

**Comments on New Jersey Highlands Water Protection and Planning Council  
Draft RMP Amendment: Plan Conformance Procedures**

Zachary Cole, Outreach & Education Director

The New Jersey Highlands Coalition applauds the Highlands Council and its staff for its renewed efforts to promote plan conformance throughout the region. Plan Conformance Procedures are established to ensure that Highlands Act Plan Conformance standards are met. While we support some flexibility in the conformance procedure based on a municipality's specific environmental condition, it is paramount that standards for conformance with the Regional Master Plan not be weakened for the sake of expediency.

Conformance to the Highlands Regional Master Plan by municipalities in both the Planning and Preservation areas is critical to the success of protecting the water and natural resources as well as the cultural heritage in the region. Adoption of Plan Conformance by every municipality will also ensure a sustainable future environmentally and economically for Northern New Jersey.

The amended procedures for Plan Conformance should aim to add transparency, enable more public involvement, and clarify issues that have arisen from towns' experience moving through the conformance process.

1. Public Comment Period

10 days is insufficient time for anyone to provide useful comment. The proposed 10 business day comment period for review of the Council's draft reports on a Plan Conformance Petition is inadequate. Also, it assumes the public are immediately aware of when a comment period has commenced.

We strongly urge the Council to adopt a minimum of 30 days for public comment on the draft Plan Conformance document, **and establish 30 days as a baseline for all matters where the public may wish to participate.**

2. Public Notice

The Council should explore posting notice of proposals in more locations than exclusively on the Council Website. Posting to a municipality's website or other forums where communities receive news of developments within the municipality, would greatly increase the number of people engaging in matters that may affect their town.

3. Highlands Council as single Arbiter of Conformance status

On page 9 of the Draft Amendment, the Council effectively asserts itself as the sole arbiter of conformance in the Planning Area. We support this assertion. Conformance determinations must be at the sole discretion of the Highlands Council and not another agency where different criteria could be used against a municipality that has successfully conformed to the RMP.

Further, we support the Council providing a clearer definition of “full conformance” but would encourage the council to provide towns with more legal documentation that demonstrates to other agencies, and potentially developers that a town is in conformance.

In *IV. Post-Petition Approval Procedures* (Section b) the Draft Amendment states that “A municipality shall be considered to be a conforming municipality after adoption of a land use ordinance and certification of said land use ordinance by the Highlands Council” (page 9). However, in a previous section the Amendment states that the Highlands Council shall issue a letter of certification that a municipality has successfully conformed. We suggest these sections be rewritten to clarify whether it is the adoption of the Highlands Land Use Ordinance or a letter of certification that legally proves a town has achieved conformance.

4. Reimbursement of grants

In Section d. of *IV. Post-Petition Approval Procedures* it states that a municipality that either fails to fully achieve conformance or following a revision of a municipality’s Master Plan, “the Council may deem the jurisdiction as not in conformance with the RMP and require the jurisdiction to reimburse the Council or the State” (page 9). In some instances towns may accrue hundreds of thousands of dollars in assistance and technical support. Would they be expected to return all that money?

The language is vague and will likely act as a disincentive for towns considering entering Plan Conformance. We urge the Council to clarify this section, explaining what grants may have to be reimbursed, and further explain the circumstances for this eventuality.

5. Implementation of the “Legal Shield”

The legal shield triggers are addressed and clarified (F. Benefits of Plan Conformance, section d. Legal Representation, pages 4-5), and with the adoption of the amendment, will have the effect of an agency rule. We strongly support this clarification. We suggest that the Council consider the possibility of extending this shield to cases in which a

municipality's conformance status is challenged by any party, including another state agency.

6. Climate change and sustainable development

Finally, the Highlands Coalition strongly encourages the Council to include in the requirements in the Appendices of this procedure, policies addressing energy and transportation infrastructure, and climate change adaptation and mitigation strategies.

In the thirteen years since the RMP was adopted, much information has emerged about the threats of climate change, and its impacts on the whole of New Jersey. The Highlands will play a role in determining how prepared the State is to meet these challenges.

We appreciate the opportunity to comment on this amendment, and the Council Staff's efforts to increase public participation in this process.

Submitted on behalf of all the members of the New Jersey Highlands Coalition.

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Re:

**Draft RMP Amendment – Highlands Plan Conformance Procedures**

New Jersey Highlands Council

100 North Road (Route 513), Chester, NJ 07930-2322

May 21, 2019

Executive Director Plevin, Chairman Richko, Council Members and Staff:

Thank you for the opportunity to comment.

New Jersey Conservation Foundation urges and strongly supports conformance of all Highlands municipalities and counties with the Highlands Regional Master Plan, including both Preservation and Planning Areas. We highly commend the Council for its renewed, concerted and energetic efforts to promote Plan Conformance throughout the Region.

Plan Conformance is a critical process by which the Highlands Council and the RMP can assure that the *entire* Highlands Region has a future that is both environmentally and economically sustainable.

Only if universally adopted by municipalities throughout the Region, can Plan Conformance protect the Highlands' critical water and forest resources and its irreplaceable natural, cultural, historic, recreational and scenic assets for the benefit of future generations – those of the Region, the State of New Jersey, and our Nation.



It is critical that Plan Conformance Procedures established to provide a clearer process and pathway to conformance strongly support and maintain the goals of the Highlands Water Protection and Planning Act and the Goals, Policies and Objectives of the Highlands Regional Master Plan. The Procedures should not in any way facilitate the lowering of essential standards.

We have several areas of concern regarding the proposed Procedures.

### **1. Transparency: Public Notice and Public Comment Opportunities**

Re: Section II. E. Plan Conformance Meetings and Public Input, pg. 3:

The opportunities proposed for public input and public notice of Plan Conformance issues before the Highlands Council need to be expanded. Until the last steps of the process, the only notice currently proposed is to be located on the Highlands Council website, which is insufficient for the vast majority of municipal residents and the general public. The affected local government and relevant county should receive direct notice, with a requirement that both post the information on their websites. There should be notice in the public press to the extent possible. Notice on social media might even be considered.

Re: Section IV. Review of Plan Conformance Petitions, B. Public Meeting for Review of Plan Conformance Petitions, pg. 8:

B. (a): The document proposes that “The Executive Director will post the draft report on the Highlands Council website for a minimum ten (10) business day public comment period.”

***The proposed timetable is inadequate for public comment. We recommend a 45-day comment period. It is during this period, when the document is still in draft, that the most productive questions, concerns and comments can be raised and addressed by Council staff..***

B. (d): “The Executive Director shall provide public notice of any determination on the Highlands Council web site and shall publish any other notices as legally required.” Again, municipalities and also the county of which they are a part, should be required to post the Council information on their websites. Print media and other venues should be utilized to the extent possible to inform the public and permit discussion and input.

### **2. Energy and Climate Change Issues Should Be More Fully Addressed in Plan Conformance**

Re: Draft RMP Plan Conformance Procedures - Appendices A and B (pages 13-17):

Appendices A and B contain serious omissions that unfortunately mirror omissions that currently exist in the RMP. These omissions should not be perpetuated by the Final RMP Plan Conformance Procedures.

**Appendix A, Municipal Planning Program Documents**, currently lacks any requirements for consideration of energy resources, energy infrastructure, or the impacts thereof, or response to or mitigation of climate change. Carbon sequestration, a significant ecosystem service provided by Highlands' forests would not be captured in planning undertaken in response to Appendix A, as proposed.

**Appendix B, Highlands Center Designation Procedures**, requires the inclusion of a Smart Growth Component that "takes into account....energy resources." However, Appendix B does not require any consideration of energy generation or transmission impacts, nor of potential climate change impacts or their mitigation.

Planning for energy is a fundamental part of land use planning. Energy uses – extraction, creation (eg. solar panels, wind turbines, nuclear/coal/gas power plants), transmission (gas or oil pipelines, electric transmission lines), transportation (rail lines, highways/truck/automobile travel) are one of the most significant uses of land, with potentially enormous impacts on both the environment and society.

Energy planning should be integrated into Highlands Council planning for the Region. The Council should not permit, by default, other agencies and interests with different missions and agendas to take control of energy-related planning in the Highlands Region.

***We urge that the final Plan Conformance Procedures include energy and climate change as critical planning elements that must be addressed during Plan Conformance.***

### **3. County Plan Conformance**

Comment re: III Plan Conformance Petition Process - Counties (pg.5- 6):

Section III, A. Initial Assessment, proposes that “the extent of modifications to existing [county] documents to achieve RMP consistency will focus on: a) provisions pertaining to roadway improvements and stormwater systems over which the county has jurisdiction,” and “b) administrative requirements ... and county capital projects.” Additional RMP implementation initiatives proposed are optional for counties, and “will include items such as development of sustainable Economic Development plans, Farmland Preservation Plans, and Agricultural Retention/Expansion Plans.”

We support these proposed implementation initiative focus areas. One aspect of roadways, over which counties have control, is bridges. In what is likely true for all counties in the Highlands

Region, the “Hunterdon County Department of Public Works, including the Divisions of Roads, Bridges and Engineering provides engineering direction, technical support and guidance for the County's roads and bridges, is charged with the maintenance and repair for County roads, bridges, culverts, [and] storm sewers...” The bridges include not only those on county roads, but also municipal streets. In the Highlands, a substantial number of these bridges, particularly in Hunterdon County, and also Warren and Somerset, form an important component of the Region’s historic and scenic resources, and thus have value for Highlands tourism. They also contribute to local residents’ quality of life. Highlands Plan Conformance goals should include protection and preservation of the Region’s historic bridge resources. Please see attached the presentation ***Hunterdon County’s Stone Arch Bridges and Stone Arch Bridge Inventory, Phase II, Hunterdon County, NJ.***

Counties often play a significant role in open space planning, preservation, and recreation, as well as in historic preservation. We suggest that counties, as part of Plan Conformance, could make significant contributions to the identification and protection of regional Highlands Scenic Resources. Potential Highlands Scenic Resources often extend far beyond individual municipal boundaries. Miles-long Highlands forested scenic ridges, or the identification of potential Highlands Scenic Byways, would be appropriate for county attention. The Highlands Trail and other larger trail networks may also lend themselves to county efforts coordinated through Plan Conformance.

Thank you for the opportunity to comment. We look forward to working with you to support and increase plan conformance.

# Stone Arch Bridge Inventory, Phase II Hunterdon County, New Jersey



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For the  
Hunterdon County Planning Board  
and the Hunterdon County  
Board of Chosen Freeholders

Flemington, New Jersey 08822

November 12, 1998



## **Stone Arch Bridge Inventory, Phase II**

Submitted to the  
Hunterdon County Planning Board and  
Hunterdon County Board of Chosen Freeholders  
Flemington, NJ

November 12, 1998

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Stone Arch Bridge Inventory, Phase II

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The authors especially wish to acknowledge the assistance and cooperation of the professional staff of Hunterdon County with whom they worked during the course of this study. Linda Weber, Principal Planner, John Glynn, Director, Roads and Bridges, and Stephanie Stevens, Historian all went out of their way to provide support and assistance. Any success that this report might enjoy can be credited to their perseverance and dedication.

The figures taken from Ruddock (1979) are used by permission of Cambridge University Press.



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## **Executive Summary**

The Stone Arch Bridge Inventory, Phase II, is a study of 92 stone arch bridges in Hunterdon County, New Jersey. The purpose of the study is to provide the County with recommendations regarding the preservation and future modifications to the bridges in view of their historical significance and current and future traffic patterns. The Stone Arch Bridge Inventory, Phase II, is a sequel to Phase I, prepared by A.G. Lichtenstein & Associates, Inc, dated November, 1995, which is a similar study of 14 stone arch bridges. The bridges in both of these phases have less than a 20 foot span and were therefore excluded from the NJ Department of Transportation's statewide study of bridges, NJ Historic Bridge Survey, 1994. Both of the Stone Arch Bridge Inventories were funded by an Intermodal Surface Transportation Enhancement Act (ISTEA) grant to the County.

With over 100 surviving stone arch bridges, Hunterdon County, NJ represents the largest concentration of stone bridges in North America. In spite of some similarities to the bridges in surrounding areas, the stone bridges in Hunterdon County represent a unique resource. Differences in craftsmanship can be observed among the structures throughout the county, with cruder and more rustic workmanship observable in the northern part of the county, and small refinements of style, design, and construction noticeable in the southern part of the county. Particular construction features can also be noted, and compared to the construction of bridges in other parts of the country. The inset style, in which the arch ring and spandrel wall lie in a slightly different plane from the 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.

Hunterdon County's stone bridges were built between the 1820's and the turn of the century, with most of the bridges built following the Civil War. 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 bridge construction of the late nineteenth century.

Due to their association with the patterns of community development and the emergence of agriculture as the main industry of Hunterdon County, those structures that have retained integrity, as defined by the Secretary of the Interior, have been found to be eligible for listing in the National Register of Historic Places on a local level. Of the 92 structures in the present

survey, over 40 have been found eligible. Approximately 12 of these structures have been determined to be exemplary and to merit preservation under any circumstances.

Traffic safety and operations have also been assessed at each of the bridge sites. Site specific recommendations for improved signing, object markers and guide rail have been made. The requirement for widening each of the structures has been determined, as well as the future traffic volume that may warrant widening. Of the structures that are to be preserved, the need for bypassing or closing the road at the bridge site has been assessed. Of the remaining eligible structures, a pool has been established, in which some of the structures may be widened when warranted, and the remainder of the structures are recommended to be preserved.

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## **I. Summary History of Stone Arch Bridges**

### **Origins of Stone Arch Bridges**

Although there is uncertainty over the exact origins of the arched method of construction, the widespread use of arches in building construction and the promulgation of practices for arch construction can certainly be credited to ancient Rome. Vitruvius, in his first century B.C. practical manual on the construction of buildings, civil works, and military machines, gives distinct advice on the construction of arches. The arched form of bridge was also widely employed by Roman architects (no distinction was made in ancient Rome between architecture and engineering), particularly for the construction of the well-known aqueduct crossings, such as the Pont du Gard, which dates to the first century. The art of building compression structures in stone was not lost during the Middle Ages in Europe, but was amplified and improved steadily throughout this period. A significant population of existing stone arch bridges in England can be dated to this time period, and the written record contains many other such structures (Jervoise 1932). By the time of the colonization of North America, the art of building stone arch bridges had matured over more than a millennium.

Although there is much to say about European stone bridge construction, in the present context it is only necessary to outline the state of knowledge at the time of the colonization of North America. By the seventeenth century, carefully cut and dressed ashlar masonry was the material of choice for enduring bridges throughout Europe. Although timber was widely employed, its tendency to decay, susceptibility to fire, and light weight made it less suitable for large and permanent structures, especially for crossings over rivers with tidal fluctuations. The spans of these British, French, and Italian structures, usually in the range of 25-50 feet, of seventeenth century bridges are timid by comparison to the daring employed in building construction, but the workmanship is refined, and the designs are carefully conceived and executed.

The principles of calculation of thrust lines in stone arches was first announced in the late seventeenth century by Robert Hooke. Analytical and mathematical methods were applied to the design and execution of stone arches, domes, and vaults from the eighteenth century onwards, particularly in the design of domes (Benvenuto, 1991). By the late eighteenth century the principles of arch behavior were synthesized by Coulomb and others (Heyman 1966). However, the design of stone arch bridges through the eighteenth century continued to rely on craftsmanship and geometry, and the piers and abutments of stone bridges are generously sized.

The oldest surviving bridge in North America is a stone arch structure, the Frankford Avenue Bridge in Philadelphia, PA, dating to 1697 (Pennsylvania Historic and Museum Commission 1986). The oldest surviving intact bridge in New Jersey, the Stony Brook Bridge in Princeton Township, Mercer County, located within 30 miles of the Frankford Ave. Bridge is also a stone structure, dating to 1792.

The early North American structures have very little in common with their contemporary European counterparts. Through the eighteenth century, the contrast in the technology and artistry of stone arch bridge construction between the United States and England was very sharp.

To illustrate this contrast, Figure 1 shows the careful execution of design details for the Westminster Bridge, designed 1738-9, and built 1740-4. It is quite typical of the monumental structures of its time, having multiple spans of about 50 feet. The piers are wide enough to support the thrust of each of the arches without the counteracting thrust from the adjacent arch. The ring is rusticated stone of narrow width, with a backing, or secondary arch tapering from 2 1/2 feet thick at the crown to the full half-width of the pier at the springline. The thrust in the arch was calculated by the relatively new methods published by Philippe de la Hire. In summary, this is a monumental structure showing the influence of a millennium old craft, combined with new information allowing the mathematical analysis of arches, and reflecting a sophisticated and unified formal treatment of the structure and all its details. In fact, the European and British traditions had, by the turn of the nineteenth century, advanced the construction of stone bridges to a high state of sophistication, both in the advanced engineering design and construction techniques, and in the sophisticated treatment of bridge form and detailing (Ruddock 1979)

This state of affairs in Britain can be contrasted to the 1792 bridge over Stony Brook between Princeton and Lawrenceville, New Jersey (see Figure 2). Although the Stony Brook Bridge is a gracious and well-proportioned structure, it reflects none of the engineering or architectural advances evident in structures such as the Westminster Bridge. In contrast to the low span-rise ratios and longer spans of contemporary British structures, the Stony Brook Bridge arches are timidly proportioned to near-semicircular shape, requiring a humpback in the road alignment. The stones, even in the arch ring are roughly shaped and the mortar joints are left wide and random in shape and location. The expedient treatment of the shape of the north span, which is conical, rather than cylindrical in shape, and the tailrace at the south abutment all point to the work of an unsophisticated craft builder.

### **Early Road Structures**

In the late eighteenth and early nineteenth centuries, a large number of chartered, privately-financed (with the exception of the Federally-funded National Road, discussed below), toll-collecting improved roads were built to facilitate regional and farm-to-market transportation. America's first major toll road was the Philadelphia and Lancaster Turnpike, completed in 1794 (Jackson 1994). The first turnpike in New Jersey had to wait until the beginning of the nineteenth century, when sufficient public sentiment for better roads had developed (Lane 1939). Turnpikes were built in great numbers in Pennsylvania and New Jersey, particularly during the first third of the nineteenth century. The first significant construction program of stone arch bridges is associated with the appearance of turnpikes in the northeastern United States. Although turnpikes are a frequently neglected component of the Transportation Revolution of the nineteenth century, they provided an important means of linking agricultural production with markets and with railroads and canals, the other components of the nineteenth century transportation system. Due to the icy and frequently wet climate in the northeastern US, the construction methods of turnpikes, using macadamized pavements and well-established means of drainage represented a significant improvement over the muddy, rutted farm roads available at the time. Stone bridges for stream crossings became an equally important addition

to the transportation infrastructure, in providing safe, reliable, and durable means of crossing streams and rivers. (Jackson, 1994).

Turnpike bridges were of primitive construction, using locally available material, left to local individual artisans. Surviving examples of turnpike bridges show a generally casual approach to laying out, cutting and setting stones. Regrettably, very few original turnpike bridges survive to the present day. As these structures were built along major through routes that evolved into modern highways, the stone arch bridges along these alignments were generally quickly replaced with more modern structures when iron, steel, and concrete became more widely used building materials. The MacClay's Mill Twin Bridge in Delaware County, PA, recently documented by the Historic American Engineering Record is an example of a turnpike bridge (Figure 3), as are examples that will subsequently be shown in Bucks County, PA and Hunterdon County. The use of semi-coursed rubble spandrel walls, the gently humpbacked vertical alignment, the expedient treatment of the skewbacks, and the rubble arch barrels are all characteristic of the construction of craft bridges from the early twentieth century, and of the type of construction practiced on turnpike structures.

The National Road, which was a turnpike from Cumberland, MD to Vandalia, IL funded by an act of Congress, and constructed from 1818 through about 1830, necessitated the construction of stone bridges on a larger scale than had previously been attempted. In particular, the crossing of Western Pennsylvania's Youghiogheny River at Big Crossings necessitated a level of engineering design and refinement or execution unprecedented in the USA. The Blaine Viaduct (see Figure 4), with its three spans of 30, 40, and 50 feet is exemplary of the National Road structures. These are transitional bridge types, standing between the crudely constructed turnpike bridges, and the sophisticated, engineered rail structures from later in the 19th century.

The emergence of S-bridges in the western Pennsylvania and Eastern Ohio is indicative of an expedient, craftsman's approach to bridge construction. An S-bridge at New Concord, OH is illustrated in Figure 5. This type of bridge is characteristic of turnpike-era stream crossings when the stream is not at a 90 degree angle to the roadway. This expedient treatment is a means of avoiding the complications in stone layout and cutting associated with a skewed stone arch bridge. The significance of the S-bridge type to the stone bridges in Hunterdon County will be discussed in detail in Section III.

Although the turnpike road construction was heavily influenced by the principles of road construction as described by the nineteenth century British engineers MacAdam and Telford and their systems of pavement construction, the bridges are not strictly engineered structures. They are still built by contracts let to individual craftsmen, and their proportions are not established by engineering analysis. In imitation of their British and Continental counterparts, they have refinements in detailing, such as string courses and buttresses, and occasional decorative treatments.

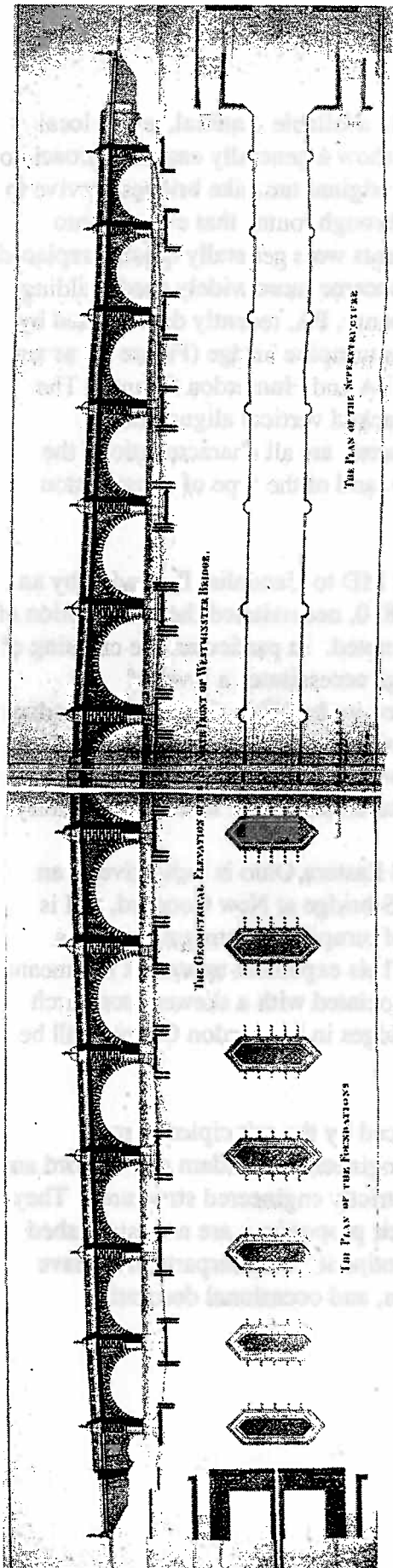


Figure 1  
New Westminster Bridge, London 1740 (Ruddock 1979)

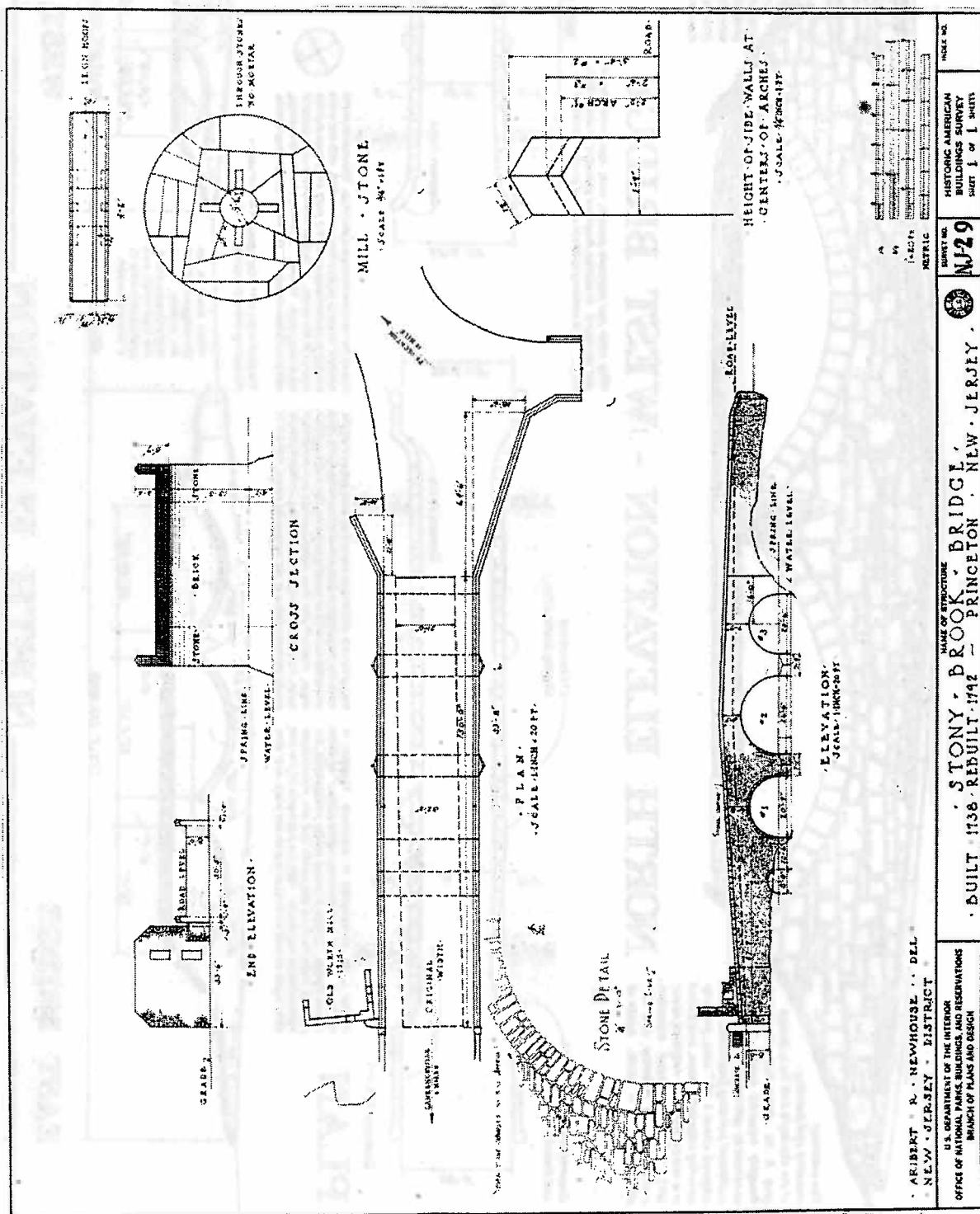
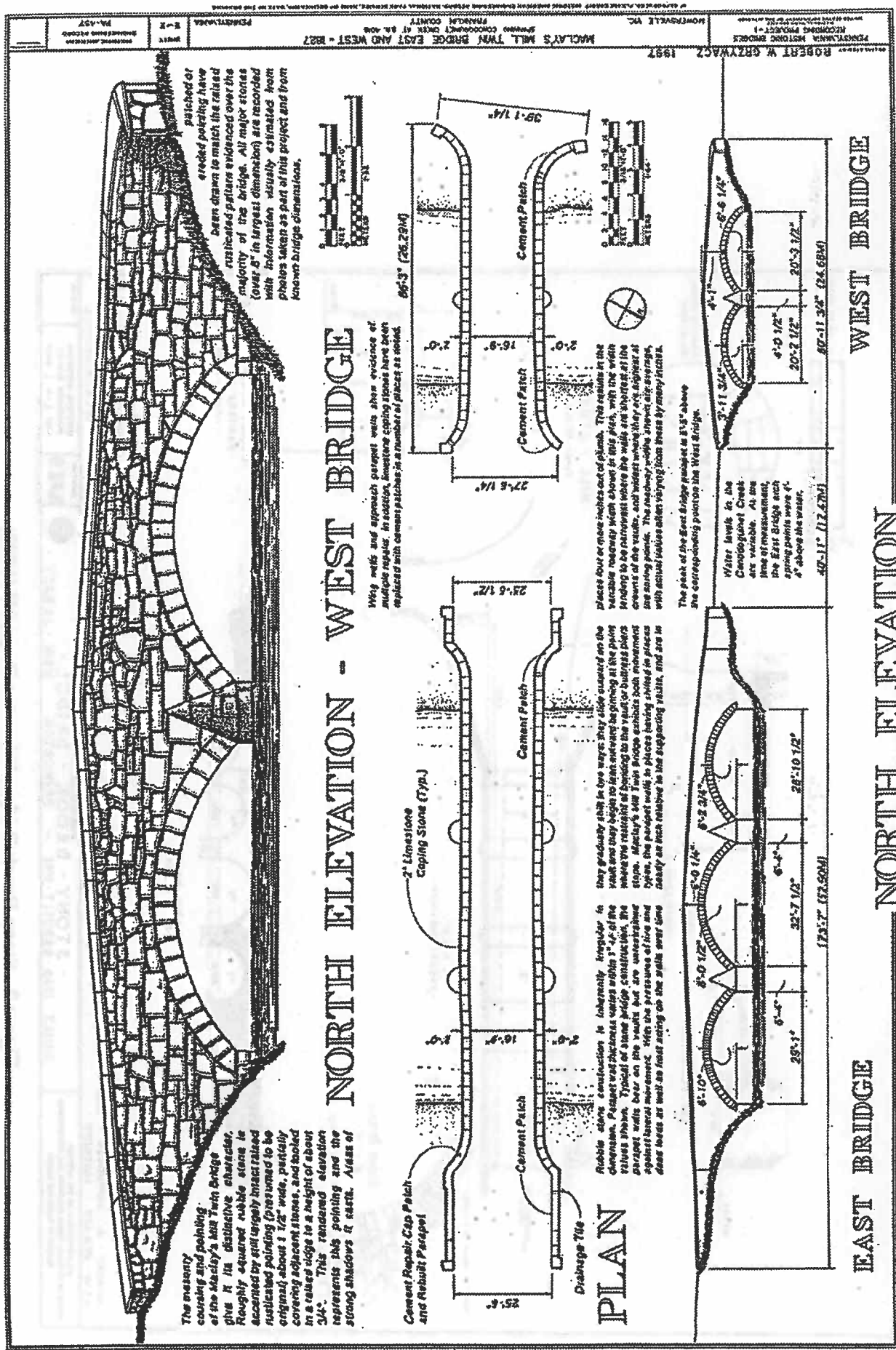


Figure 2. Stony Brook Bridge, Princeton Twp., NJ (1792)





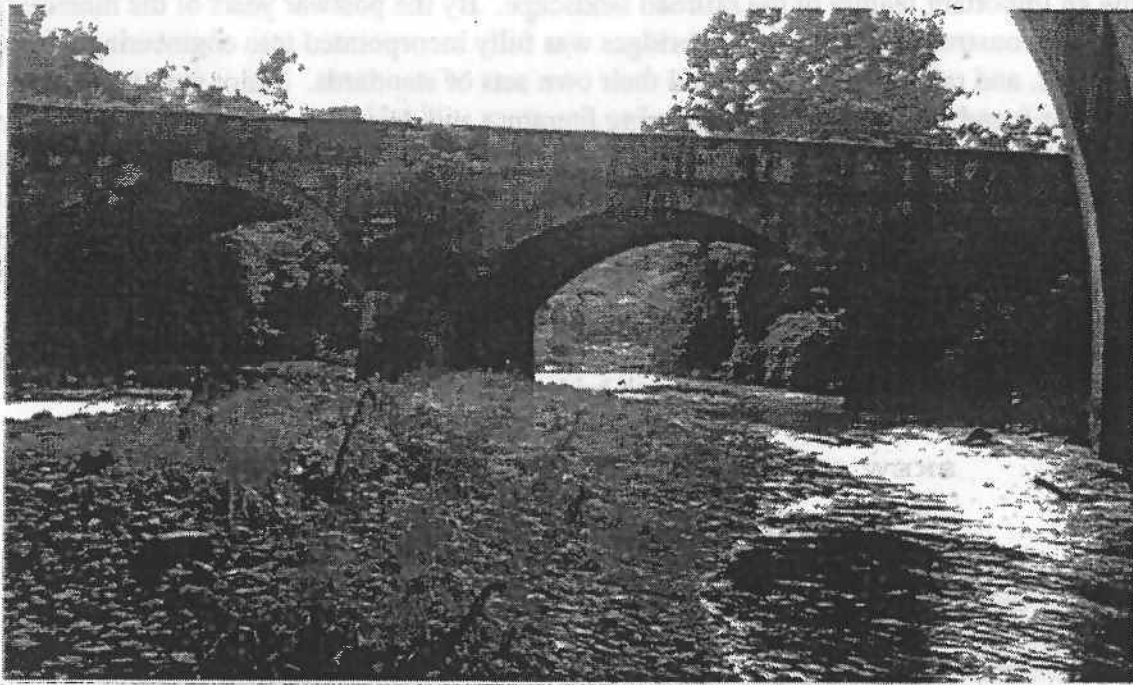


Figure 4. Blaine Viaduct, Blaine OH (1828)

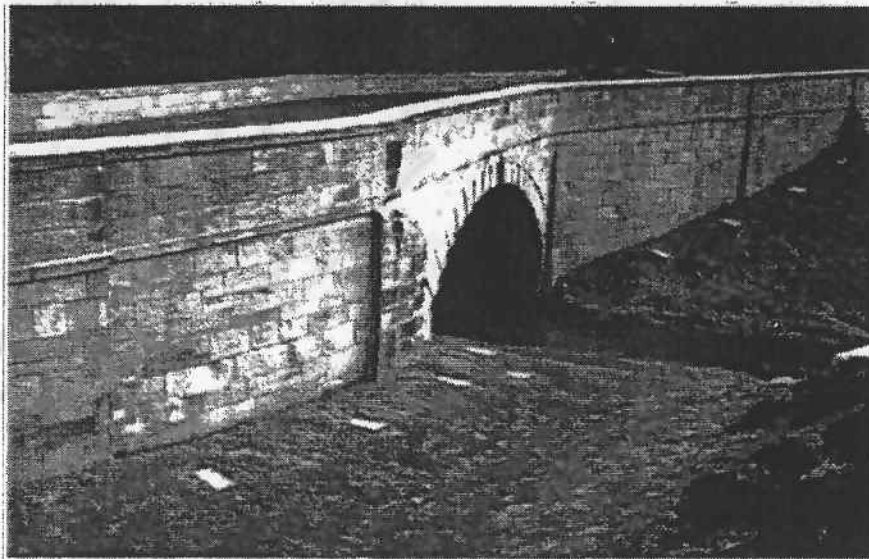


Figure 5. S-Bridge, New Concord, OH (1830).

### **Engineered Arch Bridge Structures**

Occasional engineered arch bridge structures make their appearance in Hunterdon County, such as the triple arch bridge in Musconetcong Valley. The appearance of carefully designed and executed masonry arch bridges in the USA coincides with the use of stone in railroad construction. Beginning with the construction of stone and brick arch bridges along the Baltimore and Ohio railroad in the Potomac River corridor, and Richard Osborne's Philadelphia



and Reading railroad construction program in Pennsylvania's Schuylkill valley, stone arches became an important feature of the railroad landscape. By the postwar years of the nineteenth century, the construction of stone arch bridges was fully incorporated into engineering practice and routines, and railroad lines promoted their own sets of standards. Major structures were regularly built and reported in the engineering literature and design and analysis methods were widely distributed and debated in the engineering periodical literature and in textbooks. As an illustration of the refinements that the construction of stone arch bridges had developed by the mid-late nineteenth century, a diagram of an 1840's skew arch bridge, still standing in Reading, PA is shown in Figures 6 and 7; and the Cabin John Bridge, built in the 1860's in Washington DC is shown in Figure 8. These structures are characteristic of the level of sophisticated engineering analysis, design, layout and construction practiced by engineers and stonemasons responsible for the construction of stone arch bridges in the mid-late nineteenth century.

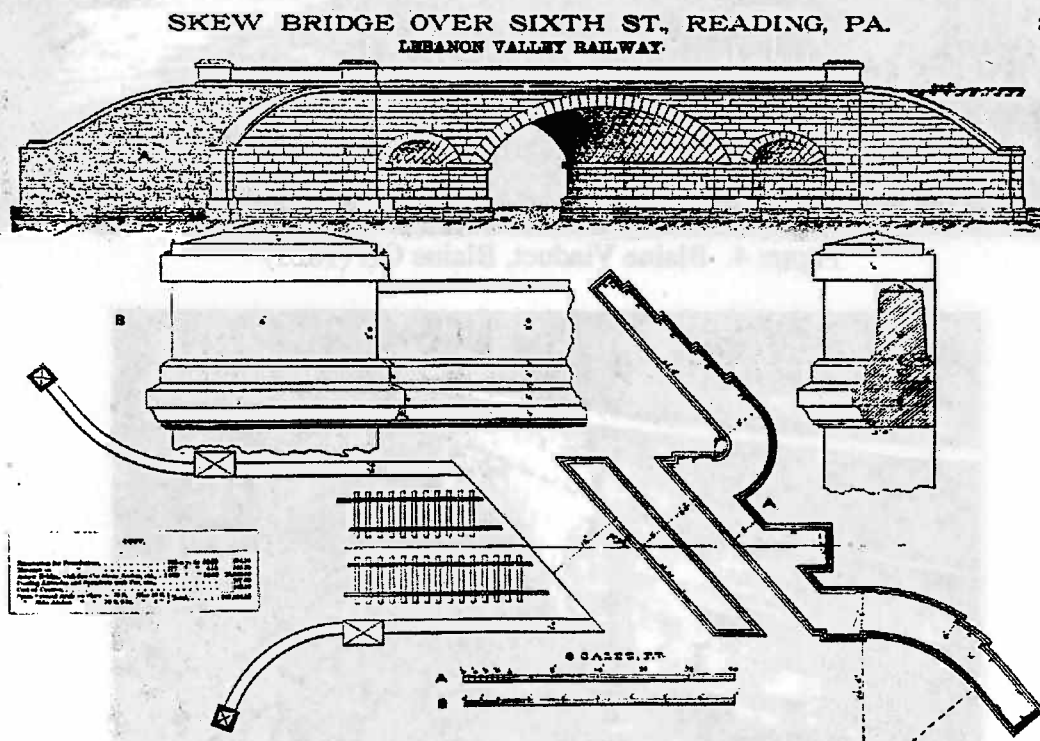


Figure 6: Skew Arch, Reading, PA

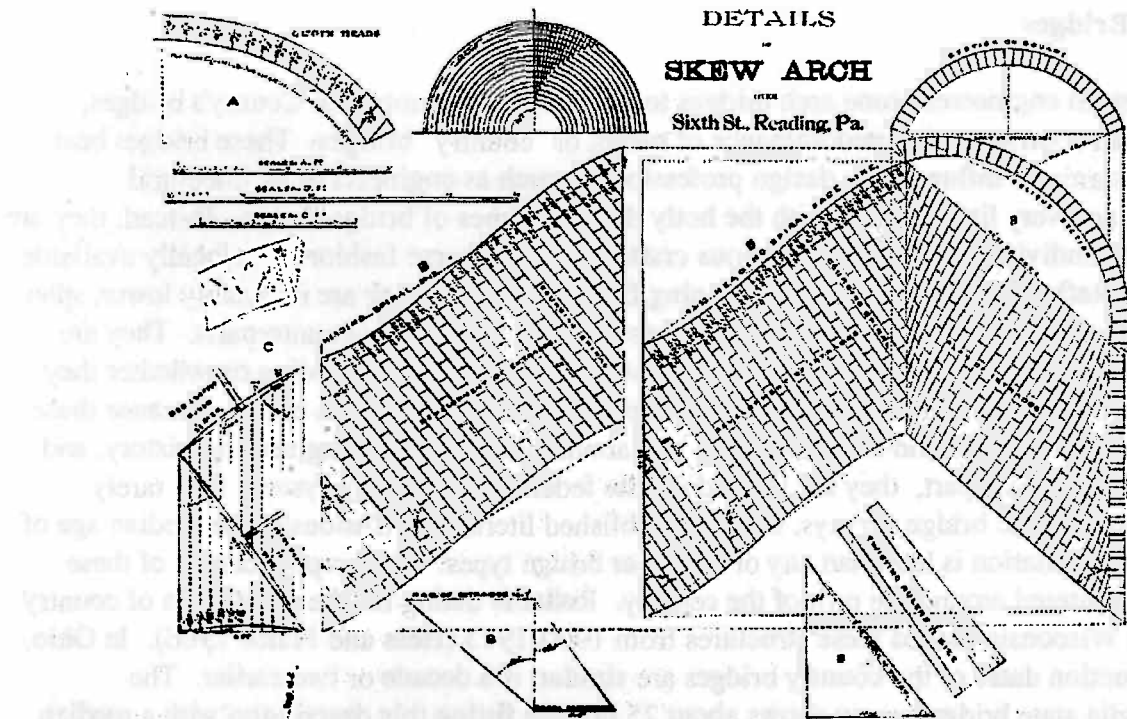


Figure 7. Skew Arch, Reading, PA

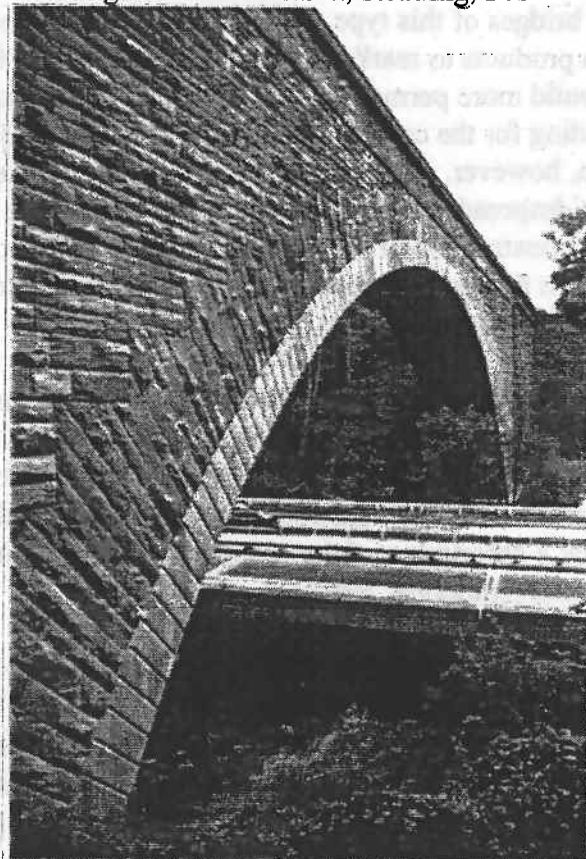


Figure 8. Cabin John Bridge, Washington, DC 1863

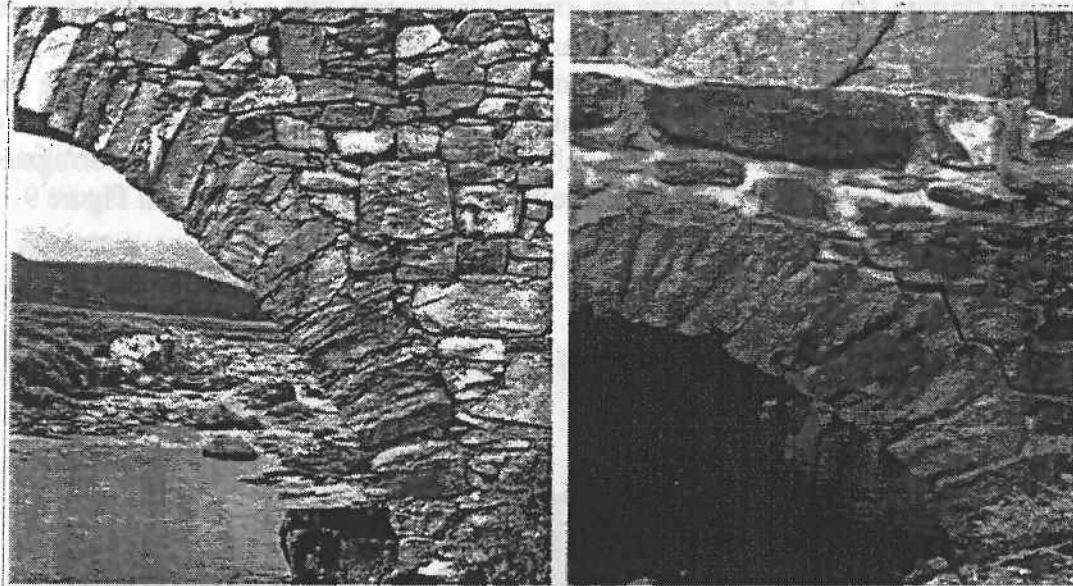
## Country Bridges

The interest in engineered stone arch bridges to an analysis of Hunterdon County's bridges, though, is in contrast to the predominance of rustic, or "country" bridges. These bridges bear very little stamp of influence by design professionals, such as engineers or architectural designers, and very little contact with the hotly debated issues of bridge design. Instead, they are executed by individual, usually anonymous craftsmen, in a coarse fashion with locally available materials. Reflecting their figurative springing from native soil, they are invariably lower, span shorter distances, and are narrower and smaller scale than their urban counterparts. They are usually characterized by a hump or a dip in the vertical alignment, depending on whether they are located in an open field and need to rise to span a small creek, or in a ravine. Because these bridges are not visible stand-alone artifacts, and are not illustrative of engineering history, and because, for the most part, they are located off the federal aid highway system, they rarely appear in state-wide bridge surveys, or in the published literature. Curiously, the median age of this bridge population is less than any of the other bridge types. The preponderance of these bridges is centered around the turn of the century. Reliable dating for the population of country bridges in Wisconsin placed these structures from 1900-1913 (Hess and Frame 1986). In Ohio, the construction dates of the country bridges are similar, if a decade or two earlier. The Pennsylvania state bridge survey shows about 25 bridges fitting this description with a median date of 1860 (Pennsylvania Historic and Museum Commission 1986). Other authors attribute the appearance of so many bridges of this type at such a late date to a combination of reasons: the requirement to get farm products to market combined with pressure from bicycling interest groups; from motorists to build more permanent structures and better roads; and with the appearance of state aid funding for the construction of more permanent improvements on local roads. The state aid system, however, also appears to have indirectly caused the demise of the masonry arch bridge as a widespread engineering type by favoring more modern materials, particularly concrete, in the construction of short span crossings. Most of the Hunterdon County stone arch bridges surveyed fit this pattern: they are short span, crudely constructed, and have dates between the end of Civil War and the turn of the century.

The location of these structures away from major through routes has spared many of them, while their small scale, vernacular character, and lack of association with well-known engineers or architects have made them underappreciated by scholars and historians of technology (Jackson, 1998). For an intelligent discussion of the construction system employed in these structures, it is necessary to turn to Ruddock's description of the "country bridges" built along the military roads in the Scottish Highlands (Ruddock, 1979).

The arches were almost invariably built of local schistose stone, commonly called 'whin', which quarries in thin flat pieces quite long enough to form the thickness of an arch but with very irregular edges and surfaces. The most regular of these stones were chosen to make the faces of the arch on the elevations and others, often thinner, were used to make up the rest of the arch. For some, and possibly for a majority of the arches, it is likely that the arch stones were first placed on the centring standing on their ends, with little or no mortar and presumably wedged tight with thin stones or slates from one abutment to

the other; mortar was then poured or packed into the irregular voids between the stones. This is suggested by the fact that the thin voussoirs on the facades of many of the bridges stand much nearer to vertical than to the direction radial to the curve of the soffit. However, there are also some bridges in which the stones for some distance up from the springings lie at angle nearer to horizontal than radial, suggesting that the other technique was used after the initial corbelling. The Scottish masons had clearly absorbed no inhibiting ideas from geometry or aesthetics about the proper direction of joints between voussoirs neither had they any notion that semicircular arches were best, for even the shortest arches, which could easily have been made semicircular, are sometimes segments of no more than  $90^\circ$  or  $100^\circ$ . This would be an advantage in the tight-wedged method of forming an arch envisaged here.



(a) Scottish Highlands  
(Ruddock 1979)

(b) Hunterdon County Bridge T-8

Figure 9 Arch Ring Construction. Country Bridges

In Figure 15, the illustration from Ruddock, showing the alignment of the voussoirs is juxtaposed with a similar view of the arch Ring of Bridge Number T-8, located on Frog Hollow Road at the Intersection with Beavers Road in Tewksbury Township. The similarities in the approaches to the alignment of the mortar joint are remarkable, although they may be thought to arise from a similar approach to an expedient treatment of forming masonry arches rather than any distinct tradition in masonry arch construction. It is much easier to place voussoirs with the bed joints near horizontal, and the construction of an equivalent to a corbelled arch results in a significant savings in time and effort.

The persistence of this building tradition in the US is also noteworthy. Well beyond the time when the railroads established engineered stone masonry construction as a mature type, with standard plans and a standard high level of workmanship, and well beyond the time when these notions had been carried through to the highway design community, and beyond the

establishment of the state aid system and the widespread adoption of concrete construction for short span bridges, large populations of crude bridges following Ruddock's model in most significant aspects of construction continued to be built.

### **The WPA and Arch Bridge Building**

A very short revival of stone arch bridges and bridge styles appeared in the 1930's, as part of an effort to put people to work pursuant to the Works Progress Administration. Bridge designers turned to the labor intensive masonry arch bridge as a way of creating additional jobs while leaving permanent monuments. During this period, curiosities such as a series of stone bridges in Eastern Colorado appeared (see Figure 9), as well as a Moderne style bridge in Southern Minnesota (Figure 10). These bridges are marked in general with a keen appreciation for the design possibilities of masonry arches, but are quite timid from an engineering point of view. Many of the bridges of this time period are not true stone arch construction. A stone faced replica of a stone arch bridge is often built, using either a filled concrete arch for the structure inside the spandrel walls. Another commonly employed method, was to use a corrugated metal pipe arch as stay-in-place centering, as in the Burro Canyon Bridge shown in Figure 9.



Figure 10. Burro Canyon Bridge. Las Animas County, CO 1936  
(Herbst and Rottman, 1986)



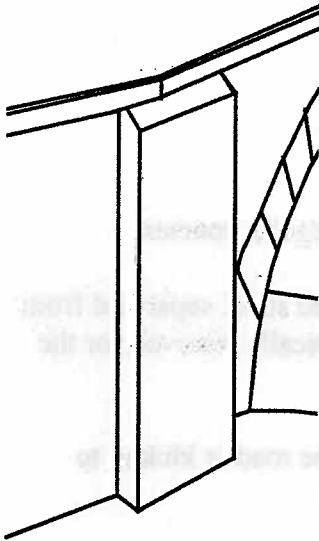
## Glossary of Masonry Arch Bridge Terms

**ABUTMENT**- solid masonry placed to counteract the lateral thrust of an arch or vault. See Figure 11

**BACKING**- randomly placed, dry-laid stone behind the arch barrel, used to give additional stability to the arch barrel.

**BED JOINTS**- the horizontal layer of mortar on which a masonry unit is set.

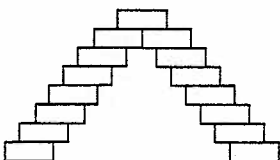
**BUTTRESS**- a mass of masonry or brickwork projecting from or built against a wall to give additional strength; usually to counteract the lateral thrust of an arch or vault.



**CENTERING**- temporary wooden framework used in arch and vault construction; it is removed or 'struck' when the mortar has set.

**CIRCULAR ARC**- the curve of an arch that follows the form of a circle; a segmental arc follows a circular form drawn from a center below the springing line.

**CORBEL**- a masonry construction in which each successive course projects beyond the one below; can be used in constructing a vault or arch.

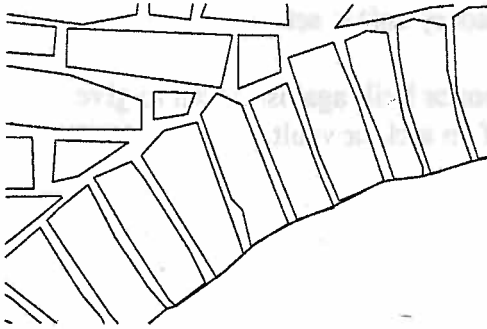


**INTRADOS**- the inner curve or underside of an arch; also called a soffit. See Figure 11

**MASONRY**- work by a mason, for example brickwork or stonework; the type of construction consisting of masonry units laid up with mortar or grout.

**PIER**- a solid masonry support, distinct from a column; the solid mass between doors, windows, and other openings in buildings. See Figure 11

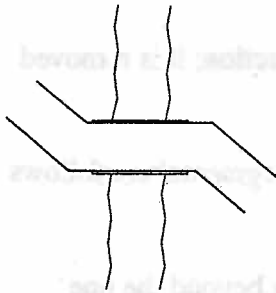
**RADIAL**-lines are said to be "radial" when they project from a central point



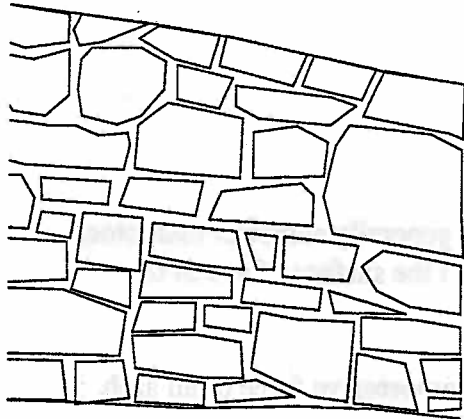
**RUBBLE**- rough unhewn building stones or flints, generally not laid in regular courses.

**RUSTICATION**- massive blocks, sometimes in their crude, quarry-dressed state, separated from each other by deep joints; employed to give bold texture to a wall and typically reserved for the lower section.

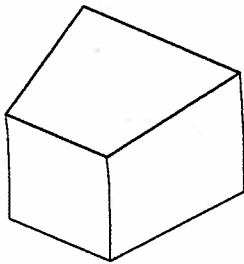
**S-BRIDGE**- one method of constructing a bridge at a skewed crossing; the road is kinked to allow a crossing at right angles; a normal bridge can then be constructed.



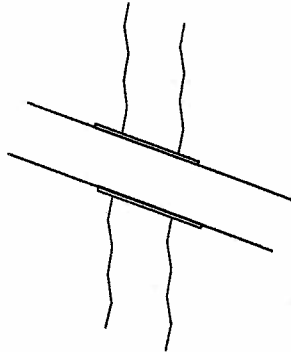
**SEMI-COURSED-** description for a masonry wall that is not built in precise continuous layers of stone or brick, but rather is laid in general rows.



**SKEWBACK-** the inclined surface of an abutment which supports the arch.



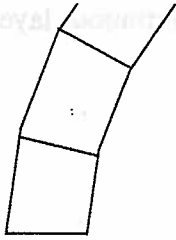
**SKEWED-** A structure that is not at right angles to its surroundings; for example, when a bridge intersects a river at an angle other than 90 degrees.



**SPANDREL-** the triangular space bounded by the adjacent curves of two arches and the horizontal tangent of their crowns. See Figure 11

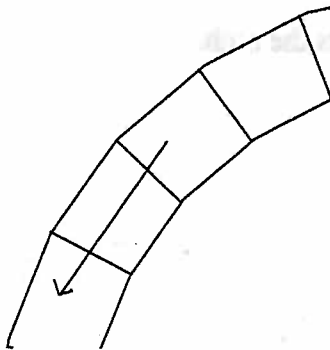
**SPRINGING-** the level at which an arch springs from its supports; the bottom stone of the arch can thus be called a springer.





**STRING COURSE**- a continuous horizontal band of masonry, generally narrower than other courses, extending across the facade of a structure; can be set in the surface of a wall or projecting from it. See Figure 11

**THRUST LINE**-the line through which the thrust, or internal compressive force of an arch, is acting.



**VOUSSOIR**-a brick or wedge shaped stone forming one of the units of an arch. See Figure 11

**WINGWALL**- a masonry wall that flanks the bridge at its junction with solid land; typically used to support the bank of a river or to hold infill. See Figure 11

## II. Stone Arch Bridges in New Jersey and Bucks County, PA

Masonry arch bridges are found throughout the State of New Jersey, concentrated within the part of the state north of Trenton. Brick arches were built within areas of the northeastern part of the state, however the larger proportion of masonry arch bridges in New Jersey are built in stone, and the largest portion of the remaining population appears to be rural stone arch stream crossings, much like the bridges found in Hunterdon County (Lichtenstein, 1994). Among the counties of New Jersey, Hunterdon County maintains the largest population of stone arch structures. The New Jersey Historic Bridge Survey (Lichtenstein, 1994) has identified thirteen stone arch bridges (over 20 foot span) in the county, rivaled only by Mercer and Morris County's 11 and Warrant County's 9. When the definition of bridges is expanded to include spans less than 20 feet, the more than 100 structures in Hunterdon county is clearly the largest concentration of stone arch bridges in North America.

The first large program of construction of stone arch bridges is associated with the construction of turnpikes. New Jersey and Bucks County, PA were caught up in the turnpike boom of the early 19th century, resulting in a large program of construction of stone arch bridges (Jackson 1998). Because, for the most part, the turnpike alignments later became through routes, very few of the bridges from this time period remain. Bucks County's Bridge No.223 (Figure 11), carrying Old Easton Road over Nockamixon Creek, with an 1826 datestone, is an instance of a turnpike bridge. In this case, the modern road is on a new alignment parallel to the old turnpike.



Figure 12. Bucks County Bridge No. 223 (1826)

This structure bears many of the hallmarks of the somewhat later Hunterdon County Bridges. The inset treatment of the arch and spandrel walls, clearly shown in Figure 11, up to the level of the extrados at the crown is a feature often associated with bridges in Hunterdon County, which is discussed in detail later in this report. The alignment of the ring stones, apparent in Figure 12(a), follows a pattern that will be discussed in the section below. The use of rough cobbles in the arch ring, past the facing stones, is shown in Figure 12(b), and is a universal feature of the

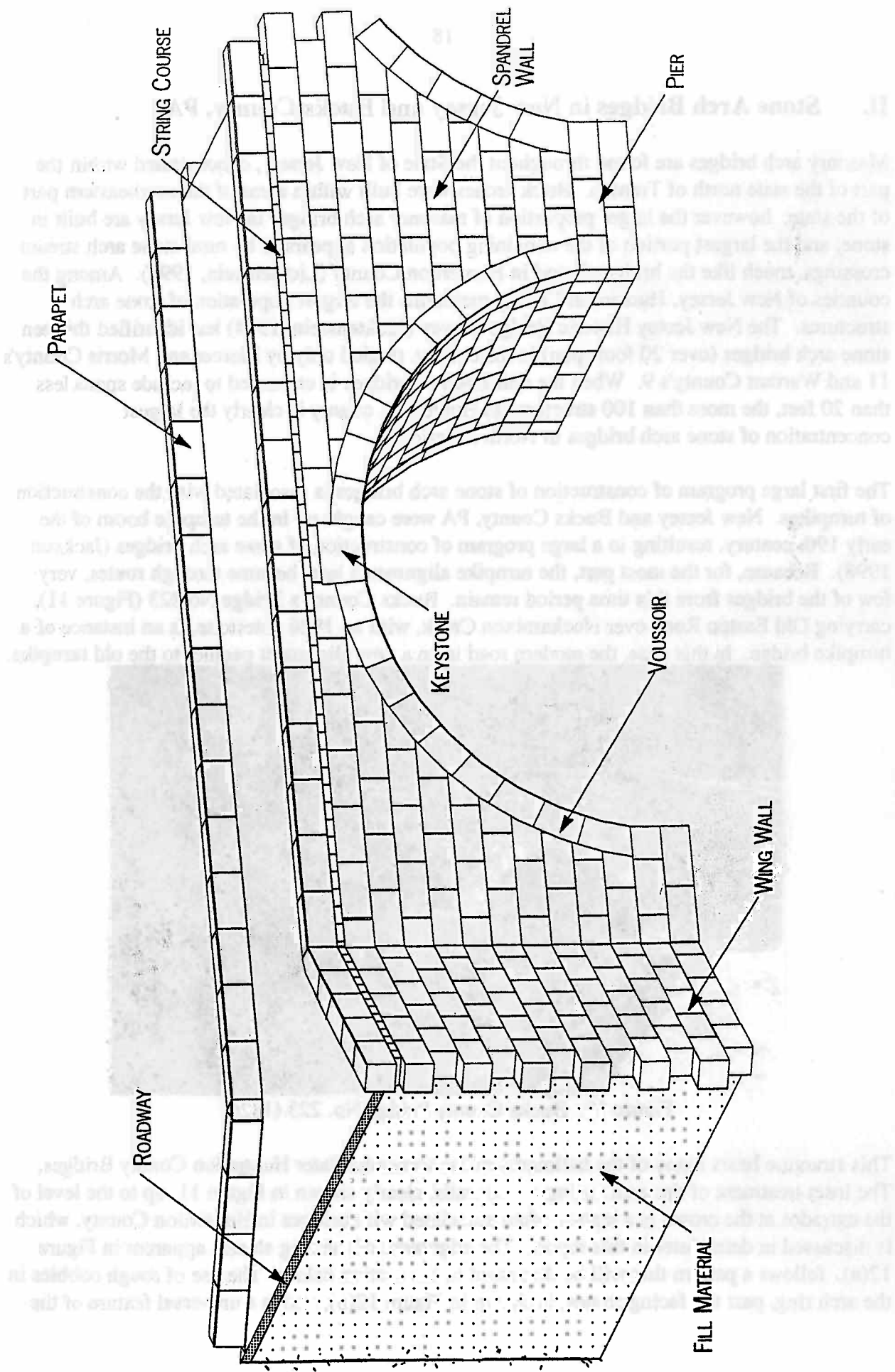


FIGURE 11. MASONRY ARCH BRIDGE TERMS

bridges in Hunterdon County. The ring is built of sandstone, apparently quarried at some distance from the bridge site, and the spandrel and parapet are built of altered shale freely available in the stream bed.



(a) detail of ring



(b) detail of barrel

Figure 13. Bucks County Bridge No. 223. Details.

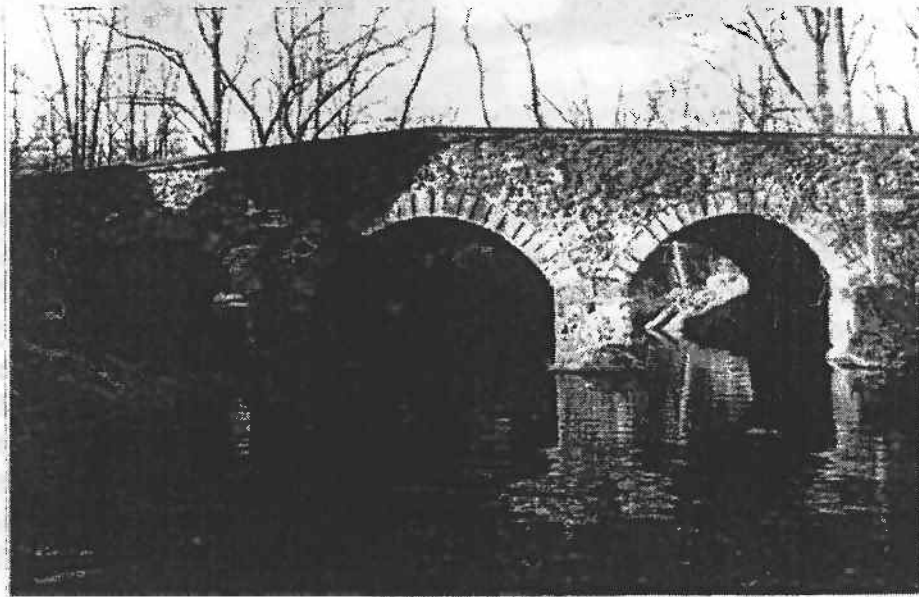


Figure 14. Bucks County Bridge No. 305 (1873)

Later bridges in Bucks County include Bridge No. 305, located on Atkinson Road in Solebury Township, illustrated in Figure 13, and an undesignated skewed bridge located within Ralph Stover State Park. Bridge No. 305 reflects a more refined and monumental treatment of the layout and cutting of the arch ring, with regularly spaced radial joints in sandstone ring stones. The barrel is filled with rubble wedged into place on the centering, and the piers are generously proportioned. The bridge in Ralph Stover State Park reflects more recent construction, probably

c. 1900, in the use of hard portland cement mortar in the forming and construction of the arch barrel. The bridge is also characteristic of most of the structures found in Hunterdon County in the construction of the arch barrel, and the provisions made for the skew angle of approximately 70 degrees.

Although cut stone masonry bridge structures do appear in New Jersey in turnpike and canal structures in the early nineteenth century, engineered stone masonry structures do not appear until the construction of stone railroad bridges. Examples of engineered railroad structures certainly appeared in New Jersey and in the region of Hunterdon County with the advent of the railroads. The more widespread adoption of stone masonry railroad bridges came after 1870 when rapidly increasing locomotive weights caused many timber and iron bridges to be rebuilt in stone masonry. Abundant examples of railroad bridges were available in Hunterdon County, such as the nineteenth century rail crossing over Forge Hill Road in Glen Gardner shown in Figure 15.



Figure 15. Rail Bridge, Glen Gardner, NJ

However, most of the remaining stone bridges in New Jersey in general, and Hunterdon County in particular have a wholly different origin from the turnpike bridges, and a wholly different character from engineered bridges. Instead, these are small scale, usually 10 foot to 20 foot span structures. In spite of some refinements of form, discussed later, these remain country bridges. They are rustic in location, being on farm to market roads off the major through routes, rustic in construction, being built crudely from locally available materials and following simple patterns for the configuration of the structures' elements. The well-preserved examples are rustic in feeling and association as well. Nearly all of them date from the period between the end of the Civil War to the turn of the century, or shortly thereafter; in transportation history from the beginning of the good roads movement in 1876 to the establishment of the federal aid system in 1916.



### III. Bridge Styles in Hunterdon County, NJ

#### Monumental Structures

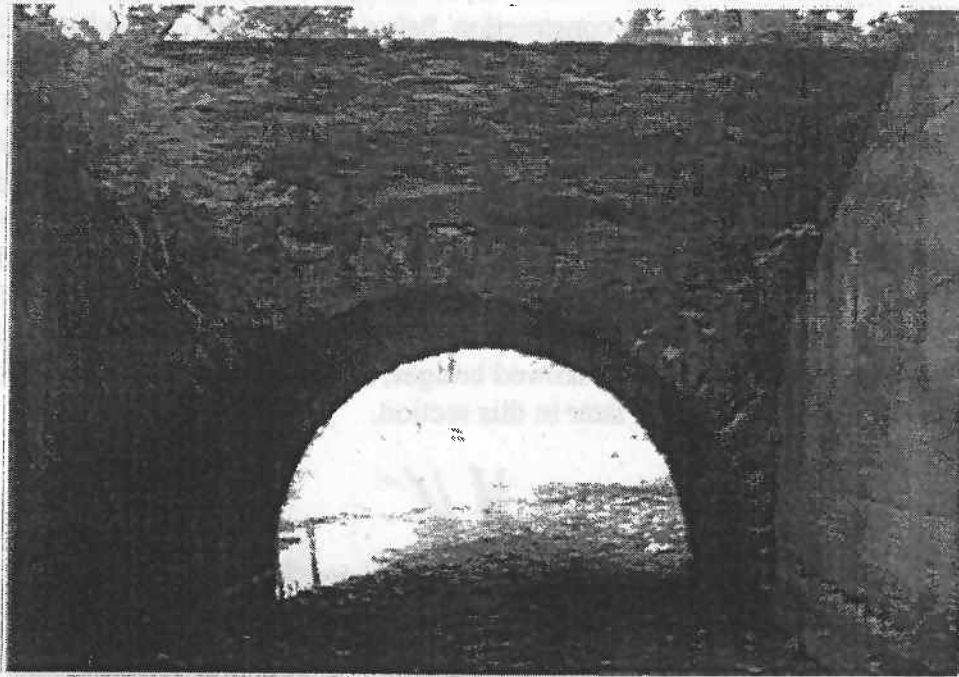


Figure 16. Bridge P-160. *This structure incorporates monumental features, such as the high semicircular opening, the formal treatment of the ring, and the high spandrel walls.*

Only a single bridge in the Phase II inventory in Hunterdon County can remotely be classified as a city bridge. Bridge P-160, located in Frenchtown, bears some of the hallmarks of a civic project. Its scale is significantly larger than the remainder of the bridges in this survey. The level vertical road alignment, the high, plumb spandrel walls, the sharply turned wingwalls, and the careful cutting and craftsmanship of the voussoirs reflect a more deliberate and careful approach to planning and execution of a stone bridge structure. The detailing is austere, much like a railroad bridge, and the effect is modestly monumental.

#### Country Bridge Variants: Stylistic Differences Between Northern and Southern Townships

Within the general method of construction of the Hunterdon County bridges outlined in the previous section, a fundamental stylistic difference can be discerned, roughly divided between the Northern and the Southern Townships. 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. Figures 18 and 19 illustrate, by the use of example bridges discussed below, the basic features of the variation between the bridges found in the Northern and Southern reaches of Hunterdon County.

The Northern township bridge styles are found roughly in Tewksbury, Lebanon, Alexandria, Holland, and parts of Union, Readington, and Clinton Township, although the largest number and the most representative are found clustered in Tewksbury Township. These bridges are characterized by extraordinarily rough construction, being usually built of granite fieldstone, very roughly dressed. Voussoirs are seldom radially aligned and never cut on the intrados or extrados. The arch ring is indistinct, and the barrel is built of very rough, sharp pieces of stone laid on the centering and slushed with mortar backing. Bridges are built as close to the ground as the waterway permits, and approach roads are also kept on a low level, resulting in a characteristic humpback. This bridge style is exemplified by the pair of bridges T-8 and T-9 (Figures 17 and 20), near the intersection of Frog Hollow Road and Beavers Road, and individually by the Bridge T-89 (Figure 21), located on Guinea Hollow Road. Most of these bridges, and all three of the examples cited above, are slightly skewed with respect to the road alignment. The practice of constructing skewed bridges, as applied to the bridges in Hunterdon County, is discussed at greater length later in this section.



Figure 17. Bridge T-8 *Typical of Northern bridges: low profile, low segmental opening, large rough random unshaped voussoirs, and random size coping stones.*

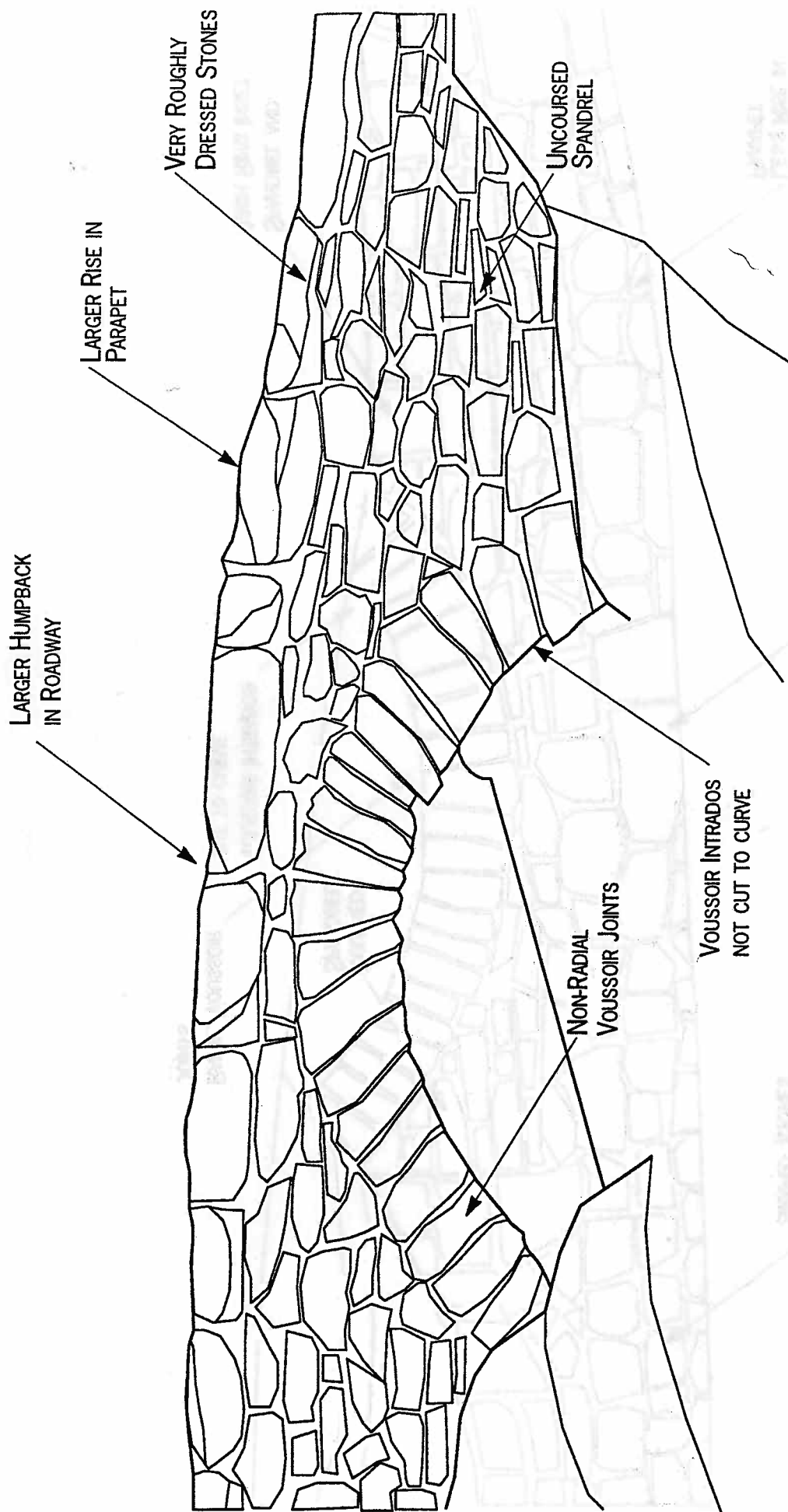


FIGURE 18 EXAMPLE OF ARCH BRIDGES OF NORTHERN TOWNSHIPS



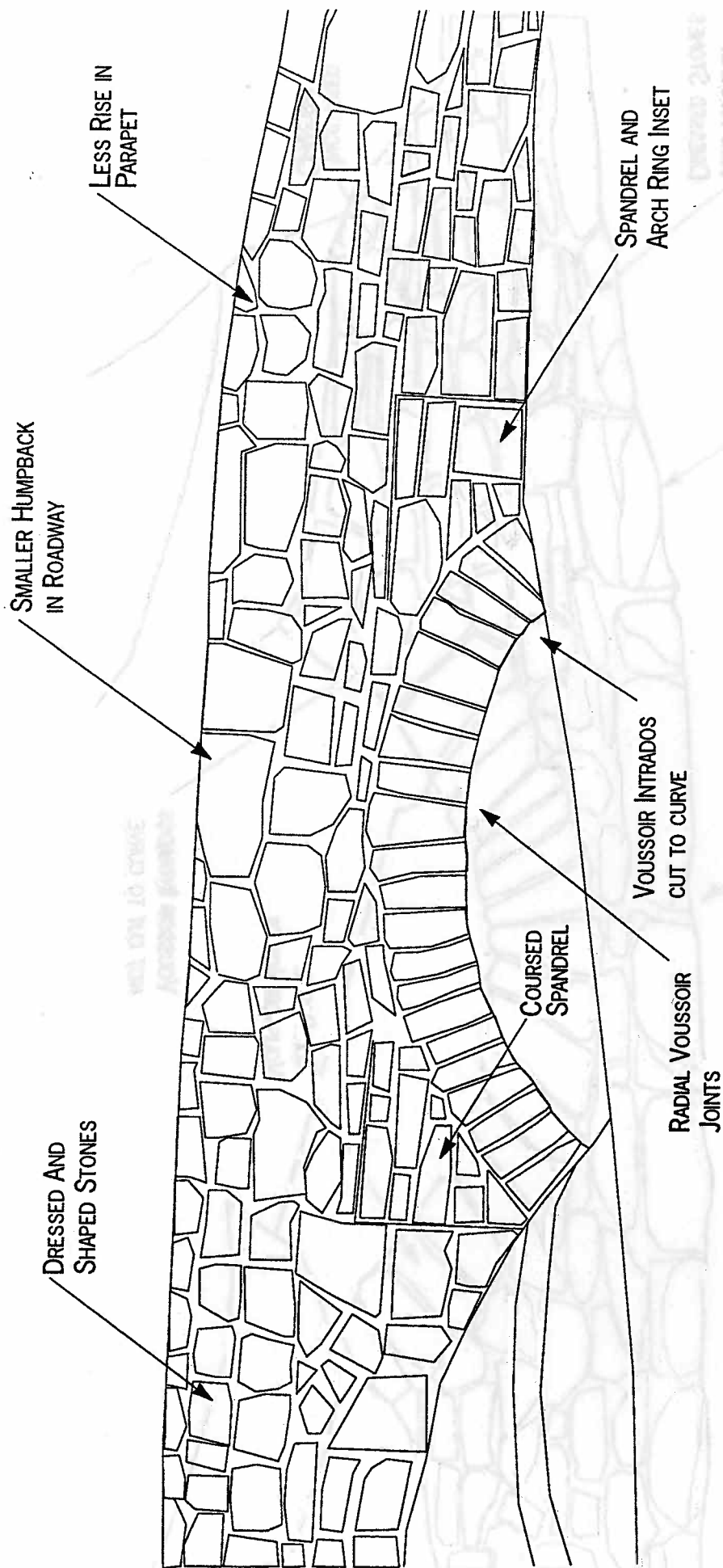


FIGURE 19 EXAMPLE OF ARCH BRIDGES OF SOUTHERN TOWNSHIPS



Figure 20. Bridge T-9. *Northern bridge: although a little more organized than its counterpart T-8, this structure displays a low profile opening, irregularly shaped stones, and random copings*



Figure 21. Bridge T-89. *Low profile, irregular shaped stones, segmental opening, and rough random uncoursed spandrel stones are hallmarks of the Northern style.*

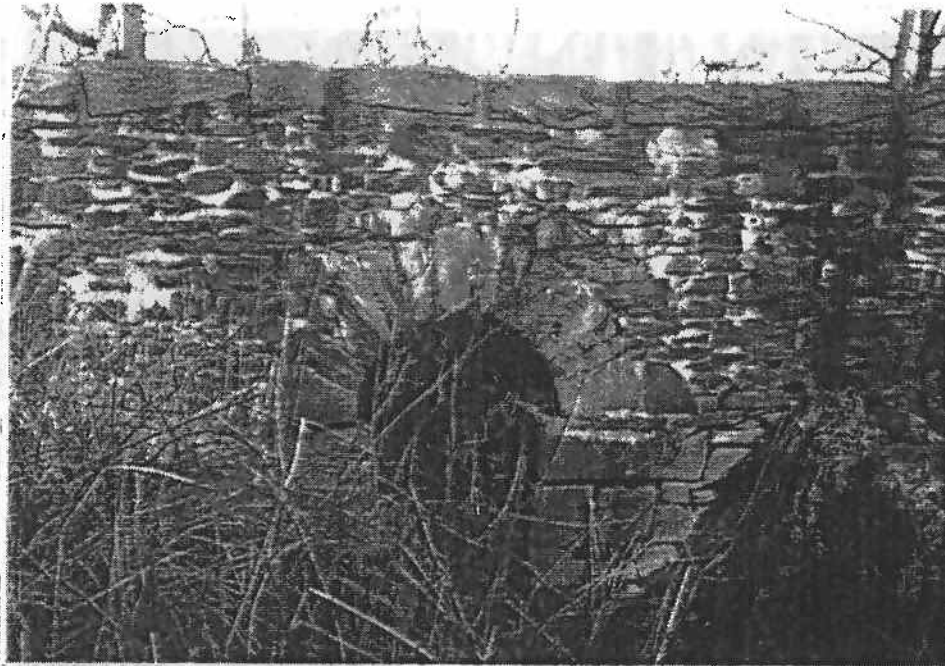


Figure 22. Bridge E-249. *Careful squaring of the abutments and a light shaping of the intrados at the opening, and choice of matching coping stones are some of the refinements visible in this structure.*



Figure 23. Bridge D-449. *Shaped regular voussoirs and a distinct curved cut of the intrados are evident in this structure.*

A distinctly different style of bridge construction prevails in the southern townships of West Amwell, East 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. More modest example is furnished by Bridge No. E-249, located on Back Brook Road in East Amwell Township, located on Worman Road near the intersection with the Stockton-Flemington Road (Figure 22), and Bridge No. D-449 (Figure 23). Although showing much of the rustic style of its northern counterparts, including the humped alignment and rising parapets, the structure has a distinct semicircular arch ring, dressed and radially aligned joints.

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 the wingwalls. In bridges such as D-368 (Figure 24), located on Sandbrook Headquarters Road at the intersection with Lambert Road, this treatment is combined with carefully cut polychrome sandstone, a shallow arch to reduce the hump in the vertical alignment, and 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.

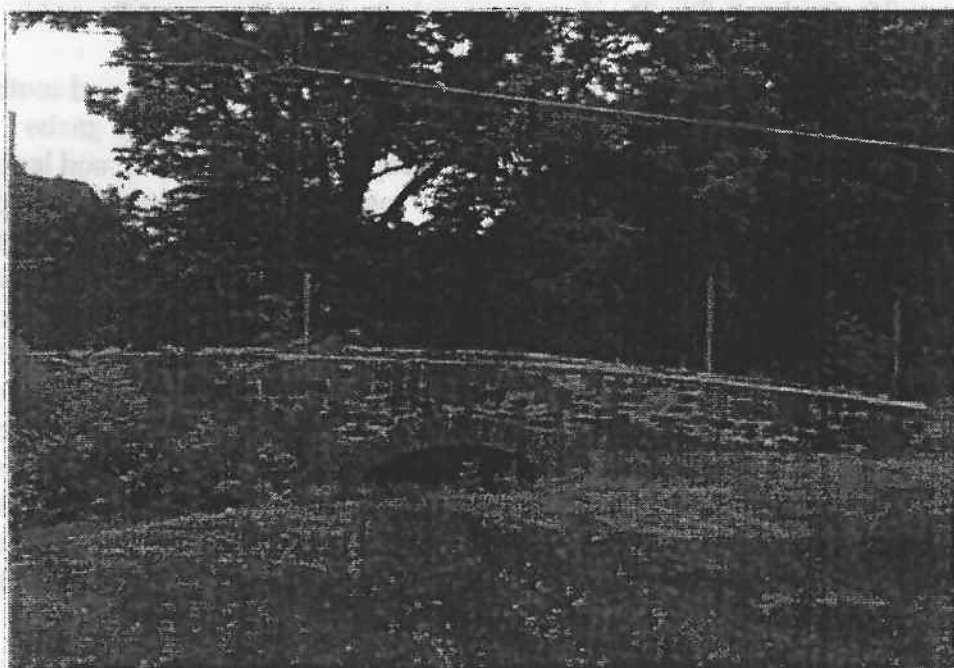


Figure 24. Bridge D-368. *A refined and gracious example of the Southern style, with carefully cut and matched voussoir stones, a graceful low vertical curve, carefully placed parapets, and inset spandrel and ring.*

Bridge K-78, located on Fairview Road near the intersection with River Road, (Figure 25) and other bridges in Kingwood township, and a pair of bridges in Frenchtown, show a stylistic



variation, including a deep inset, a parapet over the semicircular arch ring only, and the use of squared flat stones for construction of the wingwalls and the arch ring



Figure 25. Bridge K-78. *The deep inset style found in Kingwood Township*

The reasons for the divergence between the types of structures in the northern and southern parts of the County relate principally to the types of materials used. The granite and gneiss universally used in the northern part of the county is exceptionally hard to cut, and lacking the distinct bedding planes of sedimentary or metamorphic rock, is also challenging to shape. The indurated shale, sandstone, and altered shale freely available and preferred in the southern parts of the county are easier to work, and easier to shape, and came out of the quarries already at least roughly squared. Moreover, there appears to be a slight difference in the dates between the structures in Tewksbury Township and the southern locations. Those structures in Tewksbury that bear date stones, including T-114 (Phase I survey), and T-107, are from 1890 or later, whereas those in other locations are mostly from 1870-1890. The absence of date stones from the roughest of the northern bridges, and the construction methods employed indicates a lack of concern for any considerations other than strictly utilitarian. It is not unlikely that, as the responsibility for bridge construction devolved from the Board of Freeholders to individual Freeholders, and in the course of time, concern with craftsmanship and appearance of the structures also became less important.

The Depression spawned a brief revival in the use of stone bridges in the late 1930's, spurred by the boom in labor intensive public works construction under the guidance of the WPA. The influence of this movement is also noticeable in the stone bridges in Hunterdon County, both for entirely new stone structures, such as Bridge E-237, located on Manners Road at the intersection with Wertsville Road (Figure 26), and for the widening of existing stone structures, such as U-21, a nineteenth century stone structure that was widened to both sides in this era. Two basic construction methods were employed, both of which resulted effectively in stone-faced bridges built of more modern materials. In the first method, used in the 1940 construction of bridge E-

237, a corrugated steel plate arch is used as stay in place centering. An arch ring, though not necessary for the structure, is placed on the outside of the centering, and spandrel walls are constructed of semi-coursed cut stone. This method has other precedents in the 1930's, for example among the stone bridges built by the WPA in Eastern Colorado. The other method, which is visible in widening projects throughout Hunterdon County, is to build a formed concrete arch for the widened part of the bridge. The arch is usually faced, as it is in Bridge U-21, located on Strotz Road in Union Township (Figure 27) with a cut stone arch ring and a carefully built spandrel, wingwall, and parapet.



Figure 26. Bridge E-237. A 1940 structure built in a distinct WPA style.



Figure 27. Bridge U-21. This bridge was widened to both sides in a 1930's style.

**Particular Features of Hunterdon County Bridges**

### *Stone Materials and Sources*

The stone materials selected for bridges in Hunterdon County are granite, sandstone, limestone, and altered shale. The geology of the County makes all four of these materials widely available, although the granite, while universally available in the northern reaches of the county, is largely unavailable in the southern townships. The map reproduced in Figure 28 shows the main outcrops in Hunterdon County to be Triassic sedimentary rocks south of Clinton, with intrusions of diabase igneous rocks also present in the southern part of the County. Precambrian Gneiss associated with Musconetcong Mountain is the principal type of surface mineral to the north. (Lewis and Kummel 1915). The triassic sedimentary rocks of the southern part of the county consist primarily of shales. Where these materials have come in contact with the heat and pressure of the intrusive rocks, the crumbly red shales become harder in texture and darker in appearance, and are known as altered shale. As Snell (1881) reports:

Such is the case with those layers found adjacent to the trap-rocks hereafter to be described. For instance, as we ascend the Sourland Ridge from Van Lieu's Corner, all along the roadsides, at and near the base of the hill, the rock exhibits the appearance of ordinary shale; but as we ascend, the appearance of the rock becomes such that one believes it to have been altered by igneous agencies. Near the base it is easily broken, easily impressed with the hammer; on its exposed outcrop it exhibits its laminated structure, and is covered with a deep soil, made from its disintegrated laminae. About midway up the ascent we notice that the layers of rock are harder broken with more difficulty, show less of the laminar structure along the outcrop, and are covered with a less depth of soil. Farther up the layers are still harder, and the weathered surfaces present less of the lamination; the soil over the layers is also less deep. Near to and at the brow of the ridge the layers are well defined, are almost of flinty hardness, break with difficulty, and to the blow of the hammer yield a conchoidal fracture. Many of the specimens found along the brow, if suspended when struck with the hammer ring like pot-metal or like the blacksmith's anvil. Here and there specimens may be found that present an appearance that leads one to believe that, at some distant time, they have been in a state of fusion, their seams being obliterated by that coalescence of the sides of continuous layers....

The harder layers of unaltered shale keep their characteristic red color and are known as "indurated shale." This shale and altered shale are important materials for bridge building in the southern parts of the county, and appear in the full spectrum of hardness and color. They also appear to be the materials most often quarried for bridges in the County. Snell reports the location of three shale quarries, on Prall's farm in East Amwell, on the Neshanic near Reaville, and on the east bank of The Neshanic, near Nevin's Mill. None of these sites has been located, although the red indurated shale is clearly the chief mineralogical feature at these locations. The altered shale was also quarried in the Lambertville area, and possibly on Sourland Ridge. Sandstone was quarried in large amounts in Stockton, for the construction of the Delaware and Raritan Canal, and later for construction of buildings and bridges. Limestone outcrops were also worked, but very little limestone was used in the construction of the remaining bridges.

In keeping with the general character of the Hunterdon County bridges as native craft structures, built by the most expedient means possible, the material used in the bridges varies around the County, in nearly exact correspondence to the material readily at hand. It appears that the first choice of material for bridge building is the material in the stream-bed, as many instances of similar materials appearing in the stream-bed and the bridge are available. Figure 25, for instance, shows bridge K-78, with altered shale parapets and spandrel wall, and a sandstone ring, founded on a base of altered shale. Nearly all the bridges in Tewksbury and Lebanon Townships were built of rough granite, probably quarried from the stream bed or the adjacent area (no granite quarries are mentioned anywhere in Snell's mineralogical account), and dressed roughly and informally.

Sandstone, although much more easily worked, was a more costly and generally imported material. It is in many cases used in the arch ring alone, with the spandrel walls being either granite (towards the northern part of the county), or altered shale (towards the south). Bridge P-160, located in Frenchtown is in close proximity to the sandstone quarries along the Delaware River. Bridge D-368, located on Sandbrook Headquarters Road in Delaware Township, is built entirely of a very refined sandstone material, surely imported from the quarries at Stockton or Lumberville, PA (McKee 1973).

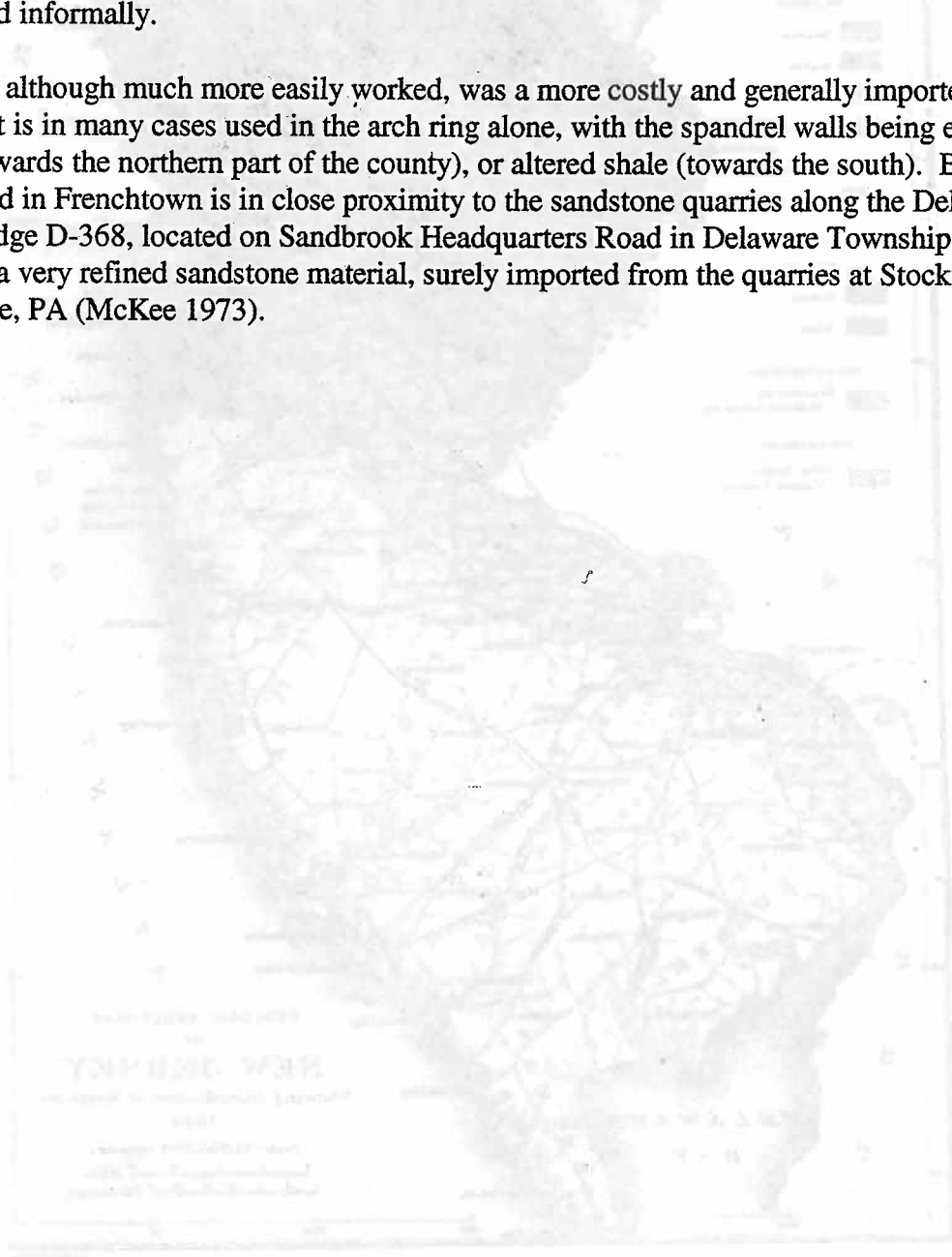


Figure 25. New Jersey Geological Survey and Natural Resources, 1973



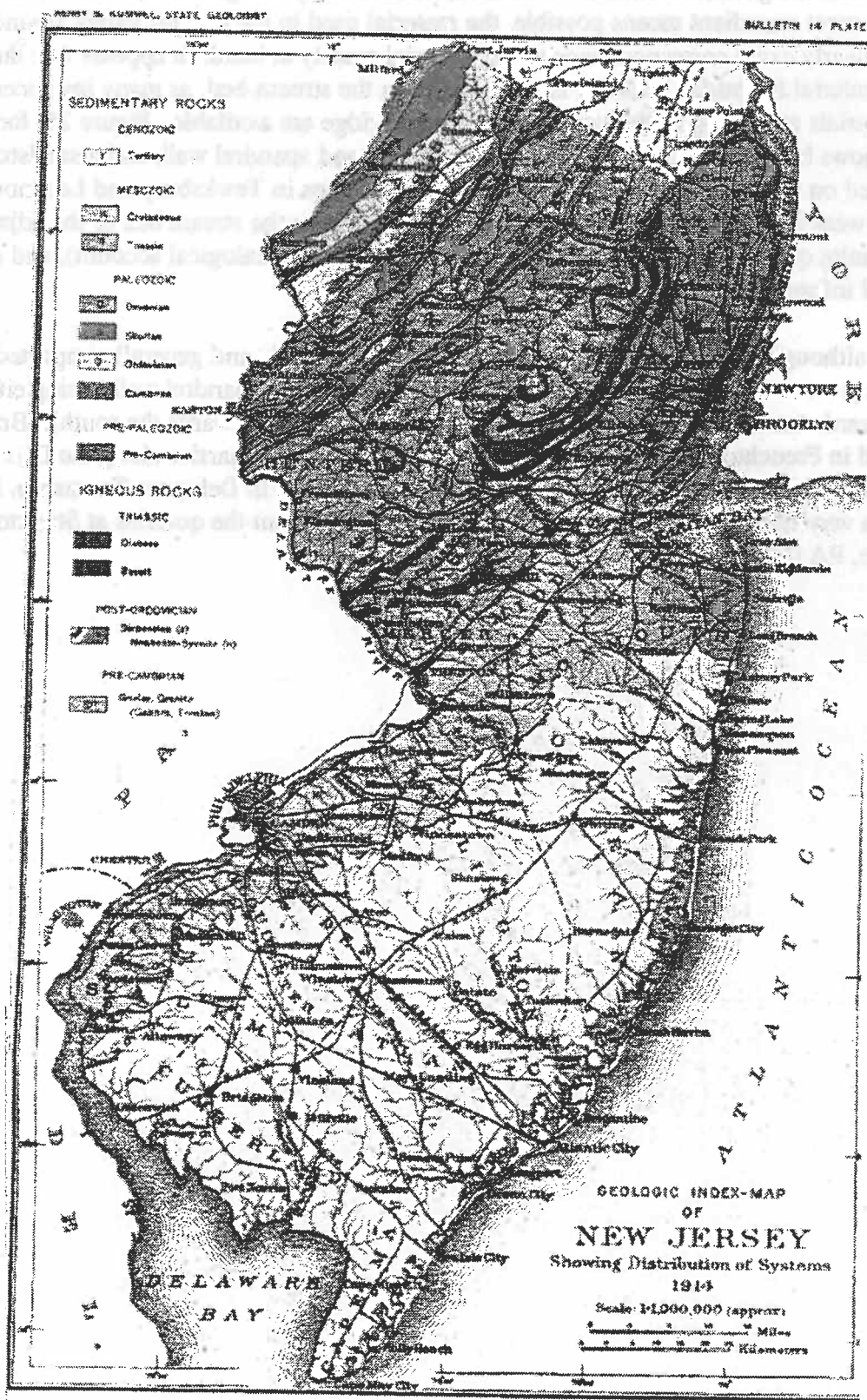


Figure 28. New Jersey Geology. (Lewis and Kummel, 1915)

## Skew Bridges

A skew bridge is a structure in which the axis of the arch barrel is not at a  $90^\circ$  angle to the centerline of the roadway. Although the construction of skew bridges is relatively simple for modern bridge types, it presents considerable challenges to the construction of stone arch bridges. Because the arch barrel requires the cutting of individual stones and the continuously varying angles of inclination around the perimeter of the arch, stone layout, cutting, and setting becomes a challenging and complicated exercise in geometry.

Four basic strategies were generally adopted for the construction of skew crossings. The S-bridge, previously described in Section I, is a response to the challenges of building a skew crossing, in which the alignment is simply kinked to allow a right bridge to be built instead of a skew bridge. In the false skew scheme, a cylindrical arch barrel is simply cut off parallel to the road centerline, and the coursing joints in the arch barrel run parallel to the abutments. In the US, builders of rail bridges often built skew bridges as a series of narrow offset right arches, called ribbed arches. The most refined type of skew arch bridge structure is the skew arch, of which a bridge in Reading, PA (Figures 6 and 7) furnishes an example. In this scheme, the joints twist around the intrados at an angle related to the skew angle of the structure. Although the angle at which the facing stones are cut is different for each stone, they are nearly normal to the face of the arch. The interior stones in the arch barrel are identical and present a rectangular face on the intrados, although their sides have to twist slightly to accommodate the curve of the arch barrel.

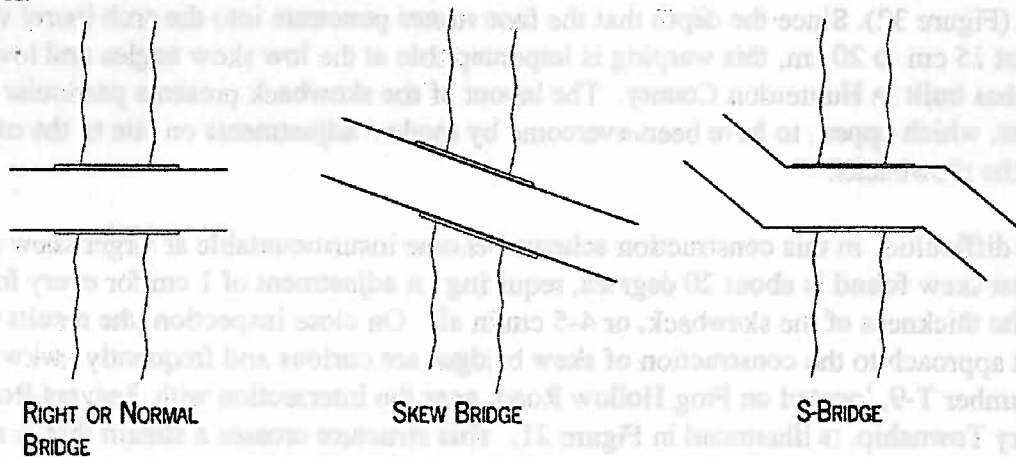


Figure 29. Types of stream crossings

Of the bridges in the Phase II survey, a surprisingly large proportion, over  $1/3$ , are built with a detectable skew alignment of the arch barrel. As previously described, the bridges in Hunterdon County universally have cut stones on the arch faces only, and the barrels are filled with elongated random rubble stones, roughly parallel to the abutments, and filled with loose mortar apparently placed after all the stones are in place on the centering. In adapting this construction process to a skew bridge, the builders would have to decide whether to make the opening follow a circular arc at the face and an elliptical curvature at the interior or *vice versa*. In every case the builders elected to use cylindrical centering, with a resulting elliptical curvatures at the face of

the arch barrel. Formwork impressions left at Bridge E-250, located on Back Brook Road in East Amwell Township, and included in the Phase I survey, and Bridge T-42, located on Palatine Road at the intersection with Cold Spring Road in Tewksbury Township, and included in the statewide survey, make the construction procedure very clear. The centering was built as a cylindrical segment, overhanging the spandrel walls on both sides. Impressions of the ends of centering planks line up parallel to the roadway centerline and at an angle to the face of the arch barrel. In the case of Bridge T-42, it appears that three centering ribs were placed within the arch barrel and two outside of the barrel. The facing stones were apparently cut and laid on the centering along a helical trace demarcating the intersection of the spandrel wall and the arch barrel. Figure 30 shows the construction scheme was used in Bridge T-42, while Figure 31 distinguishes the false skew construction scheme from that employed in the Hunterdon County arches.

The facing stones vary in size, shape, workmanship, and design. Typically in Tewksbury Township bridges, the stones are crudely dressed to conform to a very rough voussoir shape, with little concern for the radial alignment of the joints. In other locations, the voussoirs are more carefully cut, shaped and aligned. In every case, the bed joints run perpendicular to the face of the arch, rather than along the skewed axis of the arch barrel. The coursing of the barrel fill is parallel to the bridge abutment. Typically, the rise of the skewed structures is low enough practically to conceal the difference in alignment between the facing stones and the fill stones of the arch barrel. The difficulties presented by this construction scheme at large skew angles are apparent. The intrados of the face stones would need to be warped or twisted to lie flat on the centering (Figure 32). Since the depth that the face stones penetrate into the arch barrel varies from about 15 cm to 20 cm, this warping is imperceptible at the low skew angles and low rises of the arches built in Hunterdon County. The layout of the skewback presents particular difficulties, which appear to have been overcome by modest adjustments on site to the exact shape of the skewbacks.

Since the difficulties in this construction scheme become insurmountable at larger skew angles, the greatest skew found is about 20 degrees, requiring an adjustment of 1 cm for every four through the thickness of the skewback, or 4-5 cm in all. On close inspection, the results of this expedient approach to the construction of skew bridges are curious and frequently awkward. Bridge number T-9, located on Frog Hollow Road, near the intersection with Beavers Road in Tewksbury Township, is illustrated in Figure 21. This structure crosses a stream that is almost parallel to the road alignment, calling for a very large skew angle, however the structure is built with a skew angle of no more than 20 degrees. Bridge T-97, located on Philhower Road, shown in Figure 33, presents the curiosity of being a combination S-bridge and being built on a skew. The alignment of the approaches to these bridges is distinctly kinked and the barrel of the arch is skewed with respect to the faces of the spandrels. Both of these effects work together to overcome a skew angle of approximately 30-35 degrees between the roadway and the stream crossing.

INTERIOR OF THE BARREL OF T-42

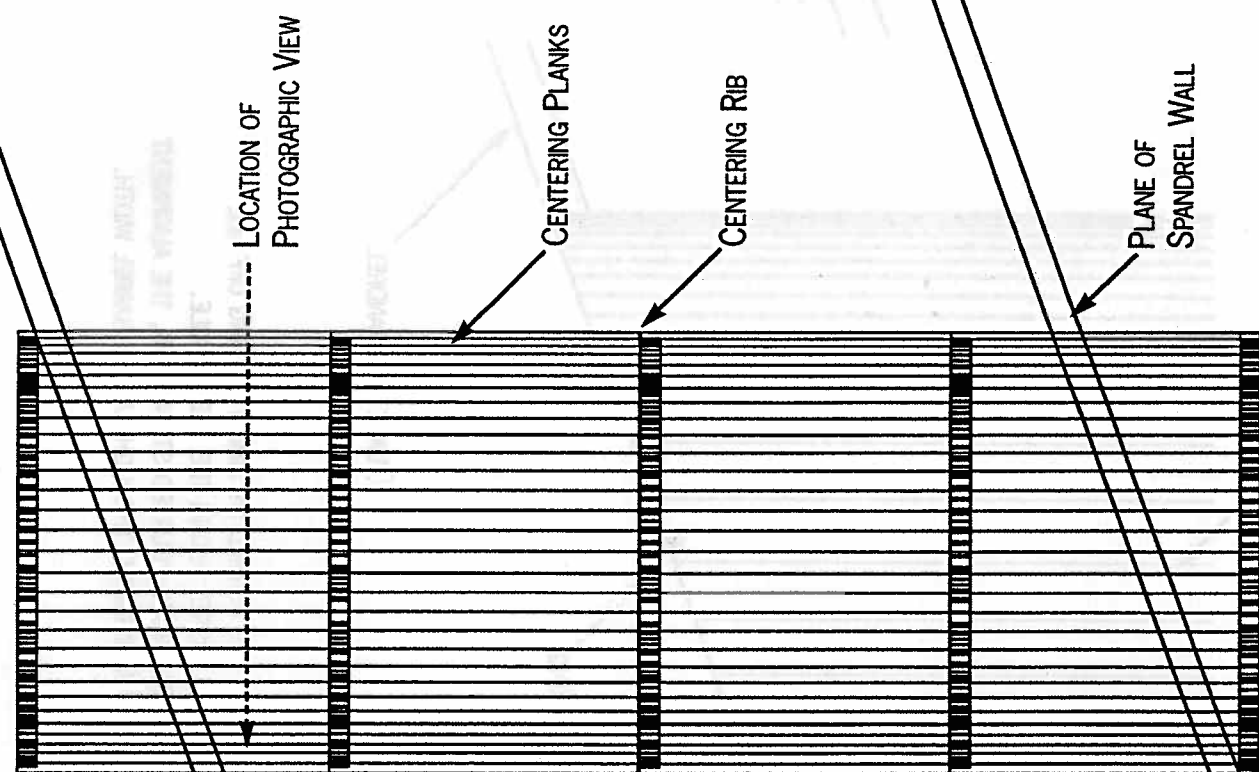
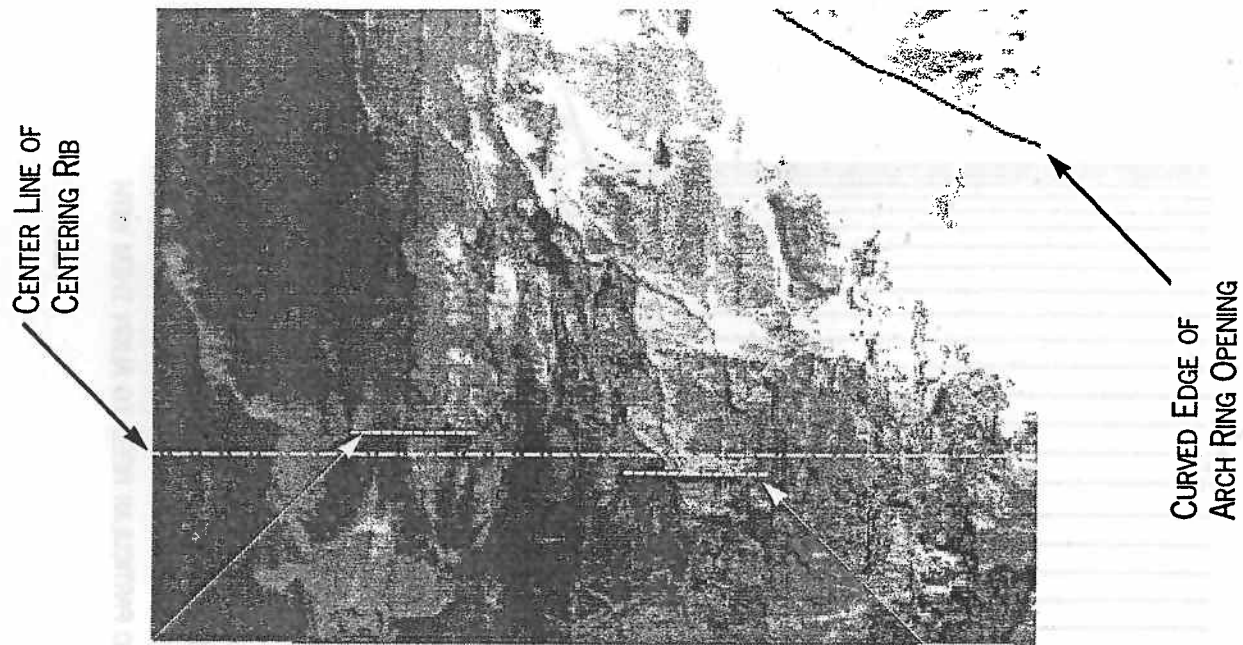
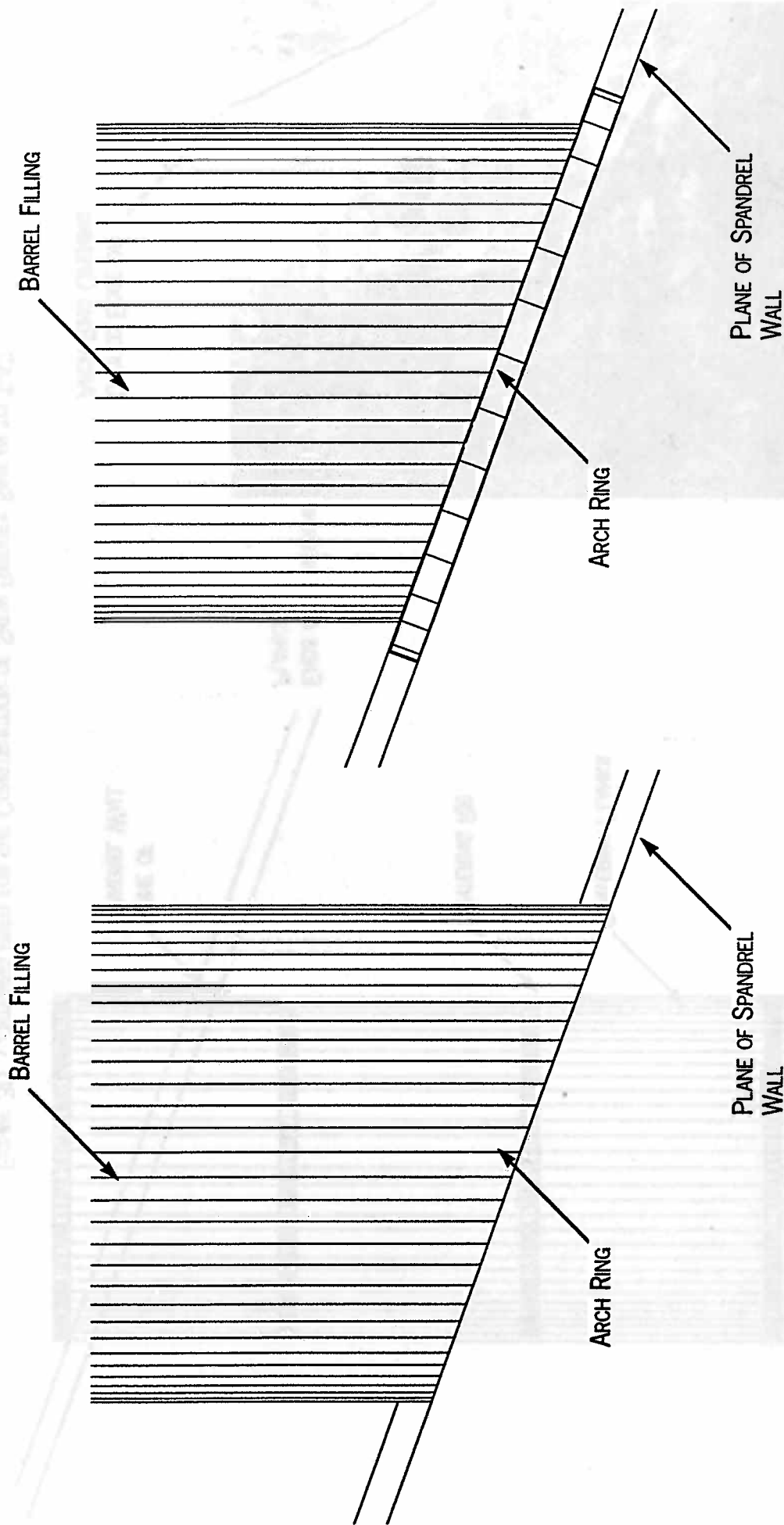


FIGURE 30 CENTERING USED FOR THE CONSTRUCTION OF SKEW BRIDGES SIMILAR TO T-42



THE RING STONES ARE FORMED BY SIMPLY CUTTING OFF THE CYLINDRICAL ARCH BARREL ALONG THE SKEW ANGLE. AS THE BARREL FILLING IS COURSED STONWORK, THE ALIGNMENT OF THE JOINTS IS MAINTAINED THROUGHOUT THE BARREL WIDTH.

THE RING STONES ARE FORMED SEPARATELY, WITH THE JOINTS RUNNING PERPENDICULAR TO THE ARCH FACE. AS THE JOINTS OF THE BARREL FILLING ARE INDETERMINATE AND RANDOM, THERE IS NO PARTICULAR NEED TO ALIGN THEM WITH THE RING STONES.

FIGURE 31 FALSE SKEW ARCH AND HUNTERDON COUNTY SKEW ARCH



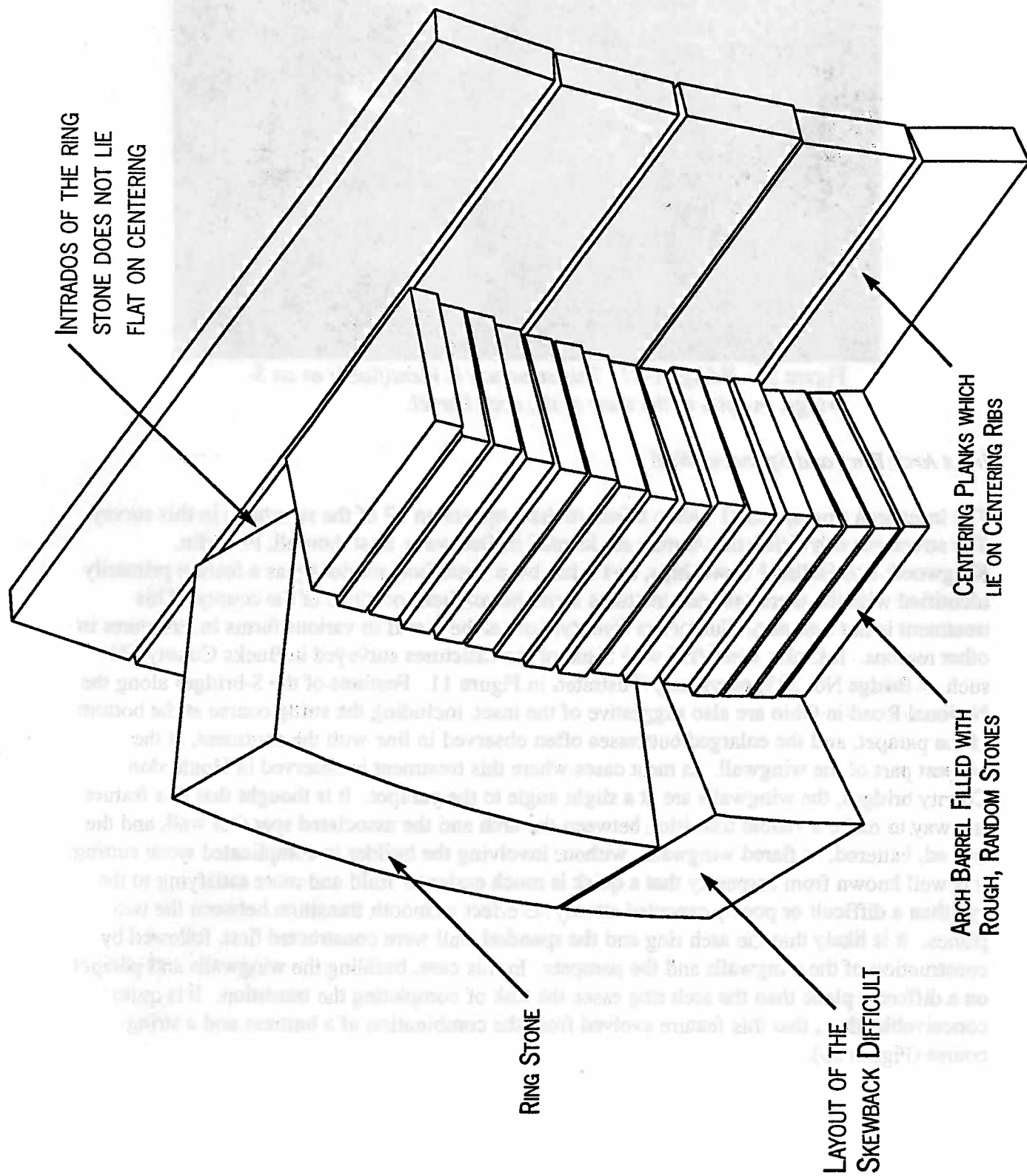


FIGURE 32 DIFFICULTIES PRESENTED BY LARGER SKEW ANGLE



Figure 33. Bridge T-97. *This structure is identifiable as an S-bridge, in spite of the skew of the arch barrel.*

#### *Inset Arch Ring and Spandrel Wall*

The inset arch ring/spandrel wall is a feature that appears on 17 of the structures in this survey. The structures exhibiting this feature are located in Delaware, East Amwell, Franklin, Kingwood, and Holland Townships, and it has been described previously as a feature primarily identified with the more refined structures from the southern portions of the county. This treatment is not unique to Hunterdon County, but can be found in various forms in structures in other regions. It is also identified with some of the structures surveyed in Bucks County, PA, such as Bridge No. 223, previously illustrated in Figure 11. Features of the S-bridges along the National Road in Ohio are also suggestive of the inset, including the string course at the bottom of the parapet, and the enlarged buttresses often observed in line with the abutment, at the deepest part of the wingwall. In most cases where this treatment is observed in Hunterdon County bridges, the wingwalls are at a slight angle to the parapet. It is thought that this feature is a way to make a visible transition between the arch and the associated spandrel wall, and the curved, battered, or flared wingwalls, without involving the builder in complicated stone cutting. It is well known from carpentry that a quirk is much easier to build and more satisfying to the eye than a difficult or poorly executed attempt to effect a smooth transition between the two planes. It is likely that the arch ring and the spandrel wall were constructed first, followed by construction of the wingwalls and the parapets. In this case, building the wingwalls and parapet on a different plane than the arch ring eases the task of completing the transition. It is quite conceivable, then, that this feature evolved from the combination of a buttress and a string course (Figure 33).

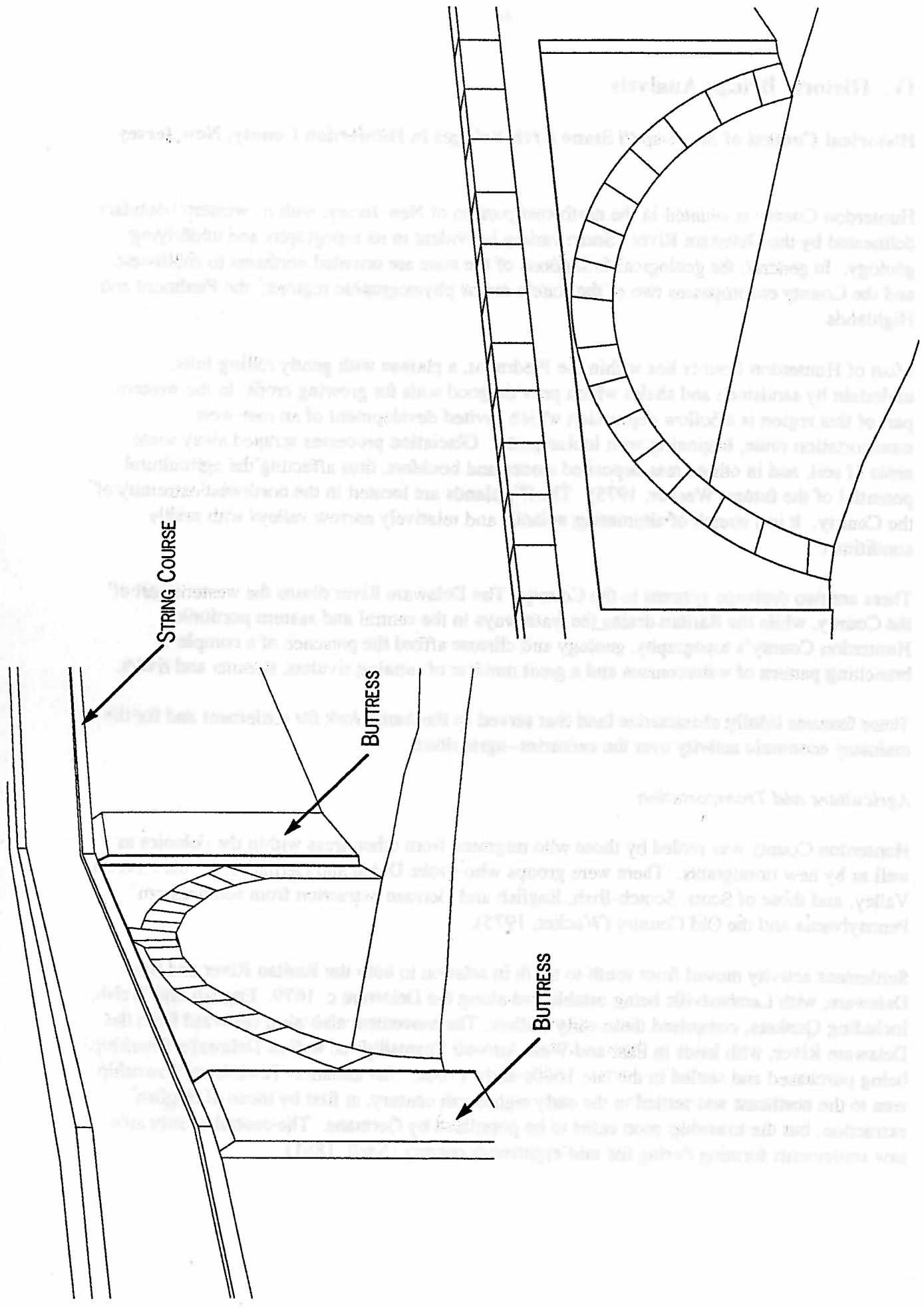


FIGURE 34 INSET ARCH RING AND SPANDREL



## IV. Historic Bridge Analysis

### Historical Context of Short-span Stone Arch Bridges in Hunterdon County, New Jersey

Hunterdon County is situated in the northwest portion of New Jersey, with its western boundary delineated by the Delaware River. Some variety is evident in its topography and underlying geology. In general, the geological formations of the state are oriented northeast to southwest, and the County encompasses two of the state's major physiographic regions; the Piedmont and Highlands.

Most of Hunterdon County lies within the Piedmont, a plateau with gently rolling hills, underlain by sandstone and shales which provide good soils for growing crops. In the western part of this region is a hollow depression which invited development of an east-west transportation route, beginning with Indian paths. Glaciation processes scraped away some areas of soil, and in other areas deposited stones and boulders, thus affecting the agricultural potential of the future (Wacker, 1975). The Highlands are located in the northwest extremity of the County. It is a stretch of alternating uplands and relatively narrow valleys with arable conditions.

There are two drainage systems in the County. The Delaware River drains the western part of the County, while the Raritan drains the waterways in the central and eastern portions. Hunterdon County's topography, geology and climate afford the presence of a complex branching pattern of watercourses and a great number of running rivulets, streams and rivers.

These features briefly characterize land that served as the framework for settlement and for the mainstay economic activity over the centuries--agriculture.

#### *Agriculture and Transportation*

Hunterdon County was settled by those who migrated from other areas within the colonies as well as by new immigrants. There were groups who spoke Dutch and German from the Hudson Valley, and those of Scots, Scotch-Irish, English and German extraction from southeastern Pennsylvania and the Old Country (Wacker, 1975).

Settlement activity moved from south to north in relation to both the Raritan River and the Delaware, with Lambertville being established along the Delaware c. 1679. English and Welsh, including Quakers, comprised these early settlers. The movement also went eastward from the Delaware River, with lands in East and West Amwell Townships as well as Delaware Township being purchased and settled in the late 1600s-early 1700s. The Lebanon-Tewksbury Township area to the northeast was settled in the early eighteenth century, at first by those of English extraction, but the township soon came to be populated by Germans. The central county area saw settlements forming during the mid-eighteenth century (Snell, 1881).

Agriculture was the occupation of virtually all the population in the eastern colonies, from the time of first settlement even until the American Revolution. Rural life and agricultural activities defined nearly everyone's existence. Quite early in the colonial period, farmers had a commercial mentality and intended to produce surplus products for market (Hurt, 1994).

Colonists sought markets and profit wherever they could, and to that end, most farmers and villages in colonial America were not entirely isolated. Instead, farms and farmers tended to be linked economically, socially, culturally--and physically. Small towns and villages created local markets and provided a means for commercial gain as well as social contact. With increasing population, towns such as New York and Philadelphia became regional markets and expanded their roles as international trade centers (Hurt, 1994).

Wheat was a dominant crop, especially in the Mid-Atlantic region and New Jersey was considered one of the "bread colonies." After the Revolutionary War, there was an interest in greater diversity of production of crops and livestock. Increased trade from major port cities expanded regional markets and further encouraged the expansion and improvement of transportation systems, including the development of backcountry road systems (Hurt, 1994). The post-war period also saw a rising interest in improving farming practices and technology. Agricultural reformers formed societies to spread information about best farming practices. In New Jersey, the Burlington Society for the Promotion of Agriculture and Domestic Manufacture was one such organization.

In the decades before the Civil War, farmers produced surplus for commercial sale. As the population expanded, farmers supported internal improvements such as canals and railroads so that their commodities could be transported as quickly and efficiently as possible. Increasingly commercial agriculture also meant that farmers were becoming less self-reliant on their own production; as a result, they were making more purchases and seeking a higher standard of living. The quality of country roads was connected with such two-way aspirations.

The Civil War proved to be profitable for northern farmers. Demand for military supplies was high, and spurred new methods of storage and production. For example, canned, condensed milk made its appearance, resulting in an increased demand for milk and a rise in dairy farming. The use of fertilizers became more widespread as a response to the need to make land more productive. Profits earned from the war led to many improved farms and a desire for improved infrastructure.

After the war, the agricultural scene began to undergo change. Midwestern and western markets began to compete with long-standing eastern markets. In the Northeast, the number of small farms devoted to specialty production increased. In New Jersey, however, the trend was to produce with greater efficiency and intensity the major crops already produced in the state. Technology in the form of mechanized equipment also helped New Jersey farmers to be less reliant on inefficient labor and to emphasize commercial production (Hurt, 1994).

During the early twentieth century, farmers continued to adjust their practices. In New Jersey, there was an increase in the specialization of eggs, poultry and truck crops. Generally,

American farmers experienced a time of prosperity during the first two decades of the century and this period is referred to as the "golden age of agriculture."

During this era, farmers also sought to modernize their lives. One important area of this modernization was the advent of rural free delivery of mail. Congress made rural delivery an established government service in 1902. Rural routes proliferated, with local congressmen encouraging the Post Office to establish them as quickly as possible. Rural delivery helped to bring the world to the farmer in the form of newspapers, catalogues, and other written information in a more timely fashion. In Hunterdon County, the first rural free delivery routes began in 1905 (Schmidt, 1945).

Not only did rural delivery bring the outside world to the farm family, but it also helped stimulate the "good roads movement" to make its appearance in the countryside. Farmers who wanted mail delivery were willing to put forth efforts to ensure that roads be kept passable. In 1916, Congress provided funds under the Federal Highway Act to help establish "post roads" (Hurt, 1994). This was the same year that parcel post deliveries were begun in the County, helping to lead to an increase in mail orders (Schmidt 1945).

Another development which contributed to the "good roads movement" was the rubber-tired bicycle. This form of mobility became immensely popular in New Jersey, particularly near the shore, and as cyclists pedaled their way to parks and the countryside, they pressured for negotiable roads. In 1891, the New Jersey legislature became the first state body to appropriate money for road improvements (Cunningham, 1976).

Transportation links were key to early settlement. As New Jersey became increasingly populated, rivers and major roads had to be supplemented by additional roads and byways to provide for sufficient access to travel. The importance of New Jersey as a major land transportation corridor, especially as a route between Philadelphia and New York is well-established. Further attention has been given in secondary sources to the historic and scenic qualities of New Jersey's minor roadways and rural byways.

In Hunterdon County, it was those 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 of watercourses--from small rivulets to streams to rivers--presented problems of passage along roadways of every size. As a result, the necessity for building bridges was a preoccupation of needful citizens as well as the Board of Chosen Freeholders, who were routinely solicited for funding bridge projects.

### *Freeholders' Minutes*

Over the course of Hunterdon County's history, the Board of Chosen Freeholders, the County's elected governing officials, have recorded their decisions in a collection of *Minutes*. One of the

issues that the Freeholders routinely addressed was the need for bridge construction and repair of bridges. As the agricultural economic base expanded, county farmers sought to establish and maintain ties to the market and the larger world, thus maintaining a network of passable roadways was an important concern. Given the number of water barriers present in the county, bridge-building went hand in hand with road building. Generally, dealing with bridge matters was a regular part of business, and the minutes show the Freeholders dealing with bridges several times a year. In some cases, such as in 1822 when there was extensive flooding, a special meeting was called for the purpose of addressing bridge damage.

The degree of detail in recording bridge transactions varies considerably. In some instances, dimensions, costs, materials and fairly explicit specifications (for example, dimensions) are noted. In other cases, a brief reference to the building or repair of a bridge suffices. To this end, it is difficult to discern from the minutes the number and nature of stone bridges that the Freeholders dealt with. Locations of bridges are also imprecisely noted. Sometimes a reference is made to the stream being crossed, and in other cases the location is linked with the name of an adjacent or nearby property owner. There is usually an indication of the township, but not always. It is apparent that small arch bridges were constructed throughout the nineteenth century, with a slightly higher number of specific references in the first few decades and last few decades.

In 1864 the power to authorize bridge construction and repairs (for a cost of up to \$500.00) was given to individual township representatives. The assumption is that a full discussion of bridge transactions would no longer appear in the minutes.

From the minutes it is evident that stone arch bridges were viewed differently by different constituents. In a few cases, individuals requesting that a new bridge be built asked for a stone arch bridge because of its sturdier construction. In at least one instance the stated preference was for a wood bridge, but no reason was given.

While the minutes do not provide as complete a picture of the Freeholder's activities as a historian might like, one thing is clear: bridges played an important role as Hunterdon County grew and its landscape evolved.

### *Local Response*

Stone used for arch bridges was attained chiefly from nearby quarries or stream beds. Demand for stone from larger-scale quarry operations was increased by bridge building activities of the nineteenth century. Granite was quarried in the Rocktown area and argillite was quarried west of Flemington. The largest operations were in the south county area from Raven Rock to Lambertville where a brown and grey building stone was used for canal building, railroads and was additionally transported to cities for building. Trap rock was also quarried near Lambertville. Quarries identified specifically for supplying stone for bridge building were the Prall quarry in East Amwell Township, and one located southwest of Reaville (Snell, 1881, Schmidt 1973).

In the history of Hunterdon County, the continuing presence of stone arch bridges represents a unique local answer to a functional need. Many of the surviving bridges were constructed by masons--who were sometimes farmers as well-- who had average skills, probably learned through apprenticeship. Schmidt, in his book on rural Hunterdon County, notes that apprenticeship was the method of transferring building technology and that architectural developments were slow to progress, including refinements. He adds that a regional style emerged which persisted over a long period of time with little or no outside influence. Early ethnic influences seemed to become less distinct and merged to create a rather uniform style (Schmidt 1945). These observations speak to a vernacular approach to building and construction.

Similarly, the bridges do not represent a high degree of refinement or craftsmanship, and the notion of persistence explains why such structures are difficult to date with precision. On the other hand, a vernacular response to design and construction is immediate and genuine. It is a statement of what was important to the people of the county; the expedience of using local labor and abilities as well as local materials to achieve an end. The resulting expression, picturesque stone bridges which enhance and help define the quality of Hunterdon's rural landscape, is a valuable vestige of the County's past.

## Definitions And Application Of The National Register Criteria, Including Historic Significance, Historic Integrity, And Historic Context

Three key concepts--**historic significance, historic integrity, and historic context**--are used by the National Register program to decide whether a property qualifies for listing.

### *Historic significance*

Historic significance is the importance of a property to the history, archeology, engineering, or culture of a community, state or the nation. It is achieved in several ways:

- A. Association with events that have made a significant contribution to the broad patterns of our history; or
- B. Association with the lives of persons significant in our past; or
- C. By embodying the distinctive characteristics of a type, period, or method of construction or that represent the work of a master, or that possess high artistic values, or that represent a significant and distinguishable entity whose components may lack individual distinction; or
- D. By yielding information, or having the potential to yield important information in prehistory or history.

Well-established procedures exist for determining eligibility for National Register Listing for historic bridges. In the 1980's, under Federal mandates, every State Department of Transportation undertook surveys of historic resources on the state highway system (those highways eligible for Federal participation). These studies vary widely in approach from state to state, with many of the states using consultant architectural historians and other states choosing to use in-house resources. Noteworthy in the former category, especially for the present purpose, is Volume I of the four volume Wisconsin Department of Transportation survey (Hess and Frame 1986), which covers stone and concrete arch bridges. In the second category, the Pennsylvania (Pennsylvania Historical and Museum Commission, 1986) and Ohio surveys (Ohio Department of Transportation 1983) are interesting in their coverage of stone and concrete arch bridges. The statewide survey methodology was to filter the statewide bridge inventory databases for bridges over 50 years old and to exclude certain types, such as concrete slab bridges, in order to have a manageable population of structures to review. Large groups of structures were then ruled out on the basis of alterations, type, or other factors. A smaller population of structures was then subjected to intensive survey and historical research resulting in a determination of eligibility or non-eligibility and a local, state, or national level of significance. This methodology has carried over into the present time, when almost all of the statewide surveys are being extended, either piecemeal, or in comprehensive surveys to "off-system" bridges: county or municipally owned structures.

The original statewide historic bridge surveys appear to have established a *de facto* standard methodology for the historic assessment of bridge structures. The context in which a particular structure is examined consists of the remaining structures of the type: *e g.*, a wrought iron truss bridge is examined in the context of wrought iron truss bridges, a stone arch bridge is examined within the population of existing stone arch bridges. Determinations of eligibility are made



almost exclusively on the basis of Criterion C, with only exemplary structures of a given type being chosen. Occasionally, for a structure within a historic district, or associated with a significant historic event, Criterion A is applied. For example, the Stony Brook Bridge in Princeton, NJ was found eligible due to its proximity to the site of the Revolutionary War Battle of Princeton (Hunter Research, Inc. 1996). Typically, the eligibility determination does not look beyond the approach roadway to the structure.

In contrast to this approach, historians of vernacular architecture and landscapes appear to have established a different methodology. Application of the National Register Criteria permits development of a contextual theme. Themes often relate to the historic development of a community, such as commercial or industrial activities. They may relate to the occupation of a prehistoric group, the rise of an architectural movement, the work of a master architect, specific events or activities, or a pattern of physical development that influenced the character of a place at a particular time in history. Criterion A can be applied to these patterns in the historic development of a community, rather than being limited to specific events at specific points in time. In this context, historians who focus on vernacular expressions establish a theme and determine the period of significance. From this point, any structure that relates to the theme, dates from the period of significance and retains integrity is eligible.

Examples of this theme approach can be found in the documentation that supports many National Register Districts, such as Wisconsin's Namur Belgian-American District or the village of Linden Hall in Pennsylvania. In applying this approach to bridges, it is necessary that the context as well as the structures retain integrity. Historic patterns of land use and land division must be reflected in the current uses, and roadways between the structures need to retain integrity. The relationship between structures and roadways is especially important: the horizontal and vertical alignment and cross section of approach roadways must retain their integrity along with the bridge structure, and must still reflect the historic patterns of the structure. In this way, the bridges can be seen as links in a larger web of a historic transportation system that is embedded in a larger context of a historic landscape.

Based on the importance of the stone arch bridges as an integral part of the County's early transportation network and based on the function of roadways as a network supporting the agriculture of the County and beyond, the collection of stone arch bridges in Hunterdon County are eligible for inclusion in the National Register under **Criterion A: Association with events that have made a significant contribution to the broad patterns of our history**. The National Register category that best characterizes the significance is **Transportation**. The National Register level of significance is **Local**.

In addition to the above criteria, significance is defined by the **area** of history in which the property made important contributions and by the **period** of time when these contributions were made.

Properties are significant within the context of prehistory or history. Historic context is information about historic trends and properties grouped by an important theme in the prehistory or history of a community during a particular period of time. Because historic contexts are

organized by theme, place and time, they link historic properties to important historic trends. In this way they provide a framework for determining the significance of a property and its eligibility for National Register listing. A knowledge of historic contexts allows for the understanding of a historic property as a product of its time and as an illustration of aspects of heritage that may be unique, representative or pivotal.

Themes often relate to the *historic development of a community*, such as commercial or industrial activities. They may relate to the occupation of a prehistoric group, the rise of an architectural movement, the work of a master architect, specific events or activities, or a *pattern of physical development that influenced the character of a place at a particular time in history*. It is within the larger picture of a community's history that local significance becomes apparent. Similarly, State and national significance become clear only when the property is seen in relationship to trends and patterns of prehistory or history statewide or nationally.

In the case of the stone arch bridges and culverts of Hunterdon County, construction of the structures relates to the development and expansion of the network of road transportation for the period from c. 1800-c. 1940, especially as transportation supported agriculture, the area's main economic activity. The presence of the bridges and culverts, fine examples of a vernacular response to a functional need, contributed to the County's rural character. Bridge construction on relatively remote roadways afforded the necessary connections between farm and marketplace.

### *Historic Integrity*

Historic integrity is the authenticity of a property's historic identity, evidenced by the survival of physical characteristics that existed during the property's prehistoric or historic period.

Historic integrity is the composite of seven qualities:

- location
- design
- setting
- materials
- workmanship
- feeling
- association

Historic integrity enables a property to illustrate significant aspects of its past. Not only must a property resemble its historic appearance, but it must also retain physical materials, design features and aspects of construction dating from the period when it attained significance. All seven qualities do not need to be present for eligibility as long as the overall sense of past time and place is evident.

All of the structures in this study are at their original location, so the location criterion is automatically satisfied. Integrity of design is assured if all of the original features of the structure are intact. Integrity of setting depends on land use remaining intact from the period of



significance for the structure to the present time. In this case, for example, the bridges with integrity still carry roadways and the surrounding landscape is rural, in a village setting or whatever applies to the particular structure. Integrity of materials requires that the original materials used in the construction of the structure be preserved intact. Integrity of workmanship was observable in the markings of the forms used in the original construction, or in chisel or drill marks remaining in the stonework. Integrity of feeling and association were assessed subjectively in combination with the objective qualities above.

The character-defining elements of the structures need to be preserved intact in order to identify the structure as retaining integrity. In the case of the stone masonry arch bridges of Hunterdon County, and based on the foregoing contextual analysis, the following features of the setting were found to be critical to the association with the past:

- Roadway approach vertical alignment
- Adjacent land use
- Roadway width

The parts of a stone arch bridge are shown schematically in Figure 34. The character-defining elements that needed to be retained for a determination of integrity are:

- Voussoir arch
- Stone material, cut, and coursing
- Parapet height and shape
- Arch barrel

Changes which have occurred to the bridges as a result of routine maintenance, or alterations carried out to meet changing traffic requirements such as repointing or deck paving, do not disqualify a structure from its ability to illustrate significant aspects of its past. In some cases, major alterations such as WPA-era widenings or reconstructions, are historic in themselves, and illustrate the continuing importance of the bridges' function in carrying rural traffic.

## Historic Preservation Recommendations

In further assessing the structures determined to be eligible for National Register listing, the bridges were assigned to pools of six representative types, as discussed in detail in Chapter III. These were then given correlating Roman numerals, as summarized in Table 1 below:

Table 1. Summary of Bridge Types

Designation	Description	Features
I	Northern	<ul style="list-style-type: none"> <li>• crudely cut ringstones</li> <li>• non-radial joint alignment</li> <li>• low rise</li> <li>• rubble masonry</li> </ul>
II	Southern	One or more of the following features <ul style="list-style-type: none"> <li>• intrados of ring cut to curve</li> <li>• radial joint alignment</li> <li>• coursed masonry</li> </ul>
III	Inset	wingwalls and parapet in different plane from spandrel and ring
IV	Deep Inset	Inset greater than 4"
V	WPA	1930's WPA style structure
VI	WPA widening	1930's WPA style widening

Within each type, semicircular arches, uncommon in Hunterdon County, are considered as a distinct subtype, in view of the very different visual character of a semicircular and a segmental arch.

The original side of bridges that were widened in the 1930's may have features of either Type I or Type II, but the structure is classified as Type VI.

Those structures that are exemplary illustrations of key characteristics of the type, or have some extraordinary characteristic (such as the skew S-bridge, T-97) are recommended to be preserved. Others have varying recommendations, depending on the ability of the example to illustrate key characteristics of the type and the number of samples in the pool.

Table 2 presents a summary of the bridge features and the conclusion of the type category of the structure. The intention of the pooling recommendations is to ensure that some reasonable number of bridges of each type are preserved as integral representatives of the population of stone arch bridges of Hunterdon County. Other bridges within the pool that currently have integrity may be allowed to be widened, when warranted, with sensitivity to the historic character of the structures. For brevity, in the individual bridge summaries, the types identified are given Roman numerals, representing the following type. A few examples have distinguishing characteristics that may not typically be found in the representative type, and

these are noted below. The table also indicates those survey examples which are not arch bridges.

In general, recommendations for widening pooled examples will have an impact on a structure's integrity. However, in those instances where widening is deemed necessary, it is strongly recommended to preserve the structure's visual appearance in a careful reconstruction. If the example has been historically widened, then the newer side should be widened, leaving the older side intact.

Because the bridges' physical context is important in the ability to communicate feelings of and associations with the historic structures, a general recommendation is to preserve the setting. Specifically, the vertical and horizontal road alignments as well as the adjacent land use help to convey the overall experience of travelling along a country road and over historic bridges. Losses to the structure and character of the setting represent not only the loss of historic detail and character of a particular bridge, but also the loss of an important resource. The road system and bridges are the legacy of Hunterdon County's physical, economic and social development.

VI	WTA 1000	1900 WTA 1000
V	WTA 1000	1900 WTA 1000
IV	WTA 1000	1900 WTA 1000
III	WTA 1000	1900 WTA 1000

Table 2: Summary of Bridge Features

Bridge	Features									Designation (Table 1)	Preservation Approach	Remarks
	Northern	radial	intrados	coursing	inset	deep inset	30' stotal	30's widening	Semicircular			
A-1	x							x		VI	Pool	
A-72												pipe
B-16												pipe
B-18												pipe
B-22		x	x		x							
B-36	x									I	Pool	
C-8		x	x									
C-65B	x											
C-68		x										
C-71	x									I	Pool	
C-72	x							x				
CT-94	x											
D-334		x	x	x	x					III	Pool	
D-368		x	x	x	x					III	Preserve	
D-379		x	x		x					III	Preserve	
D-441		x	x	x	x					III	Pool	
D-449		x						x		II	Preserve	
D-478		x	x	x	x					III	Pool	
E-156		x	x	x						II	Pool	
E-158		x	x	x						II	Pool	
E-161		x	x	x								
E-195		x										
E-200		x		x								
E-213		x	x									
E-237							x			V	Preserve	
E-242		x						x				
E-249		x	x					x		II	Preserve	
E-272		x	x	x	x					III	Pool	
FU-3		x	x	x								
F-53		x										
F-75		x		x	x					III	Preserve	
H-32	x							x		VI	Pool	

Bridge	Features									Designation (Table 1)	Preservation Approach	Remarks
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[illegible]

Bridge	Features									Designation (Table 1)	Preservation Approach	Remarks
	Northern	radial	intrados	coursing	inset	deep inset	30' stotal	30's widening	Semicircular			
Q-102		x	x									
Q-103		x	x	x								
Q-106		x	x	x						II	Pool	
RC-4												pipe
R-39												replaced
R-76		x	x	x								
R-181		x	x	x	x					III	Pool	
T-8	x									I	Preserve	
T-9	x									I	Preserve	
T-45								x				
T-52	x								x	I	Pool	
T-58		x		x				x		VI	Pool	
T-59	x									I	Pool	
T-77	x									I	Pool	
T-89	x									I	Pool	
T-93	x									I	Pool	
T-97	x									I	Preserve	S-bridge
T-98	x									I	Pool	
T-103	x									I	Preserve	
T-105	x							x		VI	Pool	
T-107		x								II	Pool	
T-109	x									I	Preserve	
T-110												pipe
U-18		x	x	x								
U-21								x		VI	Preserve	
W89M												box culvert
V-50												pipe
WE-75												pipe arch
X-16	x									I	Pool	

## V. Traffic Safety and Traffic Operational Analysis

The objective of traffic safety analysis in this project is to review the existing highway alignment, signals, signs and markings, and other field elements, identify any safety hazards, and provide recommendations for alleviating them. In this project, the existing highway alignment was first examined to determine whether it conforms to current design standards. Then, the safety of each structure was evaluated using the Bridge Safety Index (NCHRP 1979). Finally, a check of the existing signs and markings was performed, to see where improvements in signing and marking could be made, according to the Federal Manual on Uniform Traffic Control Devices (FHWA 1988).

There are two main objectives for traffic operational analyses: a) The first objective is to identify the Level of Service (LOS) at which the facility operates under the present traffic and design conditions. LOS is a qualitative measure of traffic operational quality, with LOS A signifying excellent traffic conditions, and LOS E signifying that the facility operates at capacity. b) The second objective is to identify the LOS at which the facility will operate during the "horizon" year, under future traffic and design conditions. In this study the horizon year is 2010. The future traffic conditions are typically estimated using projected growth factors, as well as any information on anticipated design or other changes in the vicinity of the site

Traffic safety and traffic operational analyses were conducted for each structure. Recommendations were compiled for each structure, encompassing both safety and traffic operational quality requirements. Recommendations for increasing safety on a structure typically included improved signing, upgrading/installing guiderail, widening of structures, and changing horizontal or vertical alignment. Traffic operational improvements typically included improving the alignment of approaches and widening the bridge.

To complete these analyses, a variety of traffic and highway alignment data were collected for every bridge. Data requirements in such analyses typically include highway geometry elements such as roadway and shoulder width, horizontal and vertical alignment characteristics, and traffic volume data. These data were primarily collected in the field, but additional information was provided by the Hunterdon County Planning Board, USGS topographic maps, and NJDOT.

An important input requirement for this study was traffic volume information, including both Average Daily Traffic (ADT) and Peak Hour Traffic (PHT) data. ADT is defined as the average traffic volume (in vehicles per day) observed within a 24-hour period. The ADT is typically obtained by averaging traffic counts over a period of time, and provides a general indication of the amount of traffic typically traveling daily on the facility. The ADT for each of the bridges was provided by the Planning Board. These were assumed to reflect 1997 traffic volumes. To estimate the respective 1998 ADT and horizon year (2010) ADT, population growth rates were applied to the 1997 values. The population growth factor was used, because traffic growth information was not available. Traffic usually grows at a rate higher than the population, but without exact figures of this increase, the recommended approach is to use the population growth factors. Each township's population growth rate was calculated using population



projections supplied by the Hunterdon County Planning Board (1997). The population growth rates were assumed to remain constant until the horizon year of 2010 is reached.

The PHT is the traffic traveling during the peak hour of the day. This variable is an essential element in this study since traffic operational analyses typically consider LOS during the peak hour. The PHT can be estimated by multiplying the ADT by an adjustment factor, K. The K-factor is the fraction of a day's traffic that occurs during the peak (McShane, Roess, and Prassas, 1998). This value typically ranges between 0.10 and 0.15, and a statistical average of NJ local roads shows this value to be 0.13 (FHWA, undated). Thus 13% of the ADT occurs during the peak hour. The next sections of the report contain descriptions of the traffic safety and operational analysis methods.

### **Highway Alignment Considerations - AASHTO Geometric Requirements**

Every state is required to have a set of legally binding design standards that all new road building and major reconstruction projects are required to meet. These standards cover all aspects of highway design, including horizontal alignment, vertical alignment, and roadway cross section. The national standard, "A Policy on Geometric Design of Highways and Streets", published by the American Association of State Highway and Transportation Officials (AASHTO), is the basis for all state design standards, and was used as the primary reference in this study.

Four aspects of roadway design that were most pertinent to the bridges in this study are horizontal curve radius, sight distance, vertical curvature, and pavement width. Each of these elements is discussed in the following paragraphs. Minimum design criteria used in this study for each of these elements are provided at the end of the section.

#### *Horizontal Curve Radius*

Horizontal curve radius was estimated by looking at USGS topographic maps. This value was then compared with current AASHTO policy, to determine whether the horizontal curve met current design standards. The 1990 version of the AASHTO "Green Book" (1994) contains tables of values for this parameter for local rural roads.

#### *Sight Distance*

Minimum sight distance was measured to determine the distance that a driver can see, perceive a threat, and safely apply the brakes, before striking an object. Sight distance can be limited by one of three elements: horizontal curvature, vertical curvature, or an intersection. For illustrative purposes, vertical and horizontal sight distance limitations are depicted in Figure 35. Horizontal sight distance limitations are typically caused by trees, buildings, or hill slopes on the inside of a horizontal curve. Vertical sight distance limitations are caused when the bridge is below the crest of a hill. The road itself becomes the obstruction for seeing the bridge in the dip below. It

should be noted that the sight distance for the bridges in this study was measured from each approach to the center of the bridge. Sight distance from one side of the bridge to the other was *not* measured for this project; it was determined to be not as important in this study as the visibility to the bridge structure itself.

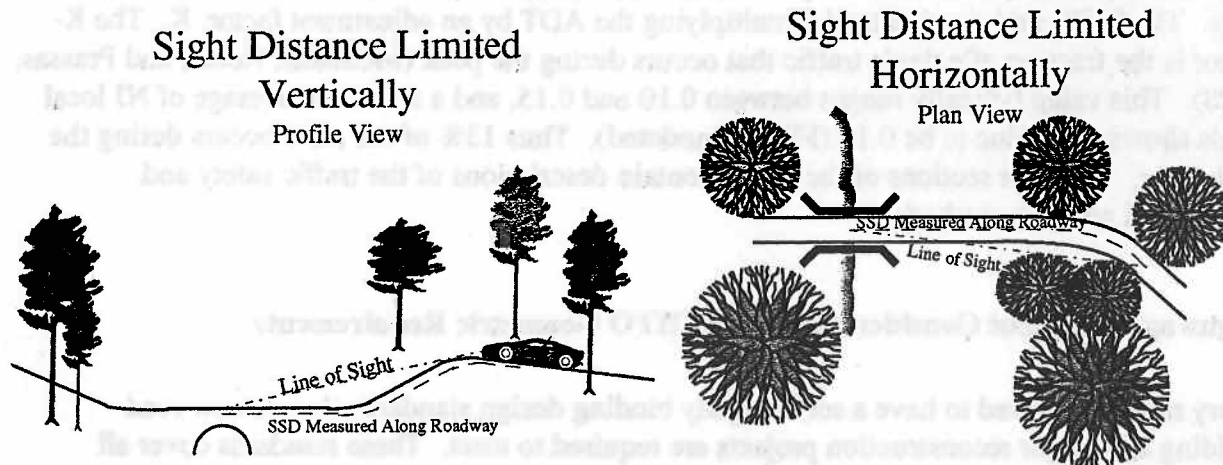


Figure 34. Sight Distance

When there was an intersection within 500 feet of the bridge, the distance from the bridge to the intersection constitutes the available sight distance. This recording of sight distance does not exactly match the way it is intended in the AASHTO policy, but in this analysis, the sight distance is used to determine if a driver would see an object or another vehicle on the bridge in time to slow or stop, due to the narrow nature of these bridges.

#### *Vertical Curvature*

The length of vertical curvature was used as another check of sight distance. Vertical curves are typically designed as parabolas, and not circular arcs as horizontal curves are. In this case, the "K"-value of the curve can be used for comparison against design standards in the AASHTO Policy. The K-value is the length, in feet, divided by the difference in grades between the two sides of the bridge:

$$K = \frac{\text{Length of vertical curve}}{\text{Difference in grades}}$$

The purpose of examining the K-value for the bridges in this study is to determine what sight distance is available *across* the bridge structure, which is a slightly different case than what was previously explained. A larger K-value denotes a "flatter" vertical curve. A smaller K-value identifies a "sharper" hill. Note that this criterion applies to both crest and sag vertical curves.

#### *Bridge Width*

Bridge width was measured in the field, to the nearest foot. The pavement width and shoulder width were added to get the total bridge width between the parapets. Current design criteria state that travel lanes should be 12 feet wide, for ideal conditions. Any lane widths narrower than 12 feet require more driver attention to stay within the lane, and may cause vehicles to

slow, causing an operational problem. In addition, narrower lanes can be a safety hazard because of closer proximity to the opposing direction of traffic.

### *Minimum Design Criteria*

The following table summarizes the design criteria used in this study. This information was adapted from tables III-6, V-2, V-6, and V-7 of the 1994 AASHTO (1994).

Table 3. Minimum Design Criteria Used in this Study

Roadway Speed (mph)	Horizontal Curve Radius (feet)	Stopping Sight Distance (feet)	Bridge Width (feet)	K for Crest Curves	K for Sag Curves
10	127	125	20	10	20
15	127	125	20	10	20
20	127	125	20	10	20
25	215	150	21	20	30
30	302	200	22	30	40
35	438	225	23	40	50
40	573	275	24	60	60
45	764	325	24	80	70
50	955	400	24	110	90
55	1186	450	24	150	100

The four geometric criteria measured in the field were compared to the minimum design criteria above, to evaluate how well the existing roadway fits current new design standards. Note that it is not necessary for all public agencies to upgrade their existing roads every time the design criteria are revised, but new construction projects are required to meet these standards.

### **Bridge Safety Index**

The TTI Bridge Safety Index Score is a quantitative measure of a combination of roadway, traffic, and roadside conditions. This scale was developed by engineers at the Texas Transportation Institute (NCHRP 1979). This index ranges from 0 to 100, with a low rating meaning that the bridge is rather hazardous, and a higher rating indicating a more safe structure. The ten factors that are considered in this safety index are:

- clear bridge width,
- bridge lane width divided by approach lane width,
- guardrail and bridge railing presence and integrity,
- approach sight distance divided by travel speed,
- distance to horizontal curve divided by curve radius,
- changes in vertical profile at the structure,

- volume-to-capacity ratio,
- reduction in shoulder width from the approach roadways to the bridge,
- traffic mix between passenger vehicles and heavy vehicles, and
- roadside distractions, such as frequent driveways, children playing, and other distractions.

Each of these factors is assigned a number, and the ten factors are summed to give the TTI Bridge Safety Index rating. The ten factors are shown in the table below. The first three factors, which account for Clear Bridge Width, the Ratio of Bridge Lane Width to Approach Lane Width, and the Guardrail and Bridge Rail Structure, can range from 0 to 20. The remaining seven factors only range from 0 to 5, showing the relative importance of the different factors.

Table 4. TTI Bridge Safety Index

Factors Used in Calculating TTI Bridge Safety Index											
F <sub>1</sub> : Clear Bridge Width		F <sub>2</sub> : Ratio of Bridge Lane Width to Approach Lane Width		F <sub>3</sub> : Guardrail and Bridge Rail Structure		F <sub>4</sub> : Ratio of Approach Sight Distance to Speed		F <sub>5</sub> : Ratio of Distance to Closest Curve to Curvature of the Curve		F <sub>6</sub> : Vertical Profile Continuity (Average Grade + (Approach Grade-Exit Grade))	
		Value	BSI Value	Value	BSI Value	Value	BSI Value	Value	BSI Value	Value	BSI Value
		0.8	0	Critical	0	5	1	10	1	10	1
		0.9	5	Poor	5	7	2	60	2	8	2
		1.0	10	Average	10	9	3	100	3	6	3
		1.1	15	Fair	15	11	4	200	4	4	4
		1.2	20	Excellent	20	14	5	300	5	2	5
F <sub>7</sub> : Percent Reduction in Shoulder Width from Approach to Bridge		F <sub>8</sub> : Volume / Capacity Ratio		F <sub>9</sub> : Traffic Mix - Distribution of Vehicle Types		F <sub>10</sub> : Distractions and Roadside Activities					
		Value	BSI Value	Value	BSI Value	Value	BSI Value	Value	BSI Value	Value	BSI Value
100%		1		0.50	1	Discontinuous	1	Continuous		1	
75%		2		0.40	2	Non-uniform	2	Heavy		2	
50%		3		0.30	3	Normal	3	Moderate		3	
25%		4		0.10	4	Fairly Uniform	4	Few		4	
0%		5		0.05	5	Uniform	5	None		5	

The following table shows how the 92 bridges in this study fared under the TTI Bridge Safety Index.

Table 5. Summary of Bridge Safety Index Scores in Hunterdon County

TTI Bridge Safety Index	Condition	Number of Bridges
0 - 25	Critical	12
25-50	Poor	55
50-75	Fair	25
75-100	Good	0

## **Traffic Operational Analysis and LOS**

The LOS for each structure was calculated using one of two different methods, depending on the width of the structure. For structures 18 feet wide or greater, the 2-lane highway methodology from the Transportation Research Board's Highway Capacity Manual (TRB 1994) was used. The HCM is the primary tool most agencies use to evaluate traffic operational performance on streets, highways, and freeways. For two-lane highways, the HCM methodology provides the LOS as a function of percent time delay. Percent time delay is estimated based on roadway width, presence of trucks, grade, and peak hour traffic. For capacity purposes, the delay is calculated for the point with the most restrictive geometry, which is the actual bridge. The approach roadways are typically less restrictive in geometric design, so analyzing the conditions actually on the structure gives the most conservative estimate of how the structure is performing for traffic operations.

For structures narrower than 18 feet, two vehicles would not be able to safely traverse the structure at the same time; therefore a new procedure was developed, based on probabilistic modeling. The procedure is based on the probability that two vehicles from opposite directions will arrive at the same time. It was assumed that vehicle arrivals are Poisson-distributed. It was also assumed that if two vehicles arrive from different directions within a ten second period, one has to stop to let the other pass. Based on these assumptions, the percent time delay for all vehicles can be calculated, and LOS can be determined, similar to the traditional HCM approach described above. It should be noted that the Level of Service for the narrow bridges calculated using this queuing analysis does not take into account some of the factors used in the traditional LOS, such as grade, presence of heavy vehicles, or width. The only input variable for the queuing analysis is the ADT.

## **Recommendations**

Recommendations were formulated for each bridge based on the comparison to AASHTO minimum design requirements, the Bridge Safety Index calculations and the LOS estimation. A brief narrative of the traffic conditions for each bridge is then presented. A set of needs for Signing, Marking, Parapet/Guiderail, Horizontal, and Vertical improvements was compiled. These needs are based strictly on design criteria and field conditions; they are not based on traffic volumes. Specific recommendations were given, to quickly show the most common recommendations for the bridges in the study, such as signing improvements and guiderail changes. The reference for the signing recommendations was the Manual of Uniform Traffic Control Devices (FHWA 1988). Specific sign recommendations include the following signs:



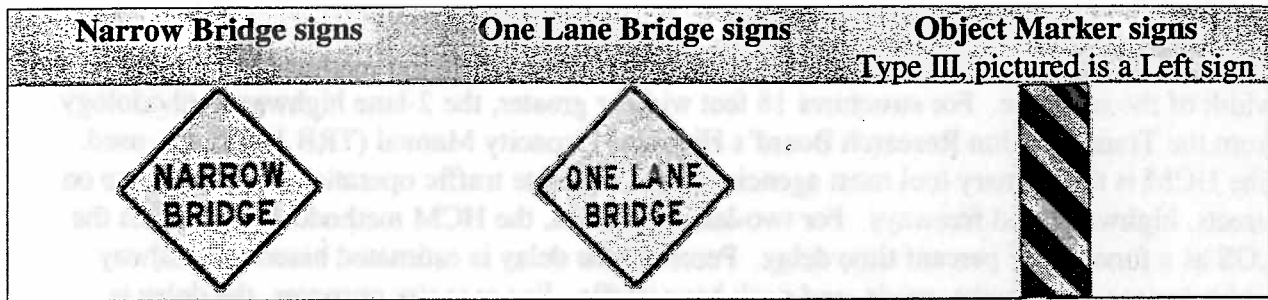


Figure 36. Traffic Control Devices

The widening priority is based on a mathematical formula that incorporates the bridge width, reduction in width at the bridge, shoulder width, and traffic volume (ADT). This widening priority was developed using engineering judgment, by grouping the bridges based on their ADT, width, and width reduction from the approach roadway to the bridge. Once the structure is placed into the group corresponding to each of these categories, a widening priority is given to the bridge. The following table shows the widening priorities for all structures, based on ADT, bridge width, and reduction in width from the approaches to the bridge.

Table 6. Bridge Widening Priorities

Very Low Traffic Volume (0-100 ADT)					Low Traffic Volume (101-500 ADT)				
Bridge Width	Width Reduction				Bridge Width	Width Reduction			
	<5%	5-15%	15-30%	>30%		<5%	5-15%	15-30%	>30%
>22	0	0	0	1	>22	0	0	1	2
18-21	0	0	1	1	18-21	0	1	1	2
13-17	0	1	1	1	13-17	0	1	1	2
<13	1	1	2	2	<13	0	1	1	2
Moderate Traffic Volume (500-1500 ADT)					High Traffic Volume (1500 - 10,000 ADT)				
Bridge Width	Width Reduction				Bridge Width	Width Reduction			
	<5%	5-15%	15-30%	>30%		<5%	5-15%	15-30%	>30%
>22	0	0	2	3	>22	0	1	3	4
18-21	0	1	2	3	18-21	1	1	3	5
13-17	1	2	3	3	13-17	1	3	5	5
<13	3	3	4	4	<13	3	3	5	5

For sites in this study that warrant guiderail installation or improvement, the recommended type of guiderail is a steel-backed timber system. This guiderail is recommended due to its safety performance and its aesthetic appeal, which will more closely fit in the rustic setting of the bridges in this study. This guiderail has been used in a handful of parkway settings, and has been used as a satisfactory alternative to typical strong-post steel guiderail (FHWA 1992).

The steel-backed timber guiderail consists of 10 inch by 12 inch timber posts set in the ground at 10 foot intervals, with a wood rail 6 inches thick by 10 inches high which is backed by a 3/8 inch thick steel plate. The steel plate and all steel fasteners are specified to be weathering steel, and the timber components are from pressure treated lumber. The weathering steel will form a protective rust coating and will look less obtrusive than galvanized steel, while providing satisfactory safety performance and low maintenance requirements.

This guiderail has been tested and is approved for sites with design speed up to 60 mi/hr. Installation cost is estimated at roughly twice the cost of standard strong-post guiderail. This guiderail is recommended on the basis of its performance and aesthetic appeal, while remaining at a competitive cost to traditional steel guiderail.

Sources on detailed specifications for construction of this guiderail include the Federal Lands Highway Project Development and Design Manual (FHWA 1996), exhibit 8-3, Standard Specifications for Construction of Roads and Bridges on Federal Highway Projects (FHWA 1996a), sections 617 and 710.08, and detailed shop drawings may be found in Federal Lands Standard Metric Drawings (Federal Lands Standard Metric Drawings, numbers M617-60 through 66.<http://www.cflhd.gov/Standard/STDTABL.htm>)

Recommendations were developed based on the safety and traffic operational assessment. Safety improvements for all bridges, regardless of volume, include signing recommendations. Safety improvements for bridges with higher traffic volumes include guiderail and parapet modifications, widening, and some horizontal and vertical improvements. Capacity related improvements include widening or replacement of structures.

Where traffic safety and capacity recommendations conflict with historic preservation recommendations, a more detailed analysis was undertaken involving an accident history analysis and examining surrounding land uses and road functions. A few possible solutions to the conflicts between traffic safety and historic preservation include limiting development near the bridge, diverting through traffic to nearby roads, and creating a one-way pair of bridges.



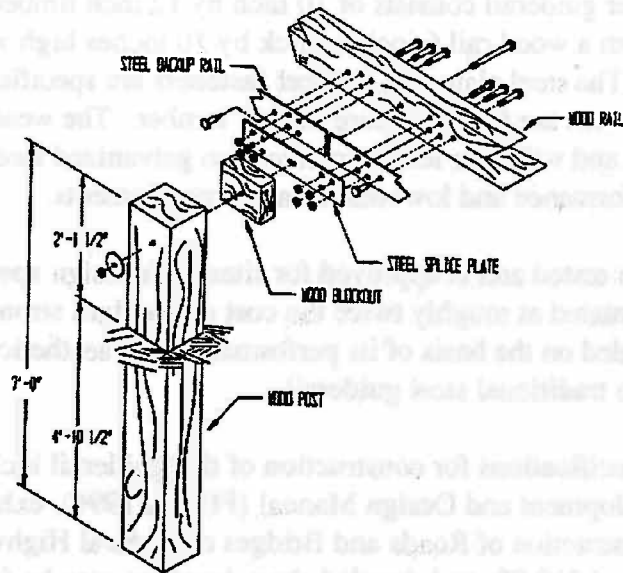


Figure 37. Steel-backed Timber Guiderail

## VI. Recommendations for a Routine Maintenance Program

The determination of maintenance recommendations will depend on a combination of visual observation, analytical load rating of selected structures, and field testing of selected structures.

During the field survey, components of the structures: ring, barrel, spandrel, wingwall, abutment, and vegetation, were evaluated based on a set of visual criteria prepared for this project. The criteria resulted in a visual rating from excellent to hazardous for each component of the structure, and for the structure overall. Although this set of condition criteria are not intended to substitute for periodic inspection of the structures, they will give a general idea of the condition of the population of stone bridges in the study, and aid in the determination of repair procedures and priorities. The criteria used in the field work are listed in Appendix B. In general, the structures were found to be reasonably well maintained. Based on the assessment of the structures in the Phase II study, the following issues can be identified as important for the routine maintenance of the population of arch bridges.

### Mortar Pointing and Patching

Repointing of selected areas of a masonry arch bridge is necessary on a 10-20 year cycle. Overall repointing of the structure is rarely necessary or desirable. The repointing is necessary in part for the maintenance of the overall structural integrity, especially in the arch barrel where the mortar is necessary to transmit arch thrusts between adjacent stones. However, for the most part, re-pointing is undertaken to resist rainwater penetration and to improve the overall appearance of the structure. Although mortar in the joints of the structure should resist the penetration of rainwater from outside the structure, provisions also need to be made to allow entrapped water within the bridge fill to drain.

Pointing of an area of masonry should begin with the careful removal of mortar from the joint with hand tools, hammers and chisels, to a depth of 1/2 inch. Hard portland cement mortar should be removed with special care. Mortars adhered to the face of the stone above the level of the joint should be carefully chipped off.

The following table, reproduced from Welch (1995), gives the recommendations of a knowledgeable British bridge owner for pointing mortars for stone arch bridge.

Table 7. Mortars for Bridge Use

cement	lime	sand	Comments on use
1	0 to 1/4	3	Use these mortars <u>only</u> when frost resistance and higher strength are the chief considerations
1	1/2	4 to 4 1/2	
1	1	6 (sharp sand)	A good compromise blend of strength and flexibility--chosen as the standard mortar in North Yorkshire
1	2	9 (sharp sand)	There may be an argument for using this more flexible mortar in the construction of masonry or brick arch rings

It is recommended that the hard portland cement mortars in the first row of the table be used only for pointing abutments within 12" above to below the waterline. The lime content for the superstructure mortars is necessary to ensure the flexibility of the mortar and to avoid damage to the historic fabric of the structures. The mortar in the bottom row, which corresponds to ASTM C270, Type 0 mortar is recommended for use for pointing or patching arch barrels, while the mortar in the second row, basically a Type N mortar is recommended for more general use.

New mortar should be carefully placed within the joint and compacted with a pointing key. The surface of the mortar should be slightly below the surface of the stonework, and the mortar should be tooled to a concave configuration. Occasional spots should be left open to allow the free passage of moisture, especially within the arch barrel.

### **Drainage**

Establishment and maintenance of drainage paths for moisture from the bridge fill is critical to the longevity of stone arch bridges. Surface grading should remove water from the vicinity of the bridge, so that as little water as possible enters the fill. Weep holes, where installed, should be kept open insofar as possible. When the fill is excavated for any reason, it is recommended that underdrains be installed within the fill. In cases where a structure has been particularly damaged by water penetration, an underdrainage systems may need to be installed. Sealing of areas of the arch barrel by excessive mortar pointing and patching is to be avoided.

### **Spandrel Walls and Parapets**

Where spandrel walls and parapets need to be rebuilt due to bulging, overturning, sliding, or vehicular damage, it is equally important to improve the backfill material behind the wall. A free draining, non-cohesive, engineered fill material is recommended for backfill material. Rebuilding of walls should be undertaken cautiously, and only when necessary, and should be consistent with the Secretary of the Interior's *Standards for the Treatment of Historic Properties*. The workmanship of the existing structure should be examined and replicated carefully, by constructing dry-laid mock-ups to study the ideal joint configuration, and by building trial patches with mortar to study mortar color and joint thickness. In cases where the soil pressures are excessive the wall may be backed with dry-laid flat stones or concrete blocks laid flat.

### **Arch Barrels**

Lateral soil pressures on spandrel walls have caused longitudinal cracking of arch barrels in many cases. This is a serious problem that evolves into the collapse of the structure over time, and it is recommended that provisions be undertaken to arrest this cracking where it has been found to develop. The first recommended line of defense is the improvement of drainage around the structure. Where these measures are insufficient, the fill should be removed, the arch barrel backed, and the remainder of the fill replaced with an engineered fill material. In rare instances the installation of stitching anchors may be required.

## **VII. Conclusions and Summary of Individual Bridge Analysis**

### **Conclusions**

With over 100 surviving stone arch bridges, Hunterdon County, NJ represents the largest concentration of stone bridges in North America and, as such, constitutes a unique and important historic resource. The value of this historic resource lies not only in the structures themselves, but also in their preservation within the setting of an intact landscape on the scale of a nineteenth century rural community. The bridges themselves represent the aspirations of several generations of this agricultural area for better year-round transportation, for people and for farm products. The bridges, by their naïve and rustic construction, are representative of the isolation of this community from the technological mainstream. The craft tradition's response to this isolation was to build sturdy, expedient structures to address the needs of the community and its development.

### **Summary of Individual Bridge Analysis**

An individual inventory and analysis was taken for each of the bridges in the Phase II study. The report of these individual analyses, including dimensional information, historical analysis, and traffic operations and safety analysis is reported in a separate document. The individual bridge analysis documents also include a historic preservation recommendation, based on the assessment of the significance and integrity of the structure, and recommendations for the improvement of traffic safety and operations. The recommendations are intended to strike an appropriate balance between the preservation of a suitably large and representative sample of the Phase II bridges, while maintaining an acceptable level of traffic safety and allowing for expansion of the road system in the County for the improvement of traffic operations.

- In cases of particularly worthy structures, the historic preservation considerations are allowed to outweigh the importance of traffic operations, and a recommendation is made to bypass the bridge, as in Bridge T-8, T-9, T-97, and E-237, or to close the road at the bridge, as at Bridge D-368.
- The remainder of eligible structures, that is, those that have integrity are pooled to ensure that a sufficient population of each type is preserved. The pooled structures are either recommended to be widened when warranted, or are designated to be preserved. It is recognized that the decision to widen or preserve an individual pooled structure can be reversed, if a sufficient number of examples of each type are allowed to remain.
- Structures whose loss of integrity is the result of a widening are recommended to be widened, when warranted.
- Structures that have completely lost integrity are allowed to be replaced, when warranted.

The table on the next three pages summarizes the results of the individual bridge analyses.

Bridge Number	Municipality	Road	Directions	Span in feet-inches	Rise in feet-inches	Width in feet-inches	Skew in °	ADT	Historic Significance	Preservation Recommendation
A-1	Alexandria	Sweet Hollow Creek	1000' E of Myler Rd	9-0	3-2	17-2.5	80	196	Local	Pool/ Widen
A-72	Alexandria	Creek	1 mi W of Tinsman Rd	6-0	pipe	28-0	90	32	None	Replace
B-16	Bethlehem	Bellwood Park Tunnel	400' E of Tunnel Rd	pipe	pipe	26-6	70	7	None	Replace
B-18	Bethlehem	Tunnel	2000' W of Bellwood Park Rd	3-9	2-7	30-0	60	209	None	Replace
B-22	Bethlehem	St Rt 173	175' E of Co Rt 643 on access road	11-0	2-8	16-6	80	1641	None	Widen
B-36	Bethlehem	Ludlow Sta	1 mi S of Co Rt 643	8-0	3-0	20-4	85	233	Local	Pool/ Widen
C-8	Clinton	Co Rt 639	500' S of Molasses Hill Rd	12-0	6-6	20-0	70	1566	None	Replace
C-65B	Clinton	Co Rt 639	1000' W of Hook Mountain Dr	9-0	4-5	19-0	90	604	None	Widen
C-68	Clinton	Co Rt 639	500' E of Mountain Grove Rd	9-0	3-0	22-0	75	1143	None	Widen
C-71	Clinton	Woods	60' E of Haytown Rd	10-3	4-6	16-9	80	113	Local	Pool/ Preserve
C-72	Clinton	Haytown	1500' S of Woods Rd	12-0	5-3	19-6	80	1011	None	Widen
CT-94	Clinton	Co Rt 639	45' W of Water St	10-0	2-9	19-0	90	650	None	Widen
D-334	Delaware	Pine Hill	1500' N of Old Mill Rd	10-0	3-0	16-0	90	112	Local	Pool/ Widen
D-368	Delaware	Sand Brook HQ	10' N of Dunkard Church Rd	11-0	2-9	14-0	80	400	Local	Preserve
D-379	Delaware	Yard	Halfway between Sandbrook HQ Rd & Co Rt 579	10-6	3-6	12-8	85	128	Local	Preserve
D-441	Delaware	Buchanan	Halfway between Sandy Ridge Rd & Lambertville HQ	8-0	4-0	15-6	85	46	Local	Pool/ Widen
D-449	Delaware	Worman	700' W of Co Rt 607	4-6	2-4.5	16-0	80	116	Local	Preserve
D-478	Delaware	Federal Twist	1000' N of Co Rt 523	7-6	2-5	16-3	90	203	Local	Preserve
E-156	East Amwell	Saddle Shop	500' W of Co Rt 607	9-4	3-0	18-0	80	170	Local	Pool/ Widen
E-158	East Amwell	Saddle Shop	200' E of Runyons Mill Rd	9-4	3-6	20-0	85	182	Local	Pool/ Widen
E-161	East Amwell	Orchard	Halfway between Linvale Rd and Runyons Mill Rd	9-0	3-6	17-0	90	47	None	Widen
E-195	East Amwell	Lindbergh	3500' S of Zion Rd, Just N of Mercer Co border	8-0	2-3	15-3	90	539	None	Widen
E-200	East Amwell	Runyon	800' S of Co Rt 602	12-5	3-0	17-0	80	446	None	Widen
E-213	East Amwell	Rocktown	800' SW of Losey Rd	9-3	3-6	36-0	80	7	None	Widen
E-237	East Amwell	Manners	40' N of Co Rt 602	12-9	6-5	23-10	80	2562	Local	Preserve
E-242	East Amwell	Van Lieu's	1000' N of Larsen Rd	6-6	3-6	24-6	75	264	None	Replace
E-249	East Amwell	Back Brook	Halfway between Dutch Ln & Van Lieu's	3-9	2-0	16-6	90	347	Local	Preserve
E-272	East Amwell	Garboski	1000' W of Boss Rd	8-0	3-6	14-9	90	514	Local	Pool/ Widen
F-53	Franklin	Lower Kingtown	2500' E of Co Rt 513	6-0	2-6	20-6	90	400	None	Replace
F-75	Franklin	Old Clinton	2500' N of Hamden Rd	18-0	4-11	13-0	85	295	Local	Preserve
FU-3	Flemington Boro, Union	Co Rt 513	3500' S of Race St/ Grandin Rd	6-6	2-6	33-6	90	7942	None	Replace
H-32	Holland	Church	240' W of Amsterdam Rd	8-7.5	3-7	32-0	85	1682	Local	Pool/ Widen



Bridge Number	Municipality	Road	Directions	Span in feet-inches	Rise in feet-inches	Width in feet-inches	Skew in °	ADT	Historic Significance	Preservation Recommendation
H-40	Holland	Co Rt 627	3500' W of Phillips Rd	7-6	3-4	21-0	70	918	None	Replace
H-45	Holland	Co Rt 627	1200' E of Crab Apple Hill Rd	17-6	9-0	23-0	90	994	None	Replace
H-46	Holland	Co Rt 627	2000' E of Crab Apple Hill Rd	6-0	3-0	25-6	90	1162	None	Replace
H-66	Holland	Bellis	700' W of Shire Rd	pipe	pipe	27-0	90	66	None	Replace
H-107	Holland	Co Rt 519	1 mi N of Co Rt 619	15-8	7-6	24-0	80	3660	None	Widen
HA-15	Holland, Alexandria	Myler	270' N of Sweet Hollow Rd	10-9	3-11	21-6	90	482	None	Widen
HA-16	Holland, Alexandria	Myler	2000' N of Sweet Hollow Rd	6-6	4-6	26-6	90	482	None	Replace
K-63	Kingwood	Tumble-Idell	1500' E of Warsaw Rd	6-9	2-5	19-6	90	35	None	Widen
K-78	Kingwood	Fairview	2500' E of St Rt 29	7-0	2-4.5	13-3	90	276	Local	Pool/ Preserve
K-100	Kingwood	Spring Hill	2500' E of Horseshoe Bend Rd	10-0	5-6	12-10	90	162	Local	Preserve
K-152	Kingwood	Locktown	3500' S of St Rt 12	8-3	3-4	16-0	90	467	None	Replace
K-166	Kingwood	Creek	4500' E of Co Rt 610/ St Rt 12	7-0	2-0	19-3	90	90	None	Widen
L-12	Lebanon	E. Hill	350' W of Sliker Rd	11-3	3-9	13-8	90	2375	Local	Pool/ Widen
L-18	Lebanon	Rocky Run	1500' S of Skinner Rd	12-0	4-4	30-5	60	1099	None	Replace
L-31	Lebanon	Buffalo Hollow	2000' E of Observatory Rd, 500' W of Mongahaque	8-1	4-4.25	15-0	90	882	None	Widen
L-34	Lebanon	Buffalo Hollow	400' E of Observatory Rd	4-1	1-0	20-0	90	600	Local	Pool/ Preserve
L-37	Lebanon	Buffalo Hollow	500' E of St Rt 31	5-4	2-2	17-6	90	791	None	Widen
L-47	Lebanon	Red Mill	75' W of Newport Rd	6-10	2-3	21-7	90	441	None	Widen
L-52	Lebanon	Red Mill	Just W of Spruce Run Rd	7-9.5	2-9	16-9	90	623	Local	Pool/ Preserve
L-58	Lebanon	Co Rt 628	300' S of Boulder Field Rd	6-6	3-0	26-0	90	2332	None	Widen
L-102	Lebanon	Anthony	Halfway between Woodglen Rd & Beechbrook Ln	8-3	3-3	22-4	90	549	None	Widen
L-103	Lebanon	Anthony	Halfway between Beechbrook Ln and Mt Lebanon Rd	6-9	3-0	19-0	90	805	Local	Pool/ Widen
L-106	Lebanon	Hickory Run	Between Kubin Ct & Stonerow Dr, 300' S of Easthill	6-11	2-7	14-8	80	1815	Local	Pool/ Widen
L-112	Lebanon	Vernoy	1500' SE of Co Rt 513	7-6	2-7	20-0	90	602	None	Widen
L-130	Lebanon	Penwell	150' E of Warren Co Line	13-3	5-1.5	28-6	90	1604	Local	Pool/ Preserve
L-136	Lebanon	Raritan River	1 mi N of Co Rt 639	10-1.5	4-2	11-6	80	20	Local	Pool/ Preserve
P-160	Frenchtown	River	900' N of W Washington St	16-0	8-6	12-0	90	102	Local	Preserve
P-164	Frenchtown	Creek	2200' E of Co Rt 610/ St Rt 12	4-8	2-6	14-6	90	0	None	Widen
P-165	Frenchtown	Creek	3000' E of Co Rt 610/ St Rt 12	4-6	2-5.5	15-0	90	0	Local	Pool/ Preserve
Q-71	Raritan	Pennsylvania	480' E of St Rt 31	11-3	3-10	36-3	90	494	None	Widen
Q-87	Raritan	Old Clinton	Halfway between Oak Ln & Cherryville Hollow Rd	pipe	pipe	pipe	90	2332	None	Replace
Q-102	Raritan	William Barnes	1500' E of Stanton Station Rd	5-6	4-4	15-0	90	47	None	Widen
Q-103	Raritan	River	700' N of St Rt 31	8-0	3-9	23-6	90	571	None	Widen

Bridge Number	Municipality	Road	Directions	Span in feet-inches	Rise in feet-inches	Width in feet-inches	Skew in °	ADT	Historic Significance	Preservation Recommendation
Q-106	Raritan	River	1000' N of Bartles Corner Rd	10-0	2-0	19-0	90	185	Local	Pool/ Preserve
R-39	Readington	Railroad	2000' W of Co Rt 523	6-0	1-9	12-10	90	1074	None	Widen
R-76	Readington	Coddington	500' S of Tunis Cox Rd	12-0	6-0	16-5	90	18	None	Widen
R-181	Readington	Foothill	1500' W of Co Rt 629	6-4.5	3-3	15-3	90	138	Local	Pool/Preserve
RC-4	Readington	Potterstown	Between two ends of Upton Rd (loop)	5-0	2-6	24-0	90	837	None	Replace
T-8	Tewksbury	Beavers	50' S of intersection with Frog Hollow Rd	10-6	3-3	25-0	80	572	Local	Preserve
T-9	Tewksbury	Frog Hollow	400' W of intersection with Beavers Rd	11-4	4-0	19-6	80	617	Local	Preserve
T-45	Tewksbury	Co Rt 517	3000' S of intersection with Laurel Mtn Way	6-0	3-6	59-0	75	14810	None	Widen
T-52	Tewksbury	Fox Hill	250' N of intersection with Palatine	5-6	2-6	16-0	80	4068	Local	Pool/ Widen
T-58	Tewksbury	Homestead	50' SW of intersection with Flint Hill	10-0	3-6	52-0	75	744	Local	Pool/ Widen
T-59	Tewksbury	Cold Springs	150 E of intersection with Alder Creek	11-9	3-6	18-0	90	115	Local	Pool/ Preserve
T-77	Tewksbury	Welsh	1500' W of Deer Hill Rd	7-0	3-0	15-0	85	368	Local	Pool/ Preserve
T-89	Tewksbury	Guinea Hollow	1000' S of intersection with Suttons Rd	15-6	5-6.5	13-7	75	454	Local	Pool/ Preserve
T-93	Tewksbury	Philhower	10' S of Suttons Rd	5-9	2-0	20-6	90	871	Local	Pool/ Preserve
T-97	Tewksbury	Philhower	2000' N of Main St/ Water St/ Saw Mill	9-0	3-0	19-5	80	492	Local	Preserve
T-98	Tewksbury	Philhower	150' N of Main St/ Water St/ Saw Mill	7-9	3-6	16-0	90	340	Local	Pool/ Preserve
T-103	Tewksbury	Water St	Just E of intersection with Long View Rd	13-0	4-0	27-6	85	622	Local	Preserve
T-105	Tewksbury	Water St	Halfway between Long View Rd & Rockaway Rd	6-3	2-9	25-5	85	609	Local	Pool/ Widen
T-107	Tewksbury	Longview	Halfway between Water St & Philhower	15-3	5-9	17-0	80	213	Local	Pool/Widen
T-109	Tewksbury	Flint Hill	500' E of Cold Spring Rd	9-10	3-0	20-6	80	115	Local	Preserve
T-110	Tewksbury	Cold Brook	460' S of Vlietown Rd	pipe	pipe	pipe	90	83	None	Replace
U-18	Union	Race Street	1500' W of Co Rt 513	11-8	5-6	21-6	90	1021	None	Widen
U-21	Union	Strotz	400' N of White Oak Dr	10-0	4-0	25-0	90	1805	Local	Preserve
V-50	Hampton	Church	470' S of E Railroad Ave	pipe	pipe	26-6	90	311	None	Replace
W-89M	West Amwell	Mt Airy-Harbourton	2000' N of Co Rt 518	12-6	4-6	22-0	90	600	None	Replace
WE-75	West Amwell	St Rt 31	3500' S of St Rt 31	12-3	4-3	25-9	90	336	None	Replace
X-16	High Bridge	Wilson	200' E of Nassau Rd	9-3	4-2	19-0	90	1235	Local	Pool/ Widen



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## Appendix B

### Structural Condition Assessment: Terms Used in Visual Assessment

#### Structural Condition

- Good** All items other than the parapet (ring, spandrel, barrel, wingwalls, abutments), rated good, or good/fair. No more than one item rated other than the parapet
- Fair** All items rated fair or above
- Poor** All items rated poor or above
- Hazardous** Hazardous condition exists at time of survey

#### Structural Condition: Individual Items

##### Ring

**Good:** No more than 10% of joints cracking or sliding: all crack opening less than 1/4" all sliding less than 1"

**Fair:** No more than 25% of joints cracking or sliding: all crack opening less than 1/4" all sliding less than 1"

**Poor:** More than 25% of joints cracking or sliding or larger crack openings or sliding

**Hazardous:** Gross widely distributed cracking or sliding or distortions in geometry.

##### Barrel

**Good:** No more than 10% of joints cracking: all crack openings less than 1/4". No more than 5% loose stones

**Fair:** No more than 25% of joints cracking: all crack opening less than 1/4" No more than 10% loose stones

**Poor:** More than 25% of joints cracking or crack openings greater than 1/4"

**Hazardous:** Obvious changes in geometry, stones on the verge of falling, openings greater than 1"

##### Spandrels

**Good:** No more than 10% of joints cracking. Sliding over ring less than 1/2". No more than 1/4" per foot out of plumb.

Fair: No more than 25% of joints cracking. Sliding over ring less than 1". No more than 1/2" per foot out of plumb.

Poor: More than 25% of joints cracking, sliding over ring greater than 1", or more than 1/2" per foot out of plumb

Hazardous: sliding over ring or out of plumb approaching over 1/4 wall thickness

#### Wingwall

Good: No more than 10% of joints cracking No more than 1/4" per foot out of plumb.

Fair: No more than 25% of joints cracking. No more than 1/2" per foot out of plumb.

Poor: More than 25% of joints cracking, or more than 1/2" per foot out of plumb

Hazardous: sliding over ring or out of plumb approaching over 1/4 wall thickness

#### Abutment

Good: No more than 10% of joints or stone faces cracking. No visible erosion at waterline. No apparent settlement or yielding.

Fair: No more than 25% of joints or 10% of stone faces cracking. Visible erosion of 1" or less at waterline. No apparent settlement or yielding.

Poor: More than 25% of joints or 10% of stone faces cracking or visible erosion of greater than 1" or apparent settlement or yielding

Hazardous: Gross settlement or yielding

#### Parapets

Good: Coping intact, shifting of stones less than 1"

Fair: Less than 25% of coping missing or damaged, shifting of stones less than 2" No more than 10% missing stones

Poor: More than 25% of coping stones missing or damaged, shifting of stones greater than 2", more than 10% missing stones.

Hazardous: Stones falling or on the verge of falling.

## Vegetation

Good: Small annual plants only

Fair: Perennial plants less than 1/2" in diameter

Poor: Perennial plants greater than 1/2" in diameter, or widespread vegetation

Hazardous: Roots causing distortions in structure geometry



# Hunterdon County's Stone Arch Bridges

**H**unterdon County's interest in stone arch bridges began in 1992, when a developer wanted to a raze a stone arch bridge so that a road could be widened for a new development. The discussions that ensued sparked an interest in three County Departments to further research the bridges. The County began its own photographic inventory of the bridges, but later consulted outside professionals to help them inventory the bridges.

*continued...*





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*continued...*



# Hunterdon County's Stone Arch Bridges

**Hunterdon County's Stone Arch Bridge Inventory includes a wide range of information that will be used by the County to prepare a long term bridge maintenance and preservation plan and an illustrated brochure and tour guide for the public. The following slide presentation was presented to the Hunterdon County Planning Board on April 8, 1999.**


**For further information on this project, please contact Linda Weber, Principal Planner, at 908.788.1490, or write to the**

**Hunterdon County Planning Board, One East Main Street, Flemington, NJ 08822.**

# Hunterdon County's Stone Arch Bridges

A black and white photograph of a stone arch bridge spanning a river. The bridge features three prominent arches. In the foreground, a waterfall cascades over rocks, creating a misty spray. The river's surface reflects the bridge and the surrounding trees. The banks are lined with bare, leafless trees, suggesting a late autumn or winter setting. The overall scene is serene and captures a natural landscape.

Spring, 1999

A photograph of a stone arch bridge spanning a small stream. The bridge is constructed from rough-hewn stones and has a semi-circular arch. The water in the stream is shallow and clear, revealing a rocky bed. Bare tree branches are visible in the foreground and background, suggesting a late autumn or winter setting. A semi-transparent dark green box with white text is overlaid on the left side of the image.

**Are these  
bridges  
of any  
historic  
value?**



**....If so, how can we preserve the integrity of the bridges while at the same time accommodate new growth?**



**The NJ Historic Bridge Survey includes bridges with a 20 foot span or greater . Hunterdon County has more than 100 stone arch bridges excluded from this study because they have less than a 20 foot span.**



**So the County began its own bridge survey. The following three County Departments worked collaboratively on a photographic inventory of the stone arch bridges:**

**Roads & Bridges**


**Cultural & Heritage Commission**

**County Planning Board**





**Local historians and other volunteers were recruited to help photograph the bridges.**



**The County  
discovered  
that it had  
many,  
many stone  
arch  
bridges still  
remaining.**

**NJ Historic Bridge Survey:**

**12 stone arches**

**County's bridge records:**

**106 stone arches**

**Stone Arches on Private Roads:**

**5-15 stone arches**

***Total* surviving stone arches:**

**123+ stone arches**



**A complete bridge inventory was commissioned by the County using ISTEA funds. The inventory was divided into two phases and offers:**

- **A complete history of the bridges**
- **Recommendations on how the bridges can be modified - if at all**
- **Comprehensive data for a future maintenance & preservation plan**

# **Stone Arch Bridge Inventory, Phase I**

## **Hunterdon County, New Jersey**

**(14 stone arch bridges)**

**\$10,000 ISTEA grant**

**Consultant: Lichtenstein & Associates**

### **Contents...**

- Historic Context of Stone Arch Bridges**
- Evaluation of Stone Arch Bridges Bridges**
- Recommendations for a Maintenance and Preservation**

**Stone Arch Bridge Inventory, Phase II**  
**Hunterdon County, New Jersey**  
**(92 stone arch bridges)**

**\$75,000 ISTE A grant**

**Consultant: Thomas Boothby & Cecilia Rusnak**  
**Pennsylvania State University**

***A Summary of Phase II  
follows.....***





**The widespread use of stone arch bridges is credited to ancient Rome over 2,000 years ago.**



**The majority of Hunterdon County's stone arch bridges were constructed in the last quarter of the 19th century.**



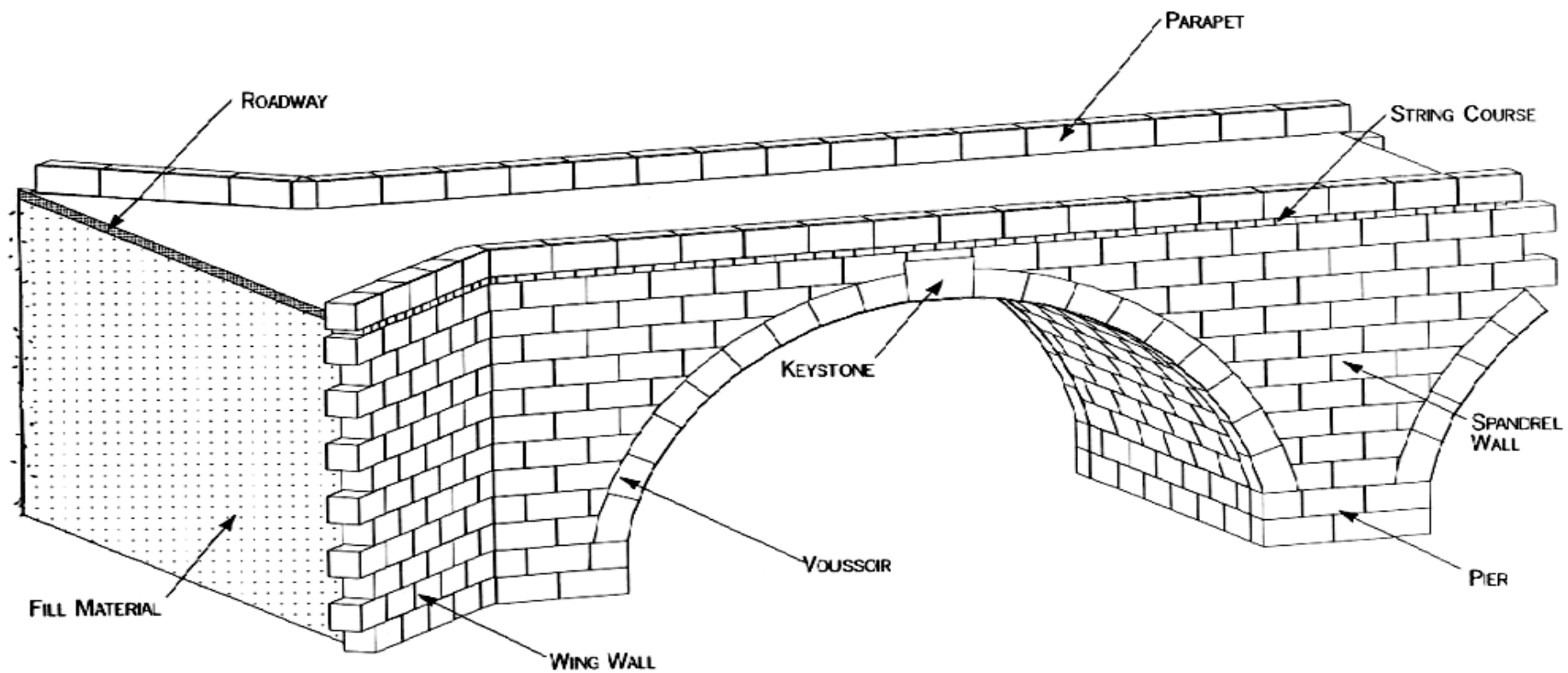


FIGURE 11. MASONRY ARCH BRIDGE TERMS



**In Hunterdon County, there are very few “engineered” stone arch bridges, ie, carefully designed bridges, typically at a larger scale, built by professionals.**



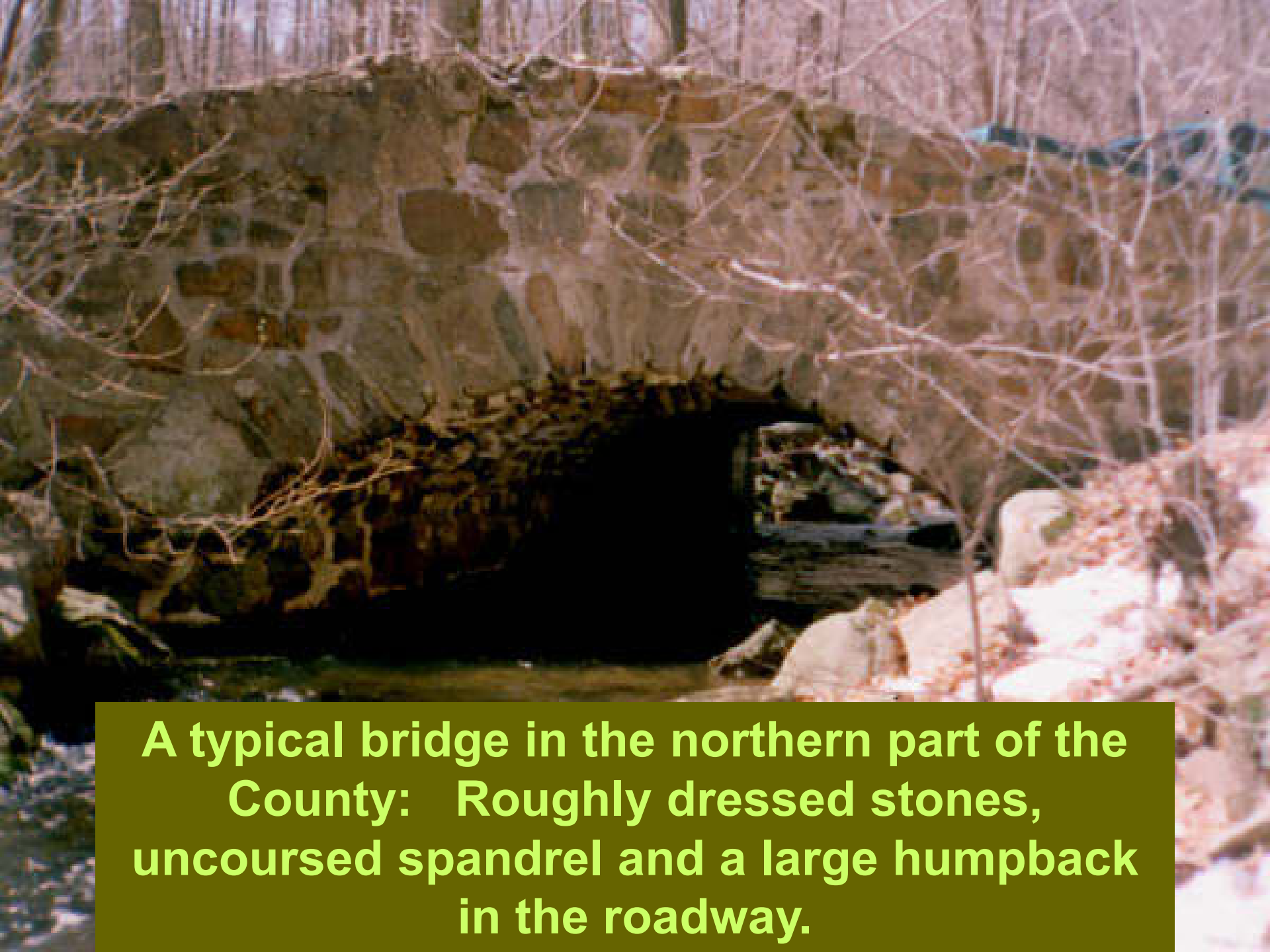
**Most of Hunterdon County's bridges are "country" bridges: with a rustic appearance and constructed by anonymous masons, craftsmen,.....**



....farmers,



.....and their friends and neighbors.




**A typical bridge in the northern part of the County: Roughly dressed stones, uncoursed spandrel and a large humpback in the roadway.**



**A typical bridge in the southern part of the County:  
Dressed and shaped stones, smaller humpback in  
roadway, coursed spandrel, radial voussoir joints,  
arch ring inset.**



A photograph of a stone bridge with a large, dark, rectangular opening in its center. The bridge is constructed from rough-hewn stones and has a curved, arched design. The opening is filled with dark, possibly water or a deep shadow. The bridge is surrounded by dry, brown grass and bare trees in the background, suggesting a late autumn or winter setting.

**In addition to the northern and southern style bridges, Hunterdon County has examples of skewed bridges,**

A photograph of a stone arch bridge. The bridge is constructed from rough-hewn, reddish-brown stones. It features a large, semi-circular archway in the center, which appears to be a culvert or a large drainage opening. The bridge spans a small, shallow stream or ditch. The surrounding area is covered in dry, brown grass and some small, bare shrubs. In the background, a paved road with a yellow center line is visible, and a person wearing a blue shirt and yellow pants is standing on the road. The overall scene suggests a rural or undeveloped area.

**...WPA bridges,**



....and bridges  
with an inset  
arch.

**“....With over 100 surviving stone arch bridges, Hunterdon County, NJ represents the largest concentration of stone bridges in North America.”**

**Thomas E. Boothby, et al, *Stone Arch Bridge Inventory, Phase II, Hunterdon County, New Jersey***



A photograph of a stone bridge pier, partially obscured by dense, dry brush and trees. The pier is constructed from rough-hewn stones and has a dark, arched opening at its base. The surrounding vegetation is thick and overgrown, with many bare branches visible. The background shows a clear sky and more trees.

## **The Inventory includes a Traffic Safety and Traffic Operational Analysis, including:**

- Highway Alignment Considerations
  - Bridge Safety Index
- Traffic Operational Analysis and Level of Service (LOS)



**Many of the stone arch bridges are historically significant because of their integral part of the County's early transportation network which supported the agriculture of the County.**





**Based upon the traffic and road analysis and the historical significance of the bridges, the Inventory recommends 13 specific bridges for preservation. In addition.....**





**...the Inventory recommends that a sufficient number of bridges be preserved within each of the six historic bridge types.**

# Categories of Historic Bridge Types



## **I. Northern**

**Crudely cut ringstones, non-radial joint alignment, low rise, rubble masonry  
(19 BRIDGES)**



## **II. Southern**

**Intrados of ring cut to curve, radial joint alignment, coursed masonry  
(10 BRIDGES)**



## **III. Inset**

**Wingwalls/parapet in different plan from spandrel/ring  
(8 BRIDGES)**

*(continued)*

# Categories of Historic Bridge Types

*(continued)*



## **IV. Deep Inset**

**Inset greater than 4 inches  
(2 BRIDGES)**



## **V. WPA**

**1930's WPA style structure  
(1 BRIDGE)**



## **VI. WPA widening**

**1930's WPA style widening  
(5 BRIDGES)**

**Finally, the Inventory  
includes a  
recommended  
Routine Bridge  
Maintenance  
Program:**

- **Mortar Pointing and  
Patching**
  - **Drainage**
- **Spandrel Walls and  
Parapets**
  - **Arch Barrels**



# ***The Importance of the Stone Arch Bridge Inventory....***







***...it offers a regional perspective  
and , as such, observes the wide  
variety of styles and shapes...***



***...provides critical information that is necessary for a successful County maintenance and preservation plan...***





***...and it is a permanent record of  
our bridges as they exist today.***

The End.

On April 30, 1999, the New Jersey Planning Officials (NJPO) presented the Hunterdon County Planning Board with an "Achievement in Planning" Award for the Hunterdon County Stone Arch Bridge Inventory.

## Corey Piasecki

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**From:** jean public <jeanpublic1@gmail.com>  
**Sent:** Wednesday, March 27, 2019 4:02 PM  
**To:** Highlands; comments; INFO@njpirg.org; humanelines; PETA Info; info; Erica Meier; ANGI METLER; APLNJ; INFORMATION@sierraclub.org; GGORMAN@stopthechop.org  
**Subject:** [EXTERNAL] Re: Public Notice: Public Hearings Scheduled

### PUBILC COMMETN ON HIGHLANDS PLANS

NOTIFICATION TO THE NEIGHBORS OF DEVELOPMETNS SHOUDL GO TO ALL NEIGHBORS WITHIN 1000 FT. THIS OLD RULE OF 200 FT IS NOT NEARLY ENOUGH. THE FACT IS WATER FROM DEVELOIPMETN SEEPS ALOT FURTHER THAN 200 FT. THAT IS ONE PROPERTY ONLY. NOBODY ELSE KNOWS ABOUT THE TERROR COMIGN TO NEIGHBORHODS IN NJ WITH THE RAMPANT DEVELOPEMTN THAT IS GONG ON, WITH LARGE CUNKS SOAKED UP WHEN DEVELOPMETN COULD BE TAKNG PLACES IN TEH OLD BUILDINGS IN THE TOWN ITSELF. THEY ALL WANT TO GO INTO NEW VIRGIN LAND AND DESTROY IT.AND THE 1,000 FT NOTICE SHUODL BE BY CERTIFIED LETTER SO WE KNOW THEY ARE NNOTIFIED. FAR TOO OFTEN NOBODY KNOWS ABOUT SNEAK DEVELOIPMENTS THAT ARE COMNIG TO A TOWN AND THE FACT THAT NJ IS SO MASSIVLY CONGESTED ALREADY NMEANS MORE PEOPLE NEED TO BE NOTIFIED. WE ALL NEED TO KOW WHAT IS COMING TO HARASS US, DESTROY U S, BRING IN POISON, BRING IN GUNS, BRING IN 200 CARS TO OUR BLOCKS,. ETC. WE ALL NEED TO KNOW THAT. CERTAINLY THE TRAFFIC ENINGERERS LIE OFTEN ENOUGH ABOUT HOW THERE WILL BE NO CONGESTION FROM THE ENDLESS DEVELOIPERS THAT THEY HIRE. THEY LIE TIME AND TIME AGAIN AND THE CONGESTION IS GETTING WORSE AND WORSE. WE ARE ALL PAYING MASSIVELY MORE TO LVKI IN A MORE AND MORE HORRIBLE NJ. NOTHING ELSE CAN LIVE HERE. THE ANIMALS AND TREES ARE ALL DYING BECAUSE OF TEH MASSIVE OVERDEVELOPMENT. WE TRY TO SAVE LAND AND IMMEDIATELY NJ AUDUBON IS WANTNKIG TO L OG IT SO THEY CAN GROW S BIRD THAT NEVER LIVED HERE IN ANY NUMBERS AND SO THEY CAN GIVE THEI FOREST GUYS MONEY AND WORK. WE ARE BEING DRIVEN OUT OF HAVNG ANY NATURAL LAND LEFT. THAT IS LAMENTABLE. JEAN PUBILEE  
JEAN [PUBILC1@GMAIL.COM](mailto:jeanpublic1@gmail.com)

On Wed, Mar 27, 2019 at 8:47 AM <[highlands@highlands.nj.gov](mailto:highlands@highlands.nj.gov)> wrote:

The Highlands Council has scheduled six public hearings to solicit public comment on draft Plan Conformance Procedures before the Highlands Council can adopt the Procedures as part of the Highlands Regional Master Plan. A public comment period regarding the procedure will coincide with the timing of the hearings. Complete details are available in the public notice.

A copy of the draft procedure and the public notice as well at the meeting schedule are available via the link below.

[www.nj.gov/njhighlands/master/amendments/](http://www.nj.gov/njhighlands/master/amendments/)

\*\*\*\*\*

You are receiving this email because you have subscribed to Highlands Council email updates. To unsubscribe, visit the subscription page of the Highlands Council website and follow the directions ([www.nj.gov/njhighlands/news/subscribe.html](http://www.nj.gov/njhighlands/news/subscribe.html)). If you have questions regarding this email or the Highlands Council in general, please direct them to [highlands@highlands.nj.gov](mailto:highlands@highlands.nj.gov).

The Highlands Council may occasionally use this subscriber list to forward information and requests from municipalities and counties within the Highlands Region where sharing such information could potentially advance the goals of the Highlands Regional Master Plan.

Good evening. My name is Susan Dodd Meacham, and I am commenting as a private Holland Township resident. My address is 66 Phillips Road, Milford, NJ. *I am not commenting in my official capacity on the Enviro Committee.*

**Regarding the draft amendment, I believe that the proposed 10 business day comment period for review of the Council's Draft Report on a Plan Conformance Petition fails to allow for real public participation. I ask the Council to change that to read a minimum of 60 calendar days for public comment on this Plan Conformance Petition as well as for any matter in which the public's participation is sought. By the time a resident knows where to look for a pending petition, a ten day deadline could well have passed. Sixty days ensures time for residents to find, review, and comment substantively on a pending petition.**

Protecting the environmental integrity of this area is of paramount importance, and I also ask that in order to provide real public participation, posting of notices of proposals should be expanded to include not only required public notices and posting on a municipality's website but also to add print media such as press releases in newspapers of general circulation in the areas affected.

Thank you.

**Conformance Procedure Amendment:**

**Public comment April 30, 2019**

**Zachary Cole, outreach & education director**

Good afternoon, my name is Zachary Cole - Outreach & Education director at the New Jersey Highlands Coalition, a non-profit organization that advocates for the natural and cultural resources in the New Jersey Highlands, and a champion for Highlands Plan Conformance.

The New Jersey Highlands Coalition commends the Highlands Council for its renewed efforts to promote plan conformance throughout the region, and we continue to offer our support in any capacity that is appropriate.

The plan conformance procedures are established to ensure plan conformance and implementation of the Highlands Regional Master Plan and the objectives of the Highlands Water Protection & Planning Act are met; namely to secure a safe and sustainable source of drinking water for the 6.2 million people depending on it. Therefore, it is critical that the standards and procedures informing plan conformance not be reduced or weakened for the sake of efficiency. Rather, amendments to this procedure should encourage more towns to enter into plan conformance, enable more public involvement, add transparency, and address issues that have proven confusing, unclear or overly complicated to achieve for towns or counties in the process, or considering entering into plan conformance.

This could best be achieved by engaging with towns that are in the process of plan conformance and conducting reviews with their planners and engineers to see what is working and what could be streamlined. Hearings like this are a great first step in seeking this important feedback, and we appreciate the Council and its staff engaging in the process.

Another consideration, is that the process for a town to come into conformance is an extensive one that can take longer than elected officials' terms. We would be encouraged to see language in the procedure stating the Council's commitment to



following through with municipalities that have started the process, but may for whatever reason be considering withdrawing.

**Regarding the draft amendment:**

1. The proposed 10 business day comment period for review of the Council's Draft Report on a Plan Conformance Petition is inadequate. 10 days is insufficient for anyone to create and provide constructive comment, and also assumes the public will be immediately aware that a comment period has commenced.

**We strongly urge the council to adopt a minimum of 30 days for public comment on the draft plan conformance document, and establish 30 days as a baseline for all matters where the public may wish to participate.**

Further, we suggest the council investigate posting notice of proposals in more locations than exclusively on the council website. Posting to a municipality's website for example would offer more people the chance to engage in matters that may affect their town. Additionally, more opportunities for public information should also be sought with print media through press releases, beyond the legally required public notices.

2. On pages 9 and 10 (section (d) of the draft procedure there is vague language regarding reimbursement of funds provided to a town, that does not complete the conformance process. In some instances towns may accrue hundreds of thousands of dollars in assistance and technical support. Are they expected to return all that money if they cannot follow through with full conformance? The language is vague and will likely act as a disincentive for towns considering plan conformance. We urge the Council to clarify this section, explaining what grants may have to be reimbursed, further explain the circumstances for this eventuality, and state that it will meet its own mandate to assist a town in achieving full conformance.
3. Finally, the highlands coalition strongly encourages the Council to include in the requirements in the appendices of this procedure, consideration of energy and

transport infrastructure, and climate change, addressing both potential impacts and mitigation strategies as a component of plan conformance.

In the thirteen years since the RMP was adopted, our understanding of climate change and how it will impact New Jersey has increased significantly. Threats include increased severe storms, extended flooding and drought periods, and a possible influx of people retreating inland from the coast as sea levels rise. The Highlands and its constituents will play a significant role in determining how prepared the state is to meet these challenges.

**Thank you for the opportunity to speak to you today.**

April 30, 2019

## Comments on Draft RMP Amendment Plan Conformance Procedures

Presented by George Cassa on behalf of the Alliance for Historic Hamlets

The Alliance for Historic Hamlets very strongly supports the Highlands Council's proposed Plan Conformance Procedures. In particular, we applaud the incorporation of these procedures in a form that will be formally adopted as an amendment to the Regional Master Plan. We offer the following comments for your consideration:

### 1. RMP Equivalent to Agency Rules

As decided by the Appellate Division In Re Highlands Master Plan on August 15, 2011, the RMP meets the criteria for administrative rulemaking under the Administrative Procedures Act, and we believe the Council's efforts with this amendment will also meet this essential standard. We suggest that this and all future proposed RMP amendments identify the equivalency of the RMP to an agency rule adopted under the Administrative Procedures Act in accordance with the following from the Appellate Division's decision:

The question is whether, despite this substantial overlap between the procedures set forth in the Highlands Act for adoption of the RMP and the provisions of the APA governing rule-making, the Highlands Council was required to follow not only the procedures set forth in the Highlands Act but also the APA in adopting the RMP. Where two statutes deal with the same or related subject, and there is an inconsistency in their provisions, the provisions of the more specific statute will generally prevail over those of the more general statute. See *Clymer v. Summit Bancorp.*, 171 N.J. 57, 69–70 (2002). In enacting the Highlands Act, the Legislature specifically set forth the procedures the Council was required to follow in adopting the RMP. Although the Council's "powers and duties" include the adoption "pursuant to [the APA of] such rules and regulations as may be necessary in order to exercise its powers and perform its duties and responsibilities under [the Highlands Act]," N.J.S.A. 13:20–6(y), they also include the adoption of "a [RMP] for the Highlands Region as provided pursuant to [N.J.S.A. 13:20–8]," N.J.S.A. 13:20–6(i). Thus, the Legislature required the RMP to be adopted in accordance with the specific procedures set forth in the Highlands Act itself, rather than the general procedures governing agency rule-making set forth in the APA. For these reasons, we reject appellant's challenge to the validity of the RMP.

### 2. PAPO as Benchmark for Planning Area Conformance

As noted on page 9 of the draft amendment, the PAPO establishes the benchmark for full conformance. The procedure discusses the issuance of a certification letter to that effect, and we strongly support the need for that document. We would also encourage the Council to consider providing such certification to those Highlands municipalities that have already achieved full conformance status.

### 3. Highlands Council as Sole Arbiter of Conformance

Also on page 9, the Council effectively asserts itself as the sole arbiter of conformance in the Planning Area. We strongly support this assertion. Conformance determinations must be at the sole discretion of the Highlands Council. It should not be made by another agency or a developer.

#### 4. Legal Shield Clarified

The legal shield triggers are addressed and clarified, and with the adoption of the amendment, will have the effect of an agency rule. We strongly support this clarification. We suggest that the Council consider the possibility of extending this shield to cases in which a municipality's conformance status is challenged by any party, including another state agency.

Thank you for the opportunity to address you on these matters this afternoon.



George Cassa

Alliance for Historic Hamlets

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Lebanon, NJ 08833

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