of Wrought Iron Bridge Company metal truss bridges survive in Hunterdon County.

Despite the late-19th century rise of bridge building companies and their eventual consolidation into large manufacturing and erecting companies such as Andrew Carnegie's American Bridge Company, Hunterdon County's truss bridge inventory includes a number of locally produced and fabricated bridges. Initially, the Lambertville Iron Works was the most recognized Hunterdon County iron truss bridge builder. Subsequently, John W. Scott, a Hunterdon County resident who maintained a foundry in Flemington, became Hunterdon County's most recognized local iron truss bridge builder. Throughout the decades

[103] Lichtenstein, 1992, p.59.
[104] Ibid, p.173.
[105] Plunkett, Barbara. "Raven Rock Road Bridge." draft National Register nomination. March 2006, Sec.8, p.10. [HPO]
[106] Lichtenstein, Bridge 10XX300 survey form.
[107] Lichtenstein, Hunterdon County Bridge WD120 Survey Form.
[108] Wikipedia: Wrought Iron Bridge Company.

from 1880 to 1920, Hunterdon County engaged Scott's company to fabricate, erect, and repair dozens of metal truss bridges. On numerous occasions in 1896 and 1897, the newspaper the *Hunterdon Republican* referred to Scott as "the well-known bridge builder" and "our bridge builder" and in December of 1896 commented: "He is a good mechanic and always has plenty of work."[109]

Even when Hunterdon County engaged the bridge building services of one of the national companies, the masonry work and the provision of lumber for construction and roadway decking was contracted separately from the iron bridge construction. Bids would be awarded for masonry work by the cubic yard and lumber by the linear foot. This system ensured that local craftsman would continue to benefit from the public expenditures. For example, in 1897, the freeholders awarded the Wrought Iron Bridge Company (Canton, Ohio) the contract to build the 90 foot long trough-truss bridge over Lackatong Creek in Delaware Township (D481). The announcement noted that the bridge contract ($850) was the lowest bid of the 10 submitted and that the county was awarding the masonry work to an Annandale contractor ($4.10 per cubic yard) and the lumber contract (3,232 feet at $3.40 per hundred feet) to local suppliers Williamson and Hartpence.[110]

The truss designs could make use of various member profiles. In 1862, Samuel Reeves, president of the Phoenix Iron Company, patented the "Phoenix column." The Phoenix column was built up of four, six or eight wrought iron, flanged, concave sections that were riveted together along the flanges. Reeves also manufactured corresponding cast bearing blocks (or feet) and connection pieces. The column was stronger and more economical than a cast-iron column, and it advanced the promulgation of metal truss bridges for railroads. Between the 1860s and 1870s, the column was successfully marketed for railroad bridges, but in the 1880s, when columns could no longer satisfy the strength and stiffness needed for railroads, the technology was successfully redirected for truss road bridges. According to Lichtenstein, there are only eight bridges remaining in New Jersey that were built "with the technologically significant Phoenix Columns" and the "three earliest and most complete are in Hunterdon County." They are the 1878 Raven Rock Road Bridge in Delaware Township (D300), the 1885 Hamden Road Bridge over the South Branch of the Raritan River in Franklin Township (F65), and the Lansdowne Road Bridge over the Capoolong Creek in Franklin Township (F82). "All three are significant in the state and national context."[111]

The earliest New Jersey highway application of the Phoenix section is the remarkably complete and historically important 1878 Raven Rock Road Pratt through-truss span in [Delaware Township] Hunterdon County [D300]. Fabricated by the nearby Lambertville Iron Works, the well preserved bridge features idiosyncratic cast iron connections that were made by the iron works. All other New Jersey bridges with Phoenix sections have Phoenix Iron Company-made connecting pieces and feet (bearings).[112]

Truss bridges are further distinguished by the type of connection used to join the primary structural

[109] *Hunterdon Republican*, July 22, August 26, September 9, December 9, 1896 and January 13, 1897.
[110] Ibid., June 27, 1897.
[111] Lichtenstein, 1992, pp.172-3.
[112] Ibid, p.58.

members. A "pin" connection makes use of forged eye-bars through which an iron pin (or rod) with threaded ends is inserted. Advocates of pin connections argued that bridges with pin connections were easy to assemble in the field. Through the 1880s, engineers debated whether pin connected or riveted truss bridges required less material, could more easily be assembled in the shop and constructed in the field, were more economical to build, were more durable or stronger and more resistant to collapse if struck, or provided better overall value.[113] Engineers acknowledged that riveted connections were more rigid and less liable to loosen, "Riveted connections largely avoid vibration, the great demoralizer of all iron and steel bridges,"[114] but, until the development of the portable pneumatic rivet system in the 1890s, pin connections retained an advantage over rivets. Although pin connected truss bridges were generally favored through the 1880s for most all iron truss bridges, by the 1890s, American engineers seemed to prefer riveted truss bridge connections for all but the largest and longest spans.[115]

According to Lichtenstein, "Hunterdon County possesses a remarkable number of well-preserved examples … of the most popular metal truss bridge type in the 19th century, the Pratt pin-connected span."[116] All five Pratt truss bridges in Delaware Township have pin connections. "Thirty-two of the total 63 metal truss bridges in [Hunterdon] county are documented or date stylistically to pre-1901, an era dominated by pinned field connection spans."[117] The other 31 were built after 1900.

The Warren truss was patented in 1848 by British engineers James Warren and Willoughby Monzani.[118] In a Warren truss, the diagonal members carry both tensile and compressive forces. The straightforward design used equally-sized members and was best suited for rigid [riveted] connections. After the adoption of riveted field connections, the Warren Truss patent was used almost exclusively. At the time of the Lichtenstein survey, there were over 77 Warren truss bridges in New Jersey which comprised 40% of the metal truss spans[119] and all of these standard Warren truss bridges have riveted connections. Warren pony-truss spans were built in Hunterdon County through World War II.[120] There are five Warren truss bridges in Delaware Township, built between circa 1900 and circa 1920.

In the last quarter of the 19th century, truss bridge designs were inclined toward uniformity and standardization. However, a pair of early 20th-century, pony-truss bridges (D388 and D390) built by local fabricator J. W. Scott of Flemington, exhibit unusual features in the execution of the truss. Both structures are a modified, hybrid version of the Warren truss system and are considered to be historically and technologically significant as the only documented examples of this variation on a Warren truss in

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[113] Cunningham, James Henry "Pin-Connected v. Rivetted Bridges" *Transactions of the Society of Engineers (London).* October 7, 1889.
[114] Gray, George E. "Notes on Early Practice in Bridge Building" *Transactions of the American Society of Civil Engineers.* Vol. XXXVII, June 1897. p.4.
[115] Cunningham, "Pin-Connected v. Rivetted Bridges."
[116] Lichtenstein, 1992, p.173.
[117] Ibid, p.71.
[118] Goodspeed, March 1999, Section 8, p.4.
[119] Zerbe, 2002, Section E, p. 18-19; Marburg, 1911, p.319-20; Lichtenstein, p.173.
[120] Lichtenstein, 1992, pp.61, 173.

New Jersey. James W. Scott ran the Flemington foundry which specialized in the design and manufacture of iron bridges. These two Delaware Township bridges represent the end of the era, before the rise of professional county engineers.[121] Bridge D388, known locally as the "Peck's Ferry Bridge," is listed in the National Register of Historic Places.

The Hunterdon County Freeholders' minutes show some overlap between the construction of stone arch and both wooden and metal truss bridges in the county; however, this is not revealed by the current inventory of historic bridges in Delaware Township. This inventory shows the construction of the last stone arch bridge (1882) approximately coinciding with the construction of the first metal truss bridge in Delaware Township (1878). Likewise, the shift in truss types is also clearly defined. Between the 1880s and 1900, Pratt pony-truss bridges were used to replace timber stringer and uncovered timber trusses. Between 1900 and 1920, Warren pony-truss bridges were used exclusively.

Steel is another factor which influenced truss bridge design in the late-19th century. The Bessemer process of making steel was introduced in 1868. Steel works in tension and compression, and it soon became the best reasonably-priced option for truss bridge components. Most truss bridges built after 1895 were made of steel. Metal truss bridge construction "peaked during the first two decades of the 20th century."[122]

After circa 1920, truss bridge construction was superseded by two new bridge types, namely – steel stringer and reinforced concrete spans – which after being developed, became more economical and required less maintenance than metal truss bridges. These bridge types became dominant in Delaware Township after 1925; the shift to their use is again clearly defined.

[121] Lichtenstein, 100D390 and 100D388.
[122] Lichtenstein, 1992, p.59; p 61.

F. Associated Property Types

The following property types are associated with this nomination: stone arch bridges and metal (cast or wrought iron or steel) truss bridges. Although Hunterdon County and Delaware Township contain historically significant railroad bridges, the context for their evaluation is ***not*** presented in this nomination.

[Note: The structure inventories used by engineers and transportation agencies classify structures with a clear span between abutments less than twenty (20) feet as "culverts" and structures with a clear span 20 feet or larger as "bridges." For ease of understanding, all structures, regardless of length, whether using trusses or arches, are called bridges in this MPDF.]

Stone Arch Bridges Built in Delaware Township Before 1882

With a few notable exceptions, all of Delaware Township's stone bridges are small, vernacular structures crossing creeks, small streams, and tributaries. With the exception of one bridge, all are single-span structures. Bridge #DQ-321 is a double-span stone arch bridge. In a stone-arch bridge, the roadway is supported by a stone barrel vault, the thrust of which is absorbed by the abutments. The arch ring supports the parapets and is visible on the outside face of the bridge. The stone-arch bridges are dispersed throughout the township. Three are located on a major road (County Route 579); the majority, however, are on minor roads, and two are on abandoned stretches of road.

Stone Arch Bridges

Stone arch bridges were also constructed when a more permanent bridge was desired. Timber bridges cost less to build, but often lacked the load-bearing capacity, resistance to freshets (floods), and longevity of stone arch bridges. The Hunterdon County Historic Stone Arch Culvert Report notes: "Through the 1860s, the [county] freeholders' discussions often centered on whether to build a stone arch or a wood (truss or stringer)
bridge….Historically, arches were regarded as more expensive, but more "durable."[16] Additionally, Hunterdon County possessed an "abundance of indigenous rock, including sandstone, shale, and limestone" that was quarried throughout the county. For these reasons, stone arch bridges became a viable substitute for the timber spans that most likely initially crossed the many small streams found throughout Hunterdon County.
The Hunterdon County Department of Roads, Bridges, and Engineering has established six (6) "stylistic" categories of historic stone arch bridges found within the county, each with a distinct visual presence on the landscape: Northern: crudely cut ring stones, non-radial joint alignment, low rise, rubble masonry Southern: intrados of ring arch cut to a curve, radial joint alignment, coursed masonry Inset: wing walls and parapet in a different plane from the [inset] spandrel and arch ring Deep Inset: inset of arch ring greater than 4 inches
WPA: 1930's vintage bridges built in the rustic style of the Works Progress Administration WPA

[16] Hunterdon County Freeholder Minutes, 8 June 1849.

Widening: 1930's bridges widened by the WPA[27]

The stone arch bridges of Delaware Township include three (3) categories, Southern, Inset, and Deep Inset.
The survey of stone arch bridges in Hunterdon County concludes: "…the typical stone arch culvert found in the_county is elliptical in design, constructed of random rubble fieldstone with ring stones [voussoirs], wing walls, and low parapets. Repairs and alterations include heavy repointing on nearly all of the structures, according to the maintenance records recorded on bridge cards in the County Engineer's office. Other common alterations include lining the culvert with corrugated metal liner and installing metal guide rails."[38]

Description

An arch is a structure designed to transform vertical loads to diagonal thrusts. The essential character-defining elements of a stone arch bridge are the voussoir arch (arch ring) and arch barrel (supporting the load and transferring it to the substructure), spandrel wall, the coursing and cut of the stone material, the parapet height and shape, the presence of cap or coping stones, the headwalls, piers (if a multiple span bridge), stone abutments and wing walls, and any decorative elements or treatments. Stone retaining walls along the roadway approach to a bridge (found with both stone and metal truss bridges) are an added but not necessary feature.
Based upon the type of stone arch bridge, finishes such as rubble or ashlar and inset or deep inset arch rings as well as construction techniques may also be character-defining features.

The construction of each stone bridge represents the area's vernacular craftsmanship and shows little or no evidence of professional design or engineering, a printed plan, or a specifications list. All of the bridges are asymmetrical, coursed or semi-coursed structures of local stone, with larger, undressed sandstone capstones. The wing walls flair and curve at imprecise angles that are often different in each quadrant of the bridge, showing the mason's own intuitive attempt to suit the road conditions and the natural terrain. The parapets and wing walls typically rise above the road deck. As a general rule, the parapets are level and the wingwalls slope to grade. The one exception is the Worman Road Bridge (D-449), which has sloping parapets and wingwalls.
In several bridges that were widened in the 1930s, the original 19th-century stone parapets and wing walls are
recognizably different from the newer work. Such is the case with DQ-313, DQ-320, DQ-321, and D-361. All of the stone arch bridges that remain today in Delaware Township have distinctive dressed sandstone arch rings with radially aligned joints that contrast with the more roughly coursed, rubble stone wing walls. They all fit Thomas Boothby's description of the typical southern Hunterdon County stone arch

[27] Weber, Linda. "Hunterdon County's Historic Stone Arch Bridges." Flemington, NJ: Hunterdon County Planning Board, April 8, 1999. http://www.co.hunterdon.nj.us/planning/historicbridges/stonearchbridges.ppt

[38] Lichtenstein A. G. and Associates Inc. *Stone Arch Bridge Inventory, Phase, Hunterdon County, New Jersey.* June 1995, p. 6.

bridge:

"A distinctly different style of bridge construction prevails in the southern townships of West Amwell, Delaware, Kingwood and Franklin. Structures in these areas, although still clearly of rustic craftsman construction, show refinements of style and execution that are not present in the northern portions of the county. In general, softer and more easily shaped stones are used, and more care is used in dressing and shaping the stones, especially the stones of the arch ring. Joints in the arch ring follow a radial alignment, and the stones are shaped on the intrados and extrados to conform to the curve of the arch ring."[49]

As a general rule, the stone bridges are associated with the natural and geological environment and the stone used to build the bridge often matches the bed of the stream that it crosses. Delaware Township's abundant supply of sandstone in the west, south, and eastern sections, and argillite, in the northern section, provided a soft and easily worked medium; this resulted in construction with a more finished appearance than that which is present in northern Hunterdon County where granite prevails. All but one of the bridges has a sandstone_substructure. Bridge D-334 is argillite as is the bed of the stream it crosses.

Overall, the stone bridges retain integrity of design and a relatively significant proportion of original material and workmanship. Alterations are consistent with normal maintenance practices and include repointing, selective rebuilding of the abutments, wing walls, and parapets, and the replacement of cap stones.
Occasionally, the arch has been reinforced with corrugated metal or extended to accommodate roadway widening.

Significance

Criterion A
The stone bridges are associated with Delaware Township's rural history, as they were a part of the historic transportation network which connected farms, mills, markets, the Delaware & Raritan Feeder Canal, and numerous railroad stations. These rural bridges are architecturally significant at a local level, and collectively on a state-wide level. They represent an early bridge type and the local population who built them.

The stone arch bridges are artifacts of Delaware Township's and Hunterdon County's distinctive geological environment and topography and are icons of the county's lengthy agricultural history. The construction of stone arch bridges corresponds to a robust period of settlement and the growth in agricultural productivity of Hunterdon County in the 19th-century. Stone arch bridges contributed much to the expansion of the rural road
network and the ability of dispersed local farmers to transport crops to mills, markets, and urban centers. Stone arch bridges are also reflections of the growth and permanence of the agricultural communities of

[4 9] Boothby, Thomas E. "Stone Arch Bridge Inventory, Phase II, Hunterdon County, New Jersey." The Pennsylvania State University, November 1998.

Hunterdon County. Although rustic in their appearance, stone arch bridges symbolized the confidence of the county and municipalities in their economic growth, prosperity, and future. Stone arch bridges, with their relative "permanence" and ability to carry heavier loads and constantly increasing volumes of traffic, symbolized the growth and maturation of the local and even regional economy and the expanding pool of local builders, contractors, and craftsman.

Criterion C
Stone arch bridges may be considered eligible for inclusion in the National Register of Historic Places under Criterion C, for their embodiment of distinctive characteristics of type, period, and method of construction. Stone arch bridges represent the application of both vernacular and highly refined levels of stone masonry and carpentry practices and craftsmanship. Stone was a building material found in abundance throughout
Hunterdon County. Stone houses began appearing in what would become Delaware Township as early as the first decade of the 18th century and the masonry and carpentry skills practiced by local builders could easily be applied to the construction of stone arch bridges. Carpentry skills were required to build the timber "falsework"
needed to frame and support the stone arch during construction. Although not generally ornamented, masonry craftsmanship can be found in the "dressed" or "fitted" stones of the arch ring and in the inset or deep inset of some of the bridges. Parapets and parapet coping stones also occasionally displayed the skills of the mason.
Many of the skills applied to the construction of these bridges have been lost as new materials and methods of construction have been introduced.[5 10]

Registration Requirements

In order to meet the criteria for inclusion in the National Register of Historic Places under this MPDF, stone arch bridges must meet the following registration requirements:

1. The bridge must have been constructed within the period of significance (1829-1882) and, if widened, the new stonework must fall into the broader period of significance (1829-1945) for all bridges in Delaware Township and Hunterdon County. (Because, within the current Delaware Township, the earliest confirmed bridge construction date 1829, this date has been established as the beginning of a period of significance.)
2. The bridge must display the characteristics of a southern Hunterdon County stone bridge
    a. The bridge must show a vernacular character in the construction of its parapets and wing walls.
    b. In a stone arch bridge, the arch ring must show a distinction in workmanship from the spandrels and wing walls.
    c. If the bridge is characterized as an inset or deep inset arch bridge, the inset should be visible.

[5 10] *Stone Highway Culverts in New Hampshire, 1750-1930*. p. F55.

3. If the bridge has not been widened, the original stone spandrels and wing walls should be intact, even if repaired or reconstructed. If the bridge has been widened within the broader period of significance, the original stone parapets and wing walls should be intact on the side of the bridge that was not widened.
4. For bridges that have been widened, the newer stone masonry must complement or harmonize with the original stone masonry and should be consistent with and convey the masonry tradition of the original construction, but must avoid falsely appearing to be original historic masonry.
5. The arch barrel must be intact, even if repaired or reinforced.
6. Repointing is acceptable, as is the presence of masonry reconstruction, provided that the rebuilt areas generally complement or harmonize with the original in stone type, color, size, and coursing
7. General repairs and even reconstruction is acceptable, as are pre-1945 widening campaigns consistent with the above criteria.
    a. Repair or reconstruction of the abutments and/or parapets would not preclude eligibility if the quality of the repair or reconstruction was consistent with and conveyed the masonry tradition of the original construction. The newer stone masonry must complement or harmonize with the original stone masonry, but must avoid falsely appearing to be original historic masonry.
    b. Wholesale rebuilding of sections with foreign stonework or poured concrete would not be acceptable. (A rebuilt stone arch bridge (DQ321) with substantial changes to the roadway width (widening), parapet removal (one side), and spandrel wall reconstruction has been included for reference purposes only and would most likely not be eligible.)
8. The following features would substantially enhance the significance of a stone arch bridge:
    a. an unexpectedly or unusually early example of the type
    b. an example of specialized masonry and carpentry skills
    c. an innovative or specialized design
    d. a span of exceptional length
    e. multiple arch spans
    f. skewed arch construction

A stone arch bridge eligible for the National Register of Historic Places must retain integrity of location and design. Integrity of setting is desirable, but not absolutely required. The widening of a bridge and the change of setting from a rural or agricultural to residential or commercial has the potential to destroy integrity of feeling, however, integrity of feeling is desirable but not crucial. Design, materials, and workmanship are most often visible in the character-defining features and their integrity can be diminished by natural causes, such as damage and deterioration, or by alterations made to accommodate the changes in construction technology and roadway use.

Metal Truss Bridges Built in Delaware Township Before 1945

Truss bridges built on stone (and subsequently concrete) abutments cross the larger creeks and waterways throughout Delaware Township (with a concentration in the northern section). Truss bridges are classified

as either a deck truss, where the roadway is atop the trusses; a through truss, with cross bracing at the upper and lower connections of the trusses; or a "pony truss," where the roadway is between parallel trusses that have lower but not upper (overhead) cross bracing. The surviving metal truss bridges of Delaware Township are either through or pony truss bridges.

Truss bridges represent the introduction of science, technology, and mathematical engineering to the art of bridge building and responded to the need in the decades after the Civil War for longer, larger, and more easily assembled bridges. Bridge trusses evolved from the early kingpost and queenpost trusses, to the Howe, Town, bowstring arch, and Fink trusses of the mid-nineteenth century to late-nineteenth and finally to twentieth century variations of the Parker, Pratt, and Warren trusses.

Description

The most important character-defining features are the primary structural components: the trusses, girders, bracing, and connections (pinned, riveted, or welded). Secondary characteristic features may include the type of metal used, cast or wrought iron or steel, the type of column (for example "Phoenix" or latticed columns), hand or guard rails, builders' plates and any decorative elements (scrollwork, finials). Abutments, piers, wing walls, approach roadway retaining walls are also secondary character-defining features. The bridge deck is generally not considered a character defining feature, since decks were routinely replaced, either in kind or with new materials (for example open steel grid or pavement overlay), however, a timber deck would enhance the integrity of feeling of a bridge. Likewise, floor beams and stringers would not be considered character defining features, however, original floor beams, if retained, would enhance the historic character and integrity of a bridge.

Significance

Criterion A
Truss bridges represent the introduction of science, technology, and mathematical engineering to the art of bridge building and responded to the need in the decades after the Civil War for longer, larger, and more easily assembled bridges. The increasing importance of the engineer in bridge building is reflected by the fact that, in the 19th century, the United States government issued over 500 patents for truss bridges and truss bridge components. "By 1880 bridge consultants [engineers] had become the first specialists within the general field of civil engineering. Bridges were the most highly developed kind of structure type, and consulting bridge engineers the most skilled and respected practitioners. They had come a very long way indeed from the frontier craftsmen who had dominated bridge building half a century before. Theodore Cooper characterized the successful bridge engineer of 1880 as not just a mere calculator of stresses but someone with a full knowledge
of the practical and theoretical elements of design, manufacturing, and erection, as well as an "instinct of design."" [611] Said another way: "Bridge engineering as a profession came of age with the truss bridge."[712]

[6 11] Delony, Eric. "The Golden Age Of The Iron Bridge." *American Heritage of Invention and Technology.* Summer 1993, Volume 9, Issue 1.
[7 12] Harshbarger, Patrick. "Project Planning for Metal Truss Bridges." Presentation at the Pennsylvania By-Ways Conference,

In Delaware Township, truss bridges permitted the crossing of wider streams with no intermediate piers and permitted larger and heavier vehicles to reach more of the county's dispersed agricultural communities. The surviving truss bridges in Delaware Township are the legacy of Hunterdon County's pioneering introduction of metal truss bridge technology beginning with the 1858 construction of the Fink Suspension Truss Bridge in Hamden Township, followed by the construction of the three (3) Lowthorp Truss bridges in 1868 and 1870.

As noted in the National Register of Historic Places nomination for the New Jersey and National Registers of Historic Places listed Peck's Ferry Bridge (D388) in Delaware Township, the surviving metal truss bridges are "an embodiment of the development of industrial techniques to solve transportation challenges in rural area, where roads were used by farmers and local craftsmen to transport their goods to market."[813] The surviving metal truss bridges also reveal the transition from local foundries and fabricators, such as the Lambertville Iron Works, to the national bridge building companies as well as tension between those who pursued bridge building through "hands-on experience and apprenticeship" and those who relied upon "academic training using the scientific method and textbook procedures."[914]

Criterion C

The design and construction of truss bridges required the application of mathematical calculations and engineering skills, the advancements of metallurgy from cast to wrought iron and subsequently to steel, and the standardization of fabrication techniques. Although design and fabrication was standardized, the truss bridge was exceptionally adaptable and versatile. Span length, width, and load bearing capacity could easily be adjusted to meet very specific needs and bridge components could be manufactured at the mill and easily fabricated on site. In the decades before states, counties, or municipalities employed the professional engineers, bridge fabrication companies such as the Wrought Iron Bridge Company of Canton Ohio (D481 and D482) widely distributed truss bridge catalogs that illustrated the types of bridges that had been and could be built.

Registration Requirements

Criterion A

In order to be eligible for inclusion in the National Register of Historic Places under Criterion A in this MPDF, the metal truss bridges of Delaware Township must meet the following registration requirements:

1. The bridge must have been constructed within the period of significance for truss bridges (1870-1945).
2. The bridge must retain the appearance of a functioning truss bridge.
   a. If the bridge has been reconstructed or widened, the trusses should be capable of supporting their own weight even if the bridge itself is carried by girders and the trusses

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May
2008.

[8] [13] Goodspeed, Marfy. "Peck's Ferry Bridge," National Register of Historic Places Nomination. March 1999.

[9] [14] Ibid.

are no longer the primary structural elements of the bridge.

b. A bridge where the trusses are present only as visual or decorative elements attached to a new bridge would not be eligible.

3. The primary structural components of the trusses as well as the braces (diagonal or lateral) must be present.
   a. Decorative features enhance the historic character of the bridge but their absence does not preclude eligibility.
   b. Neither the replacement of structural components with larger members, the presence of additional structural members or bracing, nor welded connections preclude eligibility.
4. The presence of secondary features that transition the bridge to the road, for example approach roadway retaining walls, is desirable but not necessary for a truss bridge to be eligible under

Original abutments or wing-walls enhance the historic character of the bridge, but modest alterations or additions to these structural components do not preclude eligibility.

Criterion C
In order to be eligible for inclusion in the National Register of Historic Places under Criterion C in this MPDF, the metal truss bridges of Delaware Township must meet the following registration requirements:

1. The bridge must have been constructed within the period of significance for truss bridges (1870-1945).
2. The bridge must function in a manner consistent with its original design and workmanship. It may have been strengthened with larger or additional structural members. The truss parts may not be dismantled and used merely as decorative elements.
3. The bridge must be a reasonably complete example of its type. Alterations should not compromise the integrity of the original design or detract from the aesthetics of the original truss work.
4. The addition of new or larger structural components must permit the retention of historic structural components. The addition of additional lateral bracing or the introduction of diagonal bracing at either the upper or lower chord is acceptable.
5. The replacement of pinned connections with riveted or welded connections will not disqualify a truss bridge from being considered eligible.
6. Bridges that have been moved but retain their primary structural characteristics may continue to be eligible for the National Register under Criterion C.

Activities with the potential to enhance, alter or remove essential character-defining features include structural reinforcement, including exterior bracing, larger steel beams or girders, and new structural components that supersede historic components; welded reinforcements; the replacement of pin connections with bolted or welded connections; and the replacement of rivets with bolts. Other activities with the potential to affect secondary features include concrete encasement or replacement of stone abutments or wing walls or the replacement of historic railing or the addition of corrugated guide beam railing. The widening of a truss bridge may permit the retention of primary character defining features but change the historic proportions of the structure, which may be a character defining feature, especially for pony truss bridges.

Inventory

The following inventory is organized by bridge type and lists resources which need to be individually evaluated against the significance and integrity requirements as outlined in this Multiple Property Documentation Form. Please note that this inventory may not be exhaustive and these bridges are not automatically listed on the New Jersey and National Registers of Historic Places based upon inclusion in this inventory.

Inventory of Stone Arch Bridges in Delaware Township

DQ321 - Easton-Trenton Turnpike (CR 579) at Dunkard Church Road, over a branch of the Neshanic River DQ320 - Easton Trenton Turnpike (CR 579) south of Yard Road over the third Neshanic River
DQ313 - Easton Trenton Turnpike (CR 579) north of Route 12 over the Wichecheoke Creek D379 - Yard Road over a branch of the Third Neshanic River
D368 - Sandbrook Headquarters Road near Dunkard Church Road over a branch of the Neshanic River
D441 - Buchanan Road over an unnamed creek
D449 - Worman Road near Route 523 over Shoppon's Run
D329 - Pine Hill Road just north of Route 604, over Cold Water Creek (a tributary of the Wichecheoke Creek) D334 - Pine Hill Road north of Old Mill Road over a tributary of the Wickecheoke Creek
D478 - Federal Twist Road north of Strimples Mill Road over Shirt Run Creek D448 - Covered Bridge Road over a tributary of the Wichecheoke
Unnumbered Bridge - Abandoned road that bypassed Sergeantsville and connected CR 523 with CR 604
Unnumbered Bridge - Abandoned section of CR 604 west of Sandbrook-Headquarters Road

Inventory of metal truss bridges in Delaware Township

D481 - Strimples Mill Road over Lockatong Creek D300 - Raven Rock Road over Lockatong Creek
D488 - Old Mill Road over Wickecheoke Creek D383 - Ferry Road over Plum Brook
D325 - Lower Creek Road over Wickecheoke Creek D424 - Locktown-Sergeantsville Road over Plum Brook D337 - Locktown Road over Wickecheoke Creek
D388 - Locktown-Flemington Road over Plum Brook D390 - Stone Sign Post Road over Plum Brook
WD120 - Hamp Road over Alexauken Creek

G. Geographical Data

The geographic area for the Historic Bridges of Delaware Township includes properties within the political boundaries of Delaware Township, Hunterdon County, New Jersey, and properties within Delaware Township that border and, therefore have joint ownership with, an adjacent municipality (namely Raritan Township and West Amwell Township).

H. Summary of Identification and Evaluation Methods

The National Register of Historic Places (NRHP) Multiple Property Documentation Form (MPDF) for the Stone Highway Culverts of New Hampshire (1750-1930), prepared by the New Hampshire Department of Transportation, provided a basic outline for documenting and evaluating stone arch bridges of Hunterdon County and Delaware Township. Stone arch bridge surveys from other states and counties also provided additional guidance. "The Stone Arch Bridges of Monroe County, Illinois" documented a collection of stone arch bridges with a history and historic contexts comparable to those in Hunterdon County. Bridge surveys from states such as Vermont, Pennsylvania, Delaware, New York, and Virginia, to name only the most extensive, and the New Jersey Department of Transportation's 1994 Historic Bridge Survey guided the evaluation of the metal truss bridges.

Pennsylvania State University civil engineering professor Thomas Boothby's two evaluations of stone arch bridges within the context of Hunterdon County's agricultural history provided numerous points of reference for this MPDF.

Careful examination of local relevant historic bridge surveys, inventories, and NRHP nominations included:

- *Hunterdon County Stone Arch Culvert Inventory - Phase I* by A. G. Lichtenstein & Associates, Inc.
- *Hunterdon County Bridge Inventory - Phase II* by Thomas E. Boothby, et al.
- *New Jersey Historic Bridge Survey* by A. G. Lichtenstein & Associates, Inc.
- *Historic Bridges of Tewksbury Township, Hunterdon County, New Jersey Multiple Property Documentation Form,* by Nancy L. Zerbe
- *Delaware Township Bridge Survey* by Carla Cielo
- *Metal Truss Bridges of Somerset County, New Jersey*-Multiple Property Documentation Form
- *Early Stone Arch Bridges of Somerset County, New Jersey*-Multiple Property Documentation Form

A review of primary documents included:

- Hunterdon County Freeholders Minutes Volumes 1-3
- Records of the Hunterdon County Engineer's office
- Hunterdon County Engineer's current bridge map of Delaware Township
- Historic maps
- Hunterdon County newspaper *Hunterdon Republican*

Historic research was supported by a field survey and photographs of each bridge. Every numbered bridge on Hunterdon County's bridge map for Delaware Township was examined to determine a list of historically significant property types and sub-types. Several bridge types

present in Delaware Township before 1945 were excluded, namely: concrete bridges, concrete pipe culverts with concrete parapets, and metal pipe culverts with stone parapets. Concrete bridges and culverts are commonplace throughout the state and were therefore eliminated. The timber "stringer" bridge with stone abutments and wing-walls, a once common bridge type, was excluded from this MPDF because of the almost universal replacement of timber by concrete or steel, even when stone abutments survived.

Consequently, the MPDF focused on two historic bridge types: stone bridges and metal (iron or steel) truss bridges. Hunterdon County is well known for its surviving collection of stone bridges and metal truss bridges. The significance of each property type is based on the collective grouping which together creates and conveys a strong sense of historic place. The geographic area is based on the boundaries of Delaware Township that were set in 1838.

Decisions on the level of integrity necessary for registration were based on knowledge of the condition of each property, a review of comparable standards utilized in earlier studies, and a review of previous repairs (referencing the *Secretary of the Interior's Standards for Historic Preservation Projects).* The truss bridges are in a remarkable state of preservation. Repairs of the stone-arch bridges has not diminished their ability to convey their historic significance and association with Delaware Township's historic agricultural landscape.

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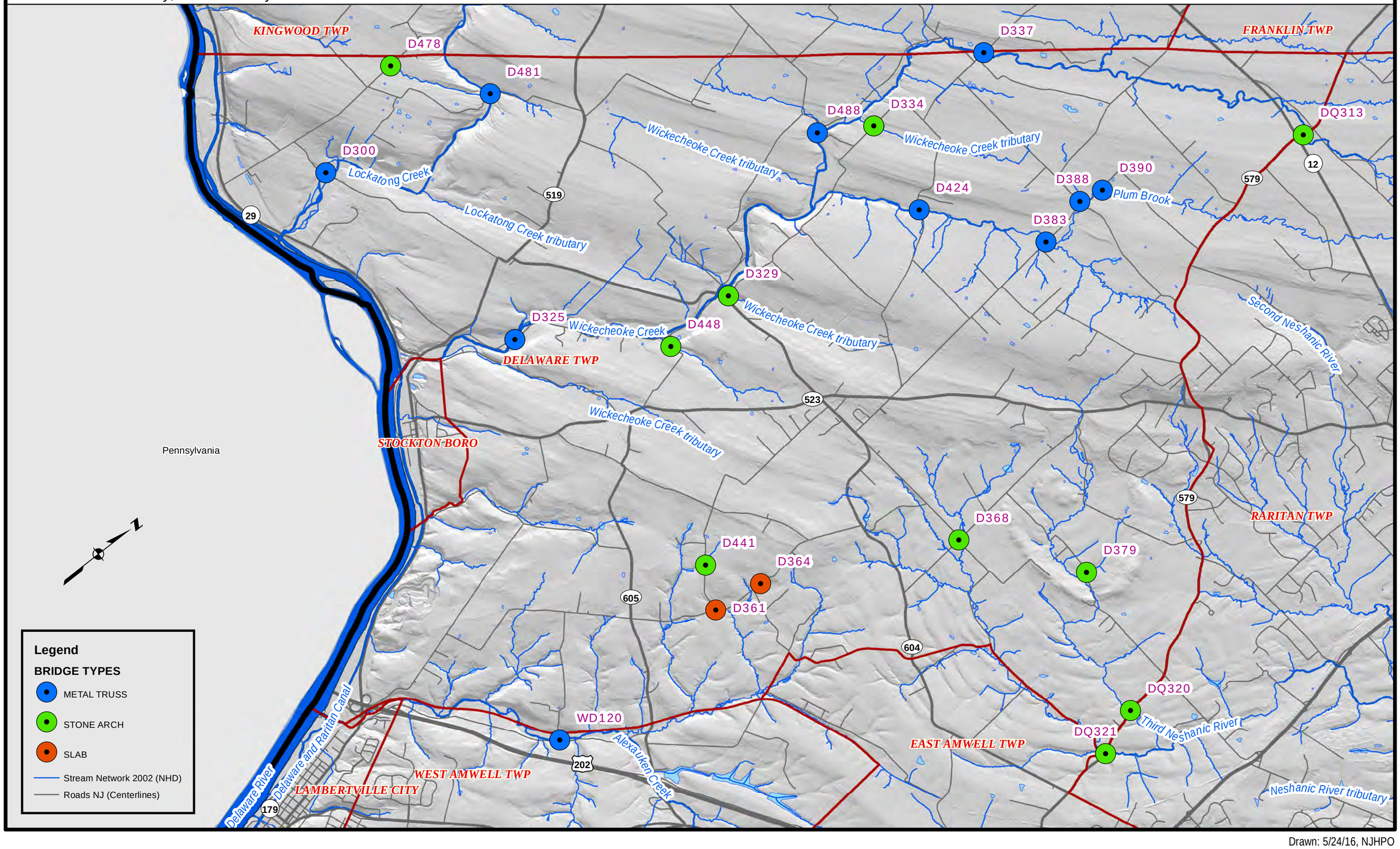
Delaware Township, Hunterdon County, New Jersey
NJ GEOWEB Map

Historic Bridges of Delaware Township MPDF

Hunterdon County, New Jersey

Fig. _____



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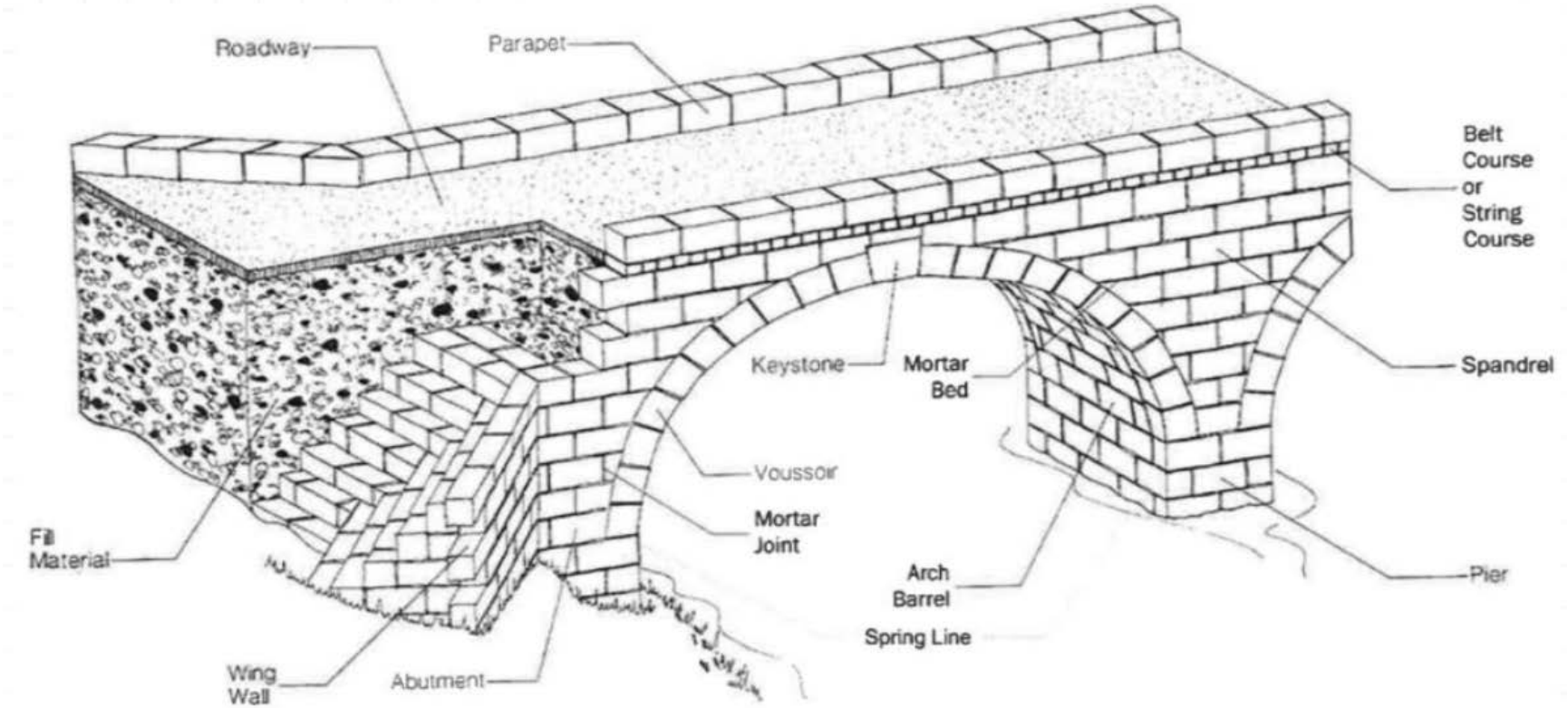
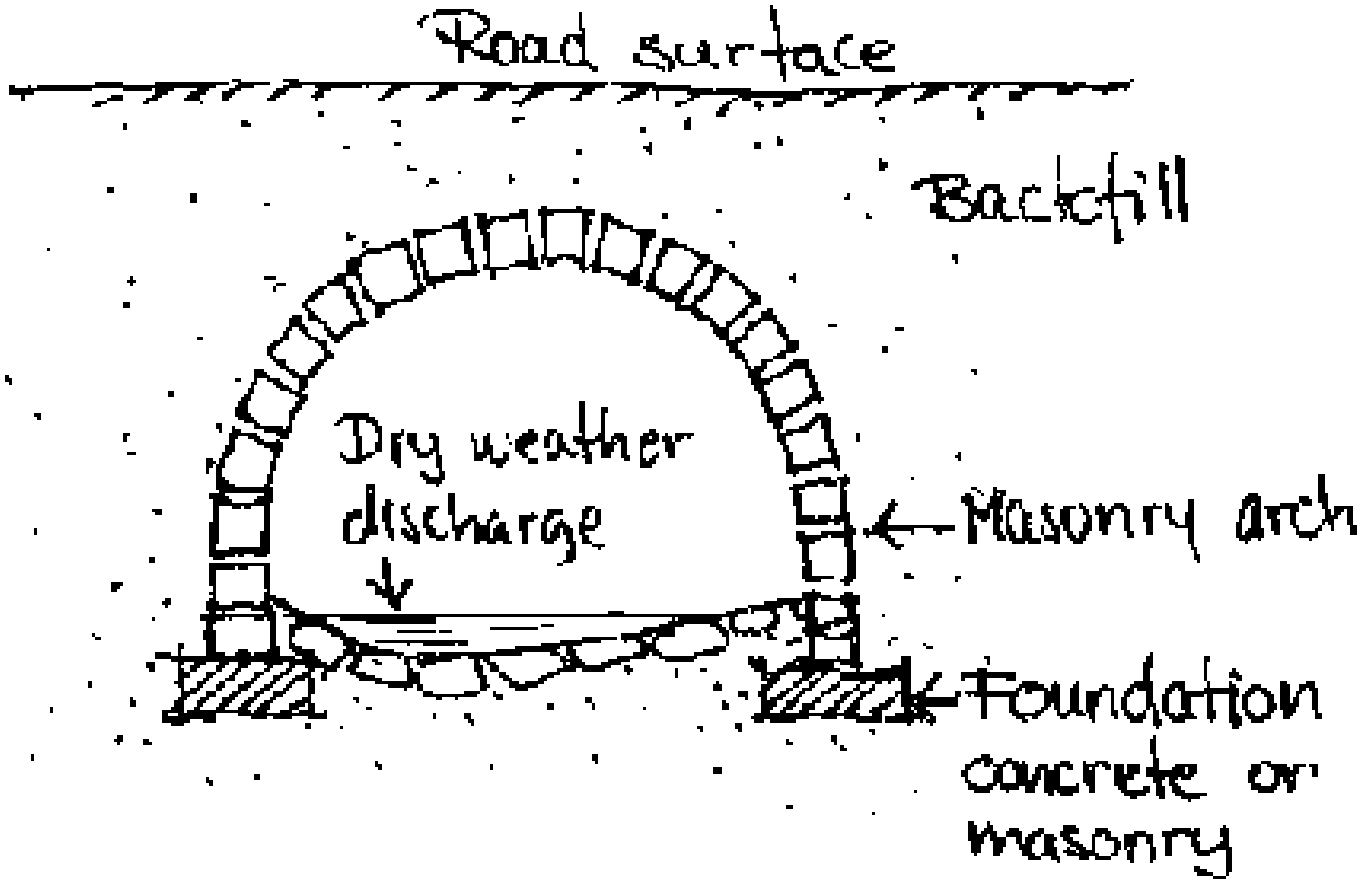
Stone Arch Bridge Components



Accompanying Documentation
Historic Bridges of Delaware Township MPDF
Hunterdon County, NJ



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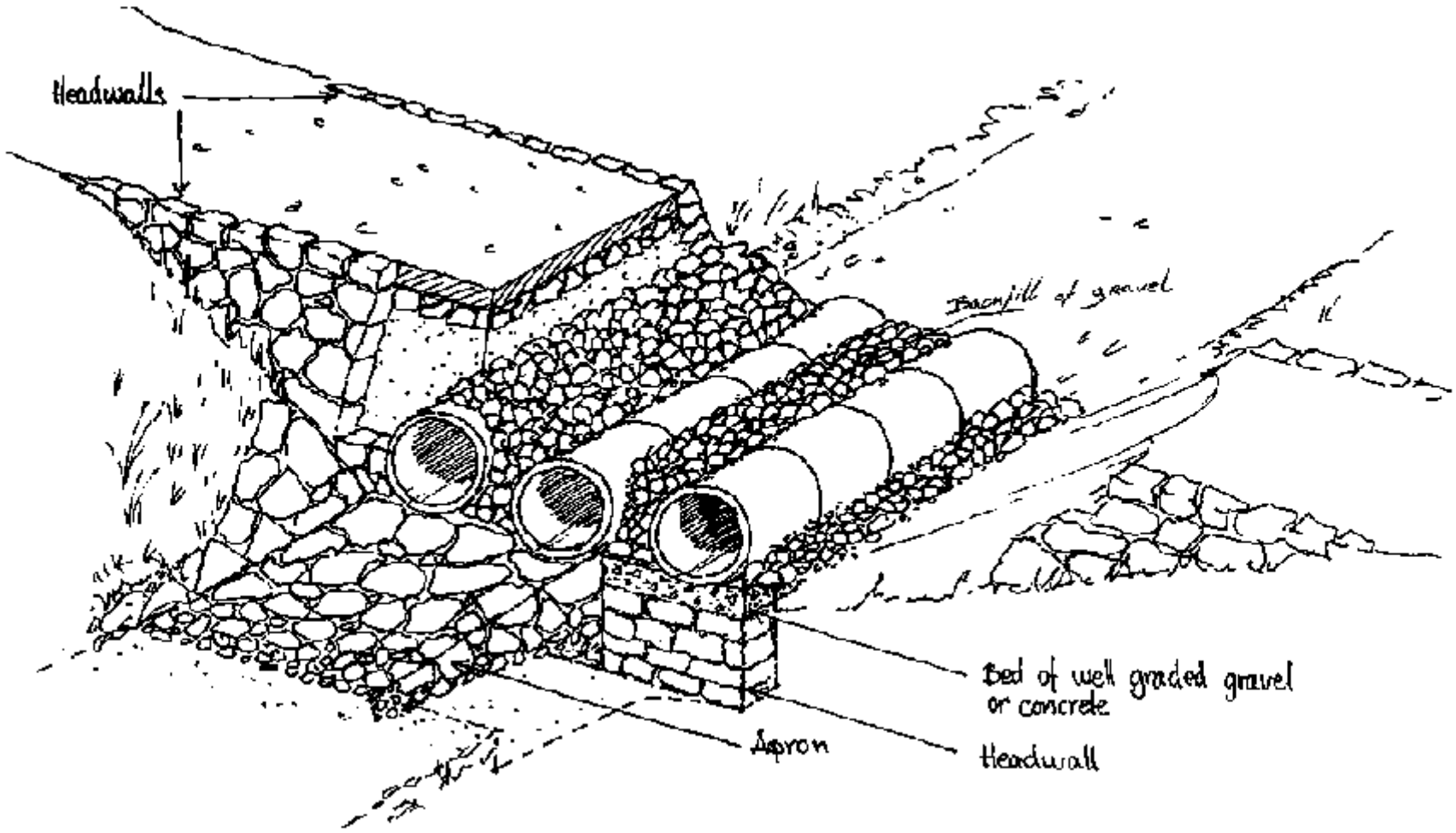
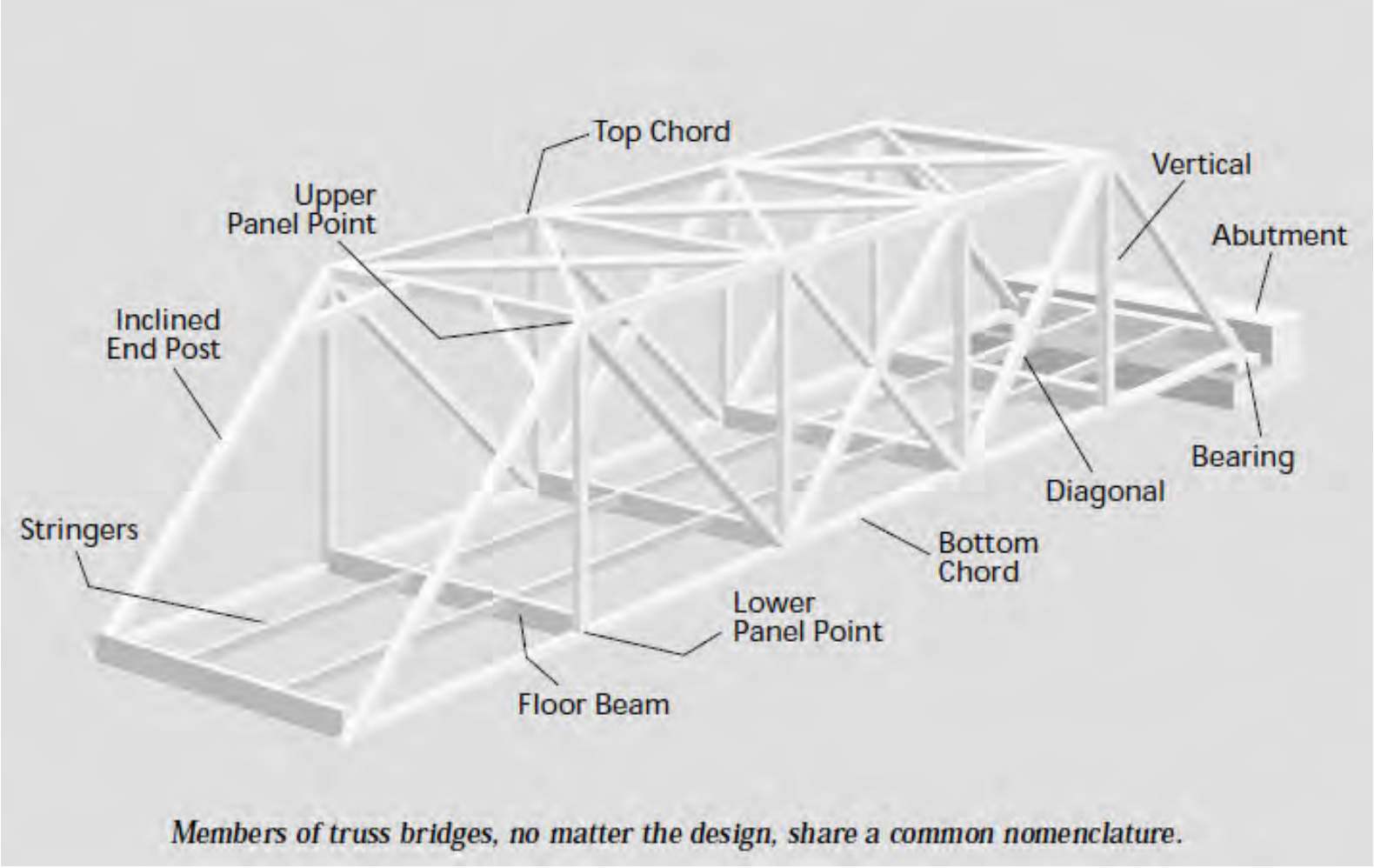


Accompanying Documentation - Culvert Construction using Pipes
Historic Bridges of Delaware Township MPDF
Hunterdon County, NJ



Members of truss bridges, no matter the design, share a common nomenclature.

Accompanying Documentation - Metal Truss Bridge Components
Historic Bridges of Delaware Township MPDF
Hunterdon County, NJ

Truss Bridge Timeline

- **Burr arch truss**: a combination of an arch and truss which gives a strong and rigid bridge. **1806**
- **Long truss**: a variant of Howe truss but made of wood and used for covered bridges.**1837**
- **Howe truss**: has vertical elements and diagonals that slope up towards the center of the bridge. **1840**
- **Pratt truss**: has vertical members and diagonals that slope downward to the center. It is a variant commonly used for railroad bridges. **1844**
- **Warren truss**: has longitudinal members joined only by angled cross-members. They form equilateral triangles. It is relatively light but strong and economical truss. **1848**
- **Bollman truss**: an all-metal truss with many independent tension elements which makes for a strong bridge that is easy to assemble. **1852-1869**
- **Lenticular truss**: uses a lens-shape truss which has an upper and lower curve and diagonal elements between them. If the curves are above and below the roadbed it is a "lenticular pony truss". **1865**
- **Baltimore truss**: made like Pratt truss but it has additional bracing in the lower section of the truss which prevents buckling in the compression members. **1870**
- **Parker truss**: a variant of Pratt truss that has a polygonal upper chord. If chord has exactly five segments it is called camelback. **1870**
- **Pegram truss**: has chords that are wider at the bottom but of the same length as each other at the top. **1885**
- **Allan truss**: a pony truss based on Howe truss. The first Allan truss was finished on 13 August 1894. **1894**
- **Vierendeel truss**: has members that are not triangular but rectangular. Rare are bridges made in this variant of truss because it is not cheap. **1896**
- **K truss**: has one vertical member and two oblique members in each panel (which form a letter "K"). **1930**
- **Bailey truss**: made for military to be easily combined in various configurations. **1941**

Created from a report for the Tennessee Department of Transportation, *The History of Bridges*, www.tn.gov/tdot/article/bridges-history, accessed 6/23/2016.

Stone Arch Bridge Example
Delaware Township Historic Bridges MPDF
Delaware Township, Hunterdon County, New Jersey

Stone Arch Bridge Example
Delaware Township Historic Bridges MPDF
Delaware Township, Hunterdon County, New Jersey

Stone Arch Bridge Example
Delaware Township Historic Bridges MPDF
Delaware Township, Hunterdon County, New Jersey

Stone Arch Bridge Example
Delaware Township Historic Bridges MPDF
Delaware Township, Hunterdon County, New Jersey

Metal Truss Bridge Example
Delaware Township Historic Bridges MPDF
Delaware Township, Hunterdon County, New Jersey

Metal Truss Bridge Example
Delaware Township Historic Bridges MPDF
Delaware Township, Hunterdon County, New Jersey

Metal Truss Bridge Example
Delaware Township Historic Bridges MPDF
Delaware Township, Hunterdon County, New Jersey

Metal Truss Bridge Example
Delaware Township Historic Bridges MPDF
Delaware Township, Hunterdon County, New Jersey