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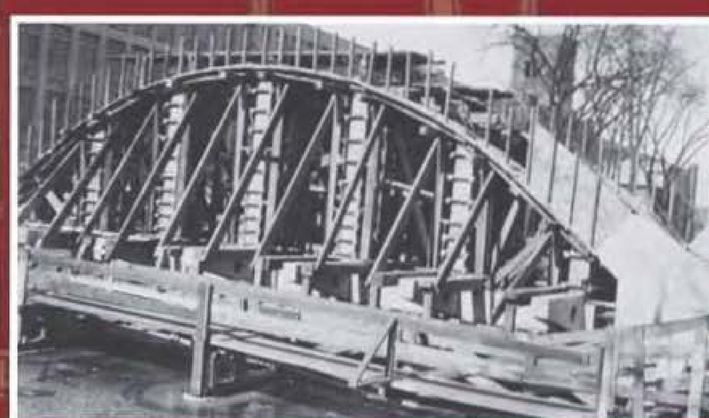
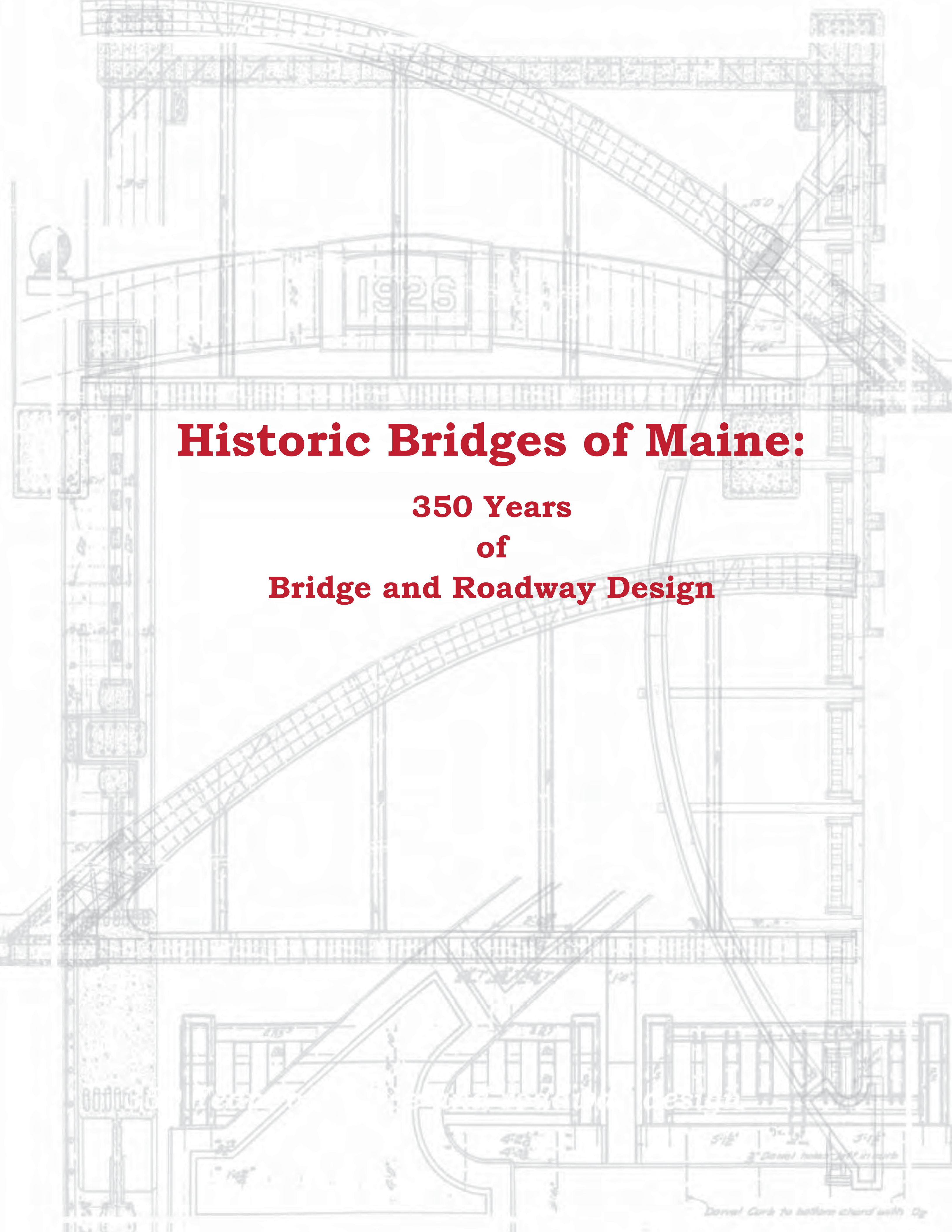
Historic Bridges of Maine



350 Years of Bridge and Roadway Design



Historic Bridges of Maine:

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Bridge and Roadway Design

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Edited by

David E. Gardner
Lisa Churchill-Dickson

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Introduction

Bridges are an essential component of our modern transportation system and have become symbols of our engineering legacy. Significant bridge building began in Maine more than 300 years ago and continues in earnest today. This book is a tribute to those bridges and the trends that led to their creation.

This book also represents more than a decade's worth of work on Maine's historic bridges, although the initial impetus can be traced to 1987. In that year, the Surface Transportation and Uniform Relocation and Assistance Act (STURAA) was passed requiring that each state inventory its historic bridges. The act did not outline a time limit for implementation and allowed the states a significant degree of flexibility to comply.

By the mid-1990s, the Maine Department of Transportation (MaineDOT) and Maine Historic Preservation Commission (MHPC) recognized that it was becoming increasingly difficult to assess the historical significance of a particular bridge in the absence of a statewide survey or a well-developed context. For example, it was not readily known if the bridge in question represented a rare or relatively common type, whether it was an early or late example, how its overall integrity compared with other existing types in Maine, and, in some cases, whether or not that particular structure was the only one of its type in Maine or elsewhere.

Both parties recognized the need to replace the project-based approach with a programmatic one and in 1997 commissioned the development of a historic context for Maine bridges with KCI Technologies. This work effort included a narrative of the regional and national trends that fueled the evolution of bridge building in the state, as well as the template and overall approach for the actual field survey of bridges.

The field inventory was conducted by Lichtenstein Consulting Engineers. It included all bridges in Maine built before 1956, greater than 10 feet in length, and either owned or maintained by the MaineDOT. Of the 2,030 bridges that fell into this category, 1,480 were slab, T-beam, or stringer types. One-page survey forms and laser-printed photos were completed for these bridges. The remaining 650 truss, arch, rigid frame, moveable, girder-floorbeam, suspension, and culvert bridge types were field inspected. Documentation for the latter group included four-page bridge survey forms, supporting historical research, black and white archival photos, sketch maps, and location quad maps in hardcopy and digital format.

National Register eligibility recommendations were made for all 2,030 bridges. These recommendations were developed by the Historic Bridge Survey Committee (see page 6) and ultimately concurred upon by the Maine State Historic Preservation Officer. In all, 136 bridges were identified as listed in or eligible for listing in the National Register.

In 2003, it was discovered that one of those historic bridges—the Waldo-Hancock suspension bridge—had experienced unexpected deterioration that would prohibit rehabilitation. The Waldo-Hancock Bridge was a significant historic structure, as one of Maine's last remaining suspension bridges and a classic example of David B. Steinman's work. The bridge's replacement resulted in an adverse impact to a National Register-listed resource. As mitigation for that impact, the Federal Highway Administration (FHWA), MHPC, and MaineDOT have worked jointly to prepare this book, which highlights the engineering and historic trends that drove the development of bridge building in Maine.

In July 1931, construction crews began stringing the cables for the Waldo-Hancock Bridge.

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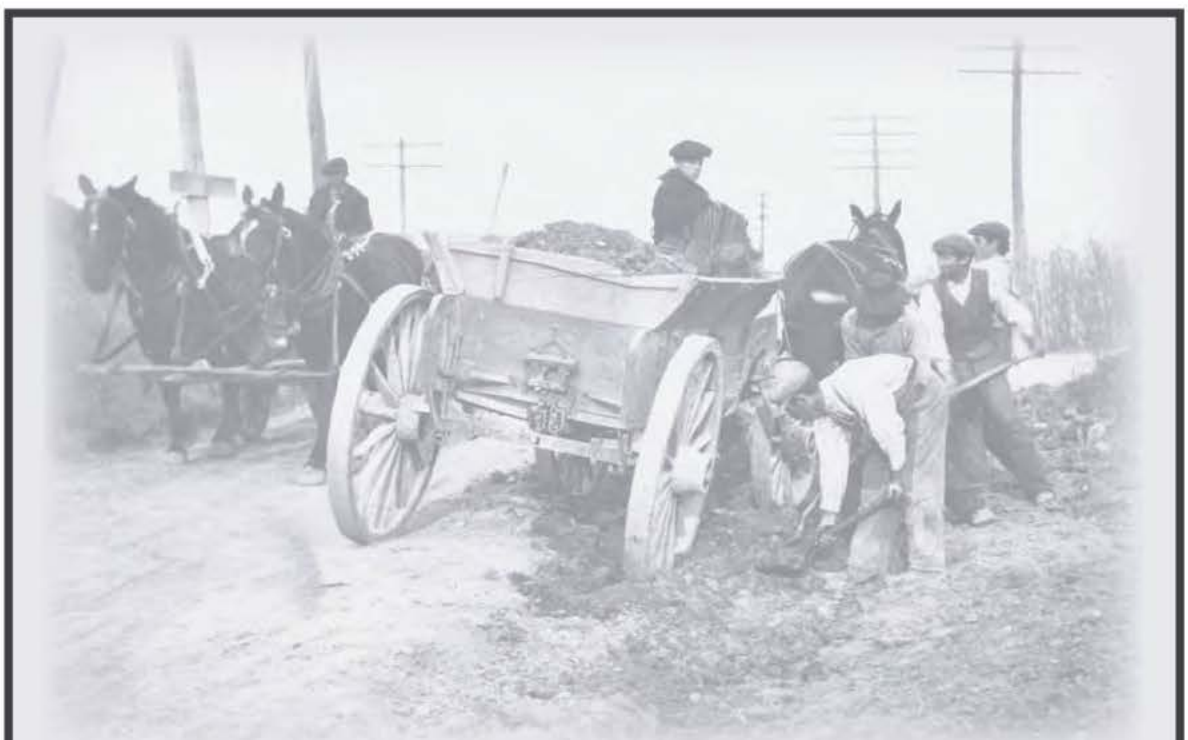
CHAPTER 1

Transportation in Maine Prior to 1900



Previous: In 1915, Route 1 in Brunswick was constructed using horse-drawn carts and wagons.

Transportation in Maine Prior to 1900

Lisa Churchill-Dickson
Amanda C. Taylor

The evolution of a transportation system, including bridge building, is shaped by responses to cultural needs, topographical constraints, and the availability of technologies. Cultural needs and topographical constraints are thus met and overcome by an individual's or group's technical knowledge. The history of transportation in Maine is a regional example of that process and illustrates local ingenuity to efficiently traverse the terrain. While the main focus of this book is on the modern aspects of the transportation system, it is necessary to understand how Maine looked before present times to fully appreciate the evolution of bridge building throughout the state.

Up until 15,000 years ago most of Maine was still blanketed beneath a sheet of ice that was as much as a mile thick in places. By 13,000 years ago the ice had retreated to northeastern New Hampshire and northwestern Maine, near the present day Canadian border.[1] As the glaciers retreated, they left behind a scarred, boulder-laden, and sediment covered landscape, carved by glacially-fed streams. The newly exposed land was quickly colonized by tundra vegetation and the early post-glacial landscapes resembled reaches of present-day northern Canada in the vicinity of Churchill, Manitoba.

Tundra vegetation, comprised of low-growing, cold climate plant species and marked by an absence of trees, dominated the region 14,000 years ago. Woodland vegetation, consisting predominately of a tundra setting with interspersed trees, had begun to take hold in the southern portions of Maine during the same period, as did some closed forests. By 13,000 years ago, the real extent of the tundra had decreased significantly with more than half the state covered by woodlands or closed forests.[2]

Early Native American Transport

The first record of human occupation in the northeast is from approximately 13,000 years ago.[3] The Paleoindian populations were migratory, small in size, and avoided living in the major river valleys, likely as a precaution against the unpredictable flooding associated with the maturing glacial drainages. The earliest transportation networks were determined by the terrain of the river because the tundra landscape allowed for traverse on foot, but may have also been supplemented by water travel using lightly-framed, skin boats.[4]

As the relatively open landscape of the tundra was replaced by thick, dense forests, transportation became more difficult for Maine's early inhabitants. Waterways and narrow footpaths were the main routes of travel. Streams and rivers cut natural, somewhat linear paths through otherwise dense forests and created an interconnected travel network throughout the wilds of Maine. Along coastal Maine, many areas would have been more easily accessed from the shore than from land.

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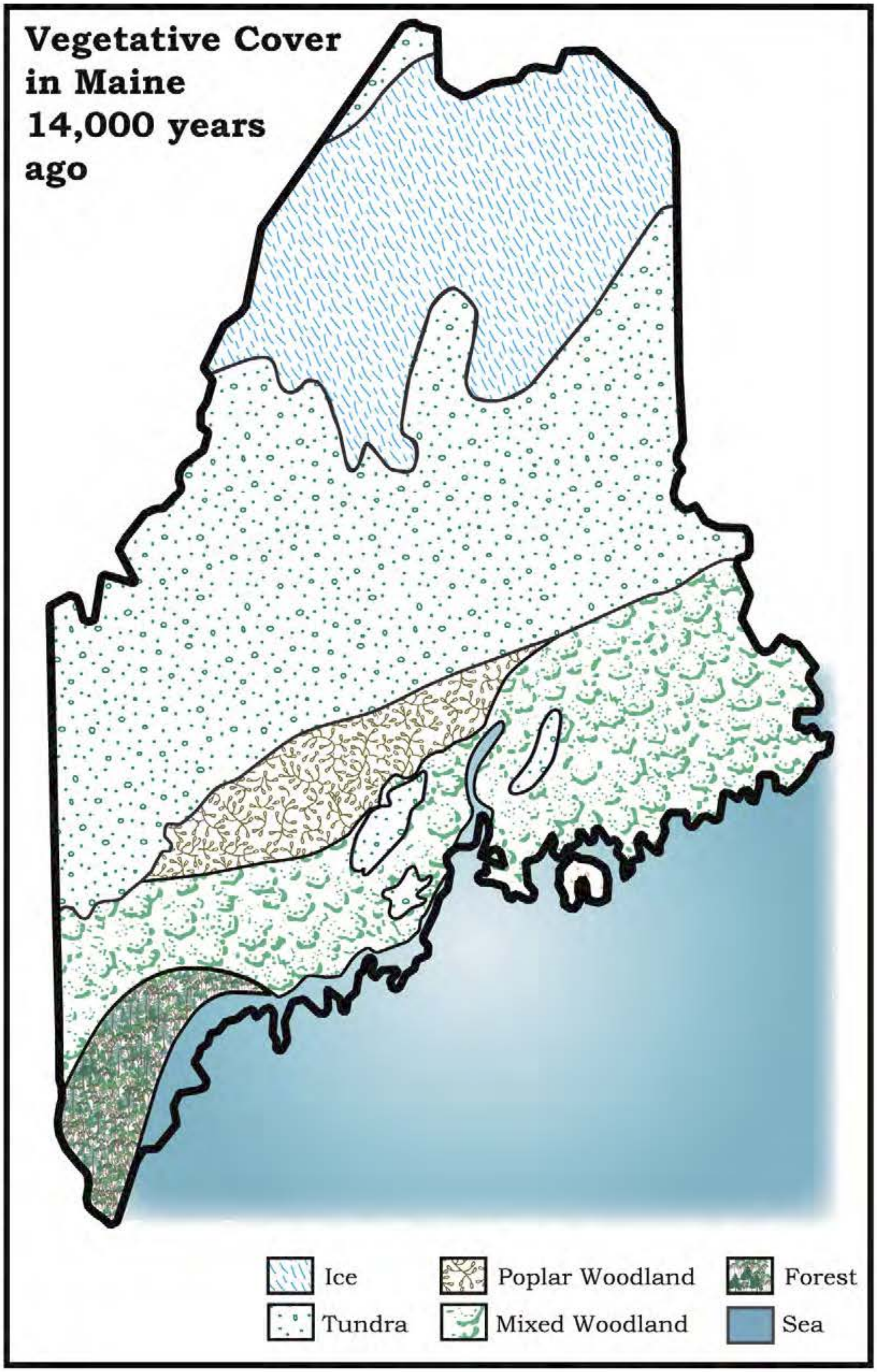
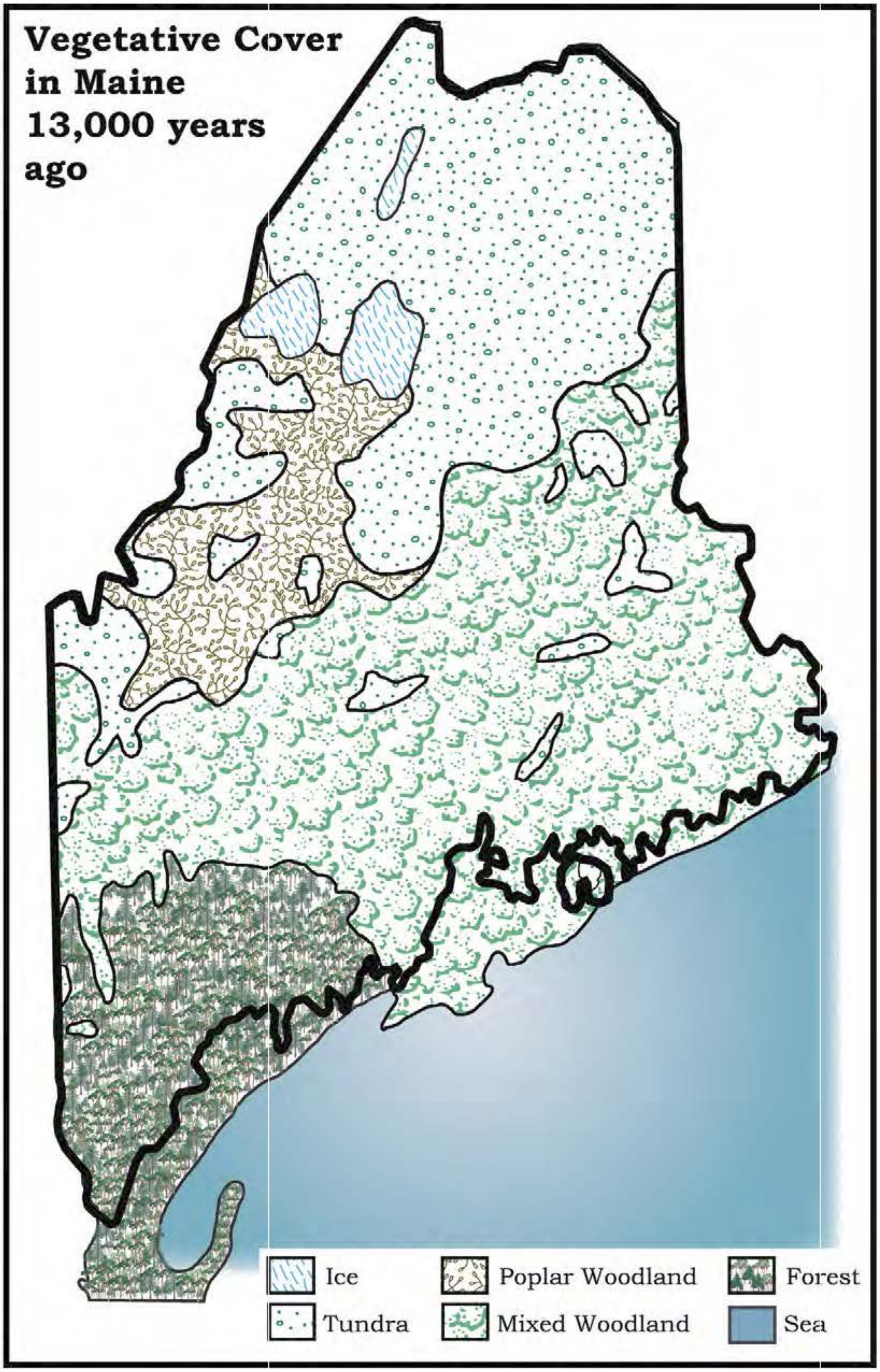
[1] J. C. Ridge, The North American Glacial Varve Project, accessed 25 March 2013, http://eos.tufts.edu/varves/; H. W. Borns, et al., "The Deglaciation of Maine, USA." in *Quaternary Glaciations-Extent and Chronology, Part II*. Elsevier: 2004, 92.
[2] Bonnichsen, et al., 1985, 152–153; R. S. Anderson, et al., "Gould Pond, Maine: Late-glacial Transitions from Marine to Upland Environments," *Boreas*, vol. 21: 1992, 363–364.
[3] R. Bonnichsen, et al., "The Environmental Setting for Human Colonization of Northern New England and Adjacent Canada" in *Late Pleistocene Time in History of Northern New England and Adjacent Quebec*, Geological Society of America Special Paper, 1985, 151.
[4] Arthur Spiess, personal communication, 2008.



Source: Modified from Bonnichsen, et al., 1985. Note: The sea level around Maine 14,000 years ago was higher than today because the weight of glacial ice sheets had bowed the Earth's crust.

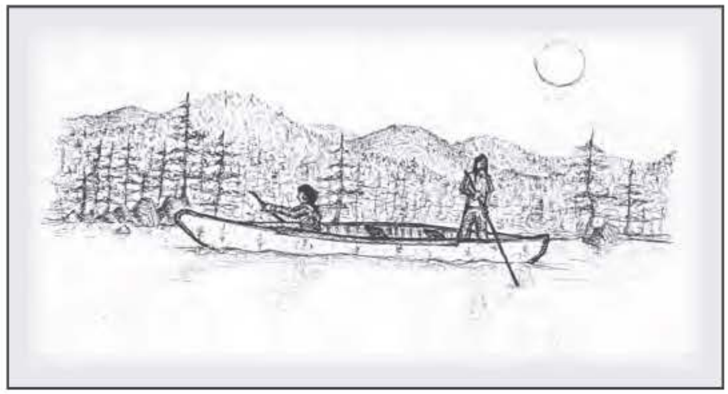


Source: Modified from Bonnichsen, et al., 1985. Note: By 13,000 years ago, sea levels around Maine were lower than today because the retreat of glacial ice caused the Earth's crust to temporarily rebound to higher elevations.

Prior to European contact, Native Americans located their villages beside water bodies and relied on canoes for transportation. The original canoes were likely constructed of dugout logs, with birch bark canoes appearing later—approximately 3,000 to 4,000 years ago. The weight of dugout canoes precluded extensive portage; they were likely made and left on each body of water for use as needed.[5] Areas that were not traversable by canoe were connected by trails.

This mural represents Native American life around 9,000 years ago and is based on a meat cache found in the Magalloway River Valley in northwestern Maine. Courtesy of Maine State Museum; Philip Carlo Paratore, artist

It was the birch bark canoe that turned Maine's waterways into functioning highway systems, predating the state's first roadways by thousands of years.[6] The invention of the birch bark canoe brought about significant changes in Native American culture. The lighter weight of the canoe meant that it could be portaged and therefore made short-term, long-distance travel a possibility. Families and stored food could be moved several hundred miles on a seasonal basis, east-west travel across the state was possible and trading could be carried out across a larger region.



Native Americans in Maine often traveled the area's many waterways in lightweight birch bark canoes. Source: Cook, 2007

Early European Transport

When European explorers and early Euroamerican settlers arrived, they too were faced with the difficulty of inland travel through the dense forests of Maine. However, both parties had the advantage of being able to make use of birch bark canoes, as well as the trails and portages already established by the Native Americans.

The earliest European explorers to this area arrived intermittently between 1524 and 1618. The waters off of the coast of Maine were attractive fishing locations for the English and French, though these early fishing stations promoted trade rather than permanent settlement. The first permanent settlements were established in the 1620s and 1630s, including Kittery and Wells. By the late seventeenth century over three thousand English settlers resided in Maine; however the settlements stretched in an isolated chain from Kittery to Pemaquid. The French also had a presence in Maine, maintaining trading and fishing stations further east near present day Castine, Mt. Desert Island, and Machias.[7]

There was continual unrest within Maine during the seventeenth century and first half of the eighteenth century. Tensions rose between Native Americans and Euroamericans as the latter continued to expand their

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[5] Ibid.

[6] D. S. Cook, *Above the Gravel Bar: The Native Canoe Routes of Maine*, 3rd Edition (Solon, ME: Polar Bear and Company, 2007), 21.

[7] E. A. Churchill, "Mid-Seventeenth-Century Maine: A World on the Edge," in *American Beginnings: Exploration, Culture, and Cartography in the Land of Norumbega*, eds. E. W. Baker, et al. (Lincoln, NE: University of Nebraska Press, 1994), 241.

The World's First Roads

The oldest recorded road in the world, the Royal Road, dates from approximately 4500 B.C. and traversed southwest Asia, between the Persian Gulf and the Mediterranean Sea. Built by the Persians, it covered more than 1,600 miles and remained in service until at least 323 B.C.

Perhaps the most famous ancient roadway is the Appian Way, which stretched across Italy and was built by the Roman Empire around 312 B.C. The roadway was designed to allow for the rapid deployment of troops and with an eye on durability. It was engineered with a solid gravel and stone base, ranging in thickness from three to five feet, and built to a width of thirty-five feet. The fact that large portions of it can still be viewed in Italy today is a testament to its durability.

A segment of the Appian Way survives within the ancient city of Minturo, Italy. Source: Wiki accessed 2008

The Roman road system fell into disarray in the eighth century and long distance travel via inland roadways was discontinued for the next three centuries. By the twelfth century, social stability returned to the region and focus shifted again to utilizing and improving the roadways.[1]

[1] *American Association of State Highway Officials, "Public Roads of the Past: 3500 B. C. to 1800 A. D" (Washington D.C.: National Press Building, 1952).*

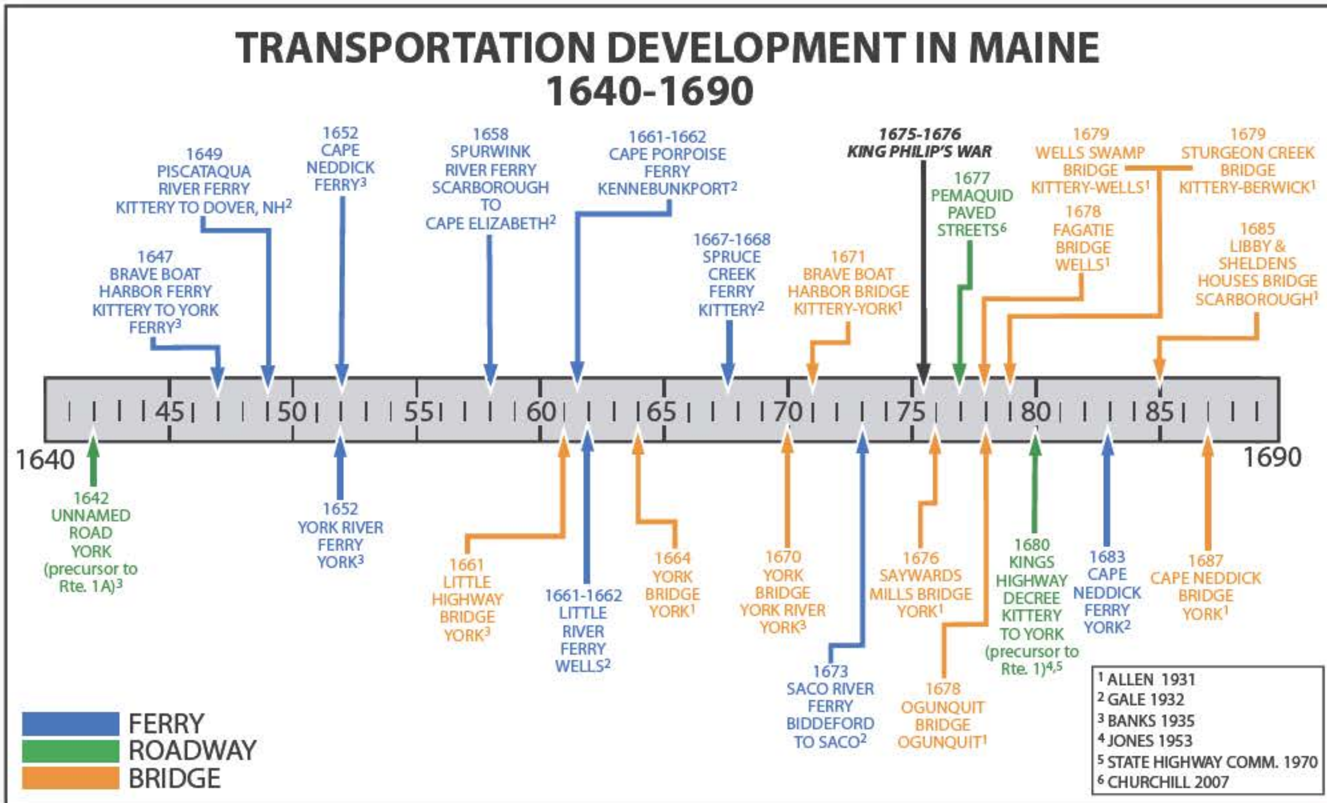
settlements into traditional Indian lands. Additionally, strife existed among the various Native American populations, such as between the Wabanakis and the Iroquois, as it did within the different Euroamerican groups, such as between the French and the English.[8] New England was undergoing a tremendous period of cultural transition which brought with it a great deal of human suffering and tragedy.

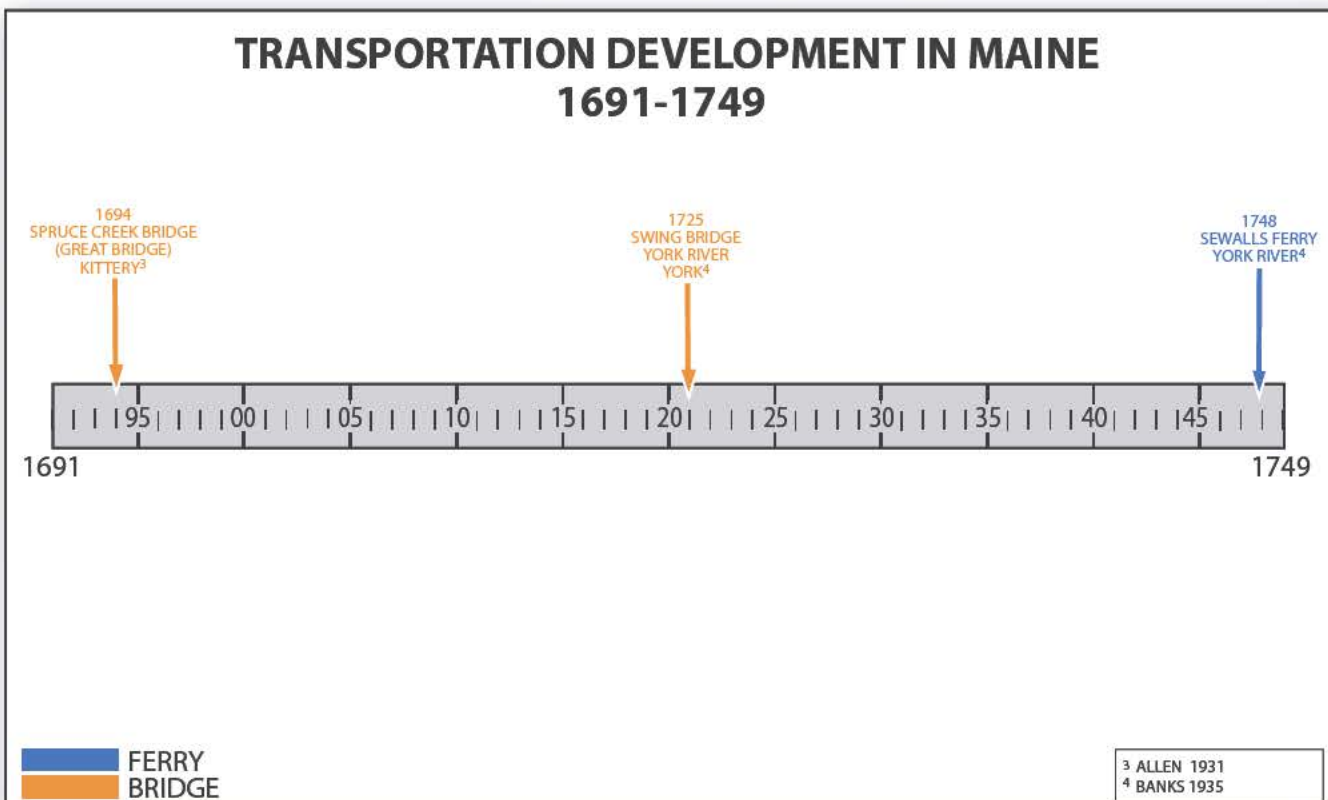
Extended armed conflict plagued the region's development until the 1760s, beginning with King Philip's War (1675–1678). The nature of warfare between the English, French, and Native Americans at that time included attacking opposing forts, settlements, and villages, greatly disrupting everyday life. The most devastating of the French and Indian wars on Maine settlements was King William's War (1689-1699). The French and the Wabanaki contested English expansion into eastern Maine and their combined forces attacked settlements along the coast. Their raids eventually destroyed the settlements at Falmouth and Berwick, and led the English to abandon all settlements east of Wells in 1690. After the war's conclusions, only a small percentage of settlers returned. Other conflicts included Queen Anne's War (1702–1713) and Dummer's War (1721–1727), which brought additional turmoil to Maine. Thirty years later, the French and Indian War (1754–1760) marked the final engagement between the English, French, and Native Americans in the Maine, closing nearly one hundred years of significant regional brutality.[9]

Early Roads

Despite the region's turmoil, the Massachusetts government, acting through the General Court, required that Maine settlers build roads to allow for the passage of "man and horse" between towns—a directive which often went unheeded. Prior to 1760, settlers had to contend with more vital tasks, not the least of which was

[8] D. L. Ghere, "Diplomacy and War on the Maine Frontier, 1678–1759" in *Maine: The Pine Tree State from Prehistory to the Present*, eds. R. W. Judd, et al. (Orono, ME: The University of Maine Press, 1995), 120–122; H. E. Prins, "Turmoil on the Wabanaki Frontier, 1524–1678" in *Maine: The Pine Tree State from Prehistory to the Present*, eds. R. W. Judd, et al. (Orono, ME: The University of Maine Press, 1995), 110, 112–114.
[9] Prins, 1995, 114–118; Ghere, 1995, 124–134, 139–141.


TRANSPORTATION DEVELOPMENT IN MAINE
1640-1690
1647 BRAVE BOAT HARBOR FERRY KITTERY TO YORK FERRY[3]
1649 PISCATAQUA RIVER FERRY KITTERY TO DOVER, NH[2]
1652 CAPE NEDDICK FERRY[3]
1658 SPURWINK RIVER FERRY SCARBOROUGH TO CAPE ELIZABETH[2]
1661-1662 CAPE PORPOISE FERRY KENNEBUNKPORT[2]
1667-1668 SPRUCE CREEK FERRY KITTERY[2]
1671 BRAVE BOAT HARBOR BRIDGE KITTERY-YORK[1]
1675-1676 KING PHILIP'S WAR
1677 PEMAQUID PAVED STREETS[6]
1679 WELLS SWAMP BRIDGE KITTERY-WELLS[1]
1678 FAGATIE BRIDGE WELLS[1]
1679 STURGEON CREEK BRIDGE KITTERY-BERWICK[1]
1685 LIBBY & SHELDENS HOUSES BRIDGE SCARBOROUGH[1]
1640
45
50
55
60
65
70
75
80
85
1690
1642 UNNAMED ROAD YORK (precursor to Rte. 1A)[3]
1652 YORK RIVER FERRY YORK[3]
1661 LITTLE HIGHWAY BRIDGE YORK[3]
1661-1662 LITTLE RIVER FERRY WELLS[2]
1664 YORK BRIDGE YORK[1]
1670 YORK BRIDGE YORK RIVER YORK[3]
1673 SACO RIVER FERRY BIDDEFORD TO SACO[2]
1676 SAYWARDS MILLS BRIDGE YORK[1]
1678 OGUNQUIT BRIDGE OGUNQUIT[1]
1680 KINGS HIGHWAY DECREE KITTERY TO YORK (precursor to Rte. 1)[4,5]
1683 CAPE NEDDICK FERRY YORK[2]
1687 CAPE NEDDICK BRIDGE YORK[1]
FERRY
ROADWAY
BRIDGE
1 ALLEN 1931
2 GALE 1932
3 BANKS 1935
4 JONES 1953
5 STATE HIGHWAY COMM. 1970
6 CHURCHILL 2007


TRANSPORTATION DEVELOPMENT IN MAINE
1691-1749
1694 SPRUCE CREEK BRIDGE (GREAT BRIDGE) KITTERY[3]
1725 SWING BRIDGE YORK RIVER YORK[4]
1748 SEWALLS FERRY YORK RIVER[4]
95
00
05
10
15
20
25
30
35
40
45
1691
1749
FERRY
BRIDGE
3 ALLEN 1931
4 BANKS 1935

weathering the numerous wars, clearing and farming rocky soil, and preparing for long cold winters. Road building was neither a priority nor a financial possibility during these times. Continuous strife between the English, French, and Native Americans meant leaving the safety of the village and venturing into the woods was a risky venture. The fear of ambush by either French or Indian forces was prevalent among the English settlers and made them reluctant to stray far from the settlement. Those settlers who worked in the woods took precautions, arming themselves, organizing in a military-like fashion, and/or hiring armed guards.[10]

Court records reveal that early road building in Maine was conducted in a piece meal fashion. The General Court often ordered town officials to construct routes between specific settlements or improve unsatisfactory or dangerous roadways. In 1667 the court detailed that the towns were not clearing their roads, "a thing neither of good report nor profitable."[11] Despite the many court orders posed to the towns of Kittery, York, Wells, and others, in 1709, as Queen Anne's War was ending, the courts again noted the general disorder of the settlements' roadways and stated that the conditions were hazardous to travellers.[12]

The task of clearing a road through the dense forest was formidable, made even more so when the Court required that it be "formally measured [and] staked out to a definitive width." Roadway construction was usually undertaken following the completion of more pressing tasks such as farm work. Using "hoes, rakes and shovels, and with plows pulled by oxen," the settlers would set about the task of clearing and leveling the roadway, often under the direction of a resident farmer.[13] Despite all their efforts and hard work, the results were usually less than satisfactory. Roots, rocks, and partially removed stumps often remained, and the lack of adequate drainage would turn the roadways to mud, making them nearly impassable during the wet season. Winter often provided an easier passage on hard-packed snow. The roads that were constructed remained more easily traversed on foot or by horse than by cart or carriage, and the majority of inland travel continued that way until the early nineteenth century. Travel by water, particularly for long-distance journeys, was still preferable. Carts and carriages were burdensome along most of the roadways and their use was generally restricted to in-town functions. Settlers around York and Wells often used the beaches for travel, a natural highway.[14]

The King's Highway exemplifies the erratic way in which roads were constructed in seventeenth-century Maine. In the late 1680s, under the auspices of the Dominion of New England, which sought to bring Puritan New England more firmly under the control of the Crown and the Church of England, Governor Edmund Andros issued a decree that included building the King's Highway from Boston to Maine. Despite this decree, the highway was not fully developed and only a few towns built roadways named the King's Highway. In 1687, the highway appeared on a survey map completed for a deed in York and the court ordered the Town of Saco to turn an "old footpath" into the highway. In 1668 and 1691, respectively, the court admonished the towns of Falmouth and Kittery for the deplorable condition of the King's Highway.

[10] E. A. Churchill, "English Beachheads in Seventeenth-Century Maine" in *Maine: The Pine Tree State from Prehistory to the Present*, eds. R. W. Judd, et al. (Orono, ME: University of Maine Press, 1995), 69–70; G. R. Taylor, "The Transportation Revolution: 1815–1860" in *The Economic History of the United States*, vol. IV (New York: Harper and Row Publishers, 1951), 16; O. W. Holmes, Jr., and P. T. Rorhback, *Stagecoach East: Stagecoach Days in the East from the Colonial Period to the Civil War* (Washington, D.C.: Smithsonian Institute Press, 1983), 3; R. G. Albion, *Forests and Sea Power: The Timber Problem of the Royal Navy, 1652–1862* (Cambridge, MA: Harvard University Press, 1926), 237.

[11] Allen, 1931, 286–287.

[12] Neal W. Allen, *Court and Province Records of Maine*, vol. IV (Portland, ME: Maine Historical Society, 1958), 372-373.

[13] Taylor, 1951, 15–16.

[14] J. Butler, "Family and Community Life in Maine" in Maine: The *Pine Tree State from Prehistory to the Present*, eds. R. W. Judd, et al. (Orono, ME: The University of Maine Press, 1995), 227, 305; F. J. Wood, *The Turnpikes of New England and Evolution of the Same Through England, Virginia, and Maryland* (Boston: Marshall Jones Company, 1919), 5, 25; Churchill, 1995, 69.

Traditionally, historical scholarship has supported the construction of the King's Highway as a connected thoroughfare across coastal Maine beginning in 1653. However, court records reveal that the roadway did not materialize in this manner during the seventeenth century and the name King's Highway soon fell out of favor due to its association with the unpopular Governor Andros.[15]

Seventeenth-century settlers paved the small colony of Pemaquid's streets with cobblestones. Source: Cartland, 1899.

More permanent roads were built at the settlement of Pemaquid during the latter part of the seventeenth century. The streets were 11.5 feet in width, paved with flat stones from the nearby beach and extended from the docks along the harbor to fields where codfish were dried on wooden stages. Earlier sources stated that the construction was carried out prior to 1620; however recent scholarship suggests otherwise. Transplanted New York colonists likely constructed the streets from 1677 to 1689.[16] The use of stone was more common in traditional New York colonial settlements and the first stone houses built in Pemaquid did not occur until the New York colonists settled in the area.

Another form of road building occurred during the settlement period in Maine. While most roads were developed to move both people and goods, mastways were developed specifically for the movement of lumber. In 1691, the English government declared that all white pines within the American colonies measuring more than twenty-four inches in diameter at twelve inches from the ground were property of the King. At that time, all navies were dependent on a steady supply of quality wood to both build and maintain their vessels, and thereby retain their supremacy on the seas. Most of England had been cleared by the end of the seventeenth century, such that less than an eighth of the country remained wooded.[17] The limited availability of tall, structurally sound trees for use as masts presented significant challenges for the Royal Navy.

The tall white pines that flourished in Maine's dense forests made choice masts and provided the resource that the English Royal Navy so desperately needed. In order to protect their newly found bounty, Parliament passed a series of acts and orders from 1691 to 1729 ensuring their singular claim to these trees—a claim that generated considerable tension with the colonists, and persisted until the onset of the Revolutionary War in 1775.[18]

The construction of mastways was a daunting task and required roadways that were of a superior quality compared to the other early New England roads. A path was cleared from the selected tree to the nearest water source, a distance that may have extended several miles. Rocks, stumps and side hills were removed

[15] Original research compiled by E. A. Churchill from Allen, *Court and Province Records of Maine*, vols. I, III, IV and P. Benes, *New England Prospect* (Boston: Boston University, 1981), 76. For traditional discussions of the King's Highway see H. G. Jones, *The King's Highway from Portland to Kittery: Stagecoach and Tavern Days on the Old Post Road* (Portland, ME: Longfellow Press, 1953).
[16] Maine State Highway Commission, *A History of Maine Roads: 1600–1970* (Augusta, ME: Maine State Highway Commission, 1970), 2; Churchill, 2007.
[17] S. F. Manning, *New England Masts and the King's Broad Arrow* (Kennebunk, ME: Thomas Murphy, Publisher, 1979), 33; W. D. Barry and F. W. Peabody, *Tate House: Crown of the Maine Mast Trade* (Portland, ME: National Society of the Colonial Dames of America, 1982), 11; Albion, 1926, ix, 97.
[18] Albion, 1926, 248–251; Manning, 1979, 33–35; Barry and Peabody, 1982, 11.

and bridges were built or strengthened. Often times, the felled trees were moved in the winter over packed snow both as a matter of more convenient passage and because the available work force was not as heavily involved in agricultural activities during that time.[19]

The construction of mastways opened up the backcountry and provided the opportunity for settlement and development further inland. In most cases, however, once an area was harvested, the mastways were abandoned and the roadways were quickly overgrown.[20] In Maine, a few mastways were subsequently developed into permanent travelways and survive today. One such example is Mast Landing Road in Freeport.

This illustration shows the construction of a mastway. Source: Manning, 1979

Early Bridges

Road building in seventeenth-century Maine was also accompanied by bridge construction. The General Court often ordered southern Maine towns to construct small-scale bridges over feasible waterways in attempts to link the settlements. Oftentimes roads led travelers to the shallowest part of a waterway to wade across or take a ferry, but log constructed bridges were also prevalent. These bridges were created by lashing timber logs together and laying a plank across the top. A wider bridge was made by laying parallel logs further apart and topped with flat planking. General Court documents record numerous orders in Kittery, York, Wells, and other towns to construct new "sufficient" bridges and make repairs for "insufficient" bridges. The following is a list of known bridges constructed during the seventeenth century. The accompanying dates reflect the earliest references made to these bridges.[21]

1664	**York Bridge**	York
1671	**Brave Boat Harbor Bridge**	Kittery–York
1676	**Saywards Mills Bridge**	York
1678	**Fagatie Bridge**	Wells
1678	**Ogunquit Bridge**	Ogunquit
1679	**Sturgeon Creek Bridge**	Kittery–Berwick
1679	**Wells Swamp Bridge**	Kittery–Wells
1685	**Libby & Sheldens Houses Bridge**	Scarborough
1687	**Cape Neddick Bridge**	Cape Neddick
1694	**Spruce Creek Bridge (Great Bridge)**	Kittery

Early twentieth-century historian Charles Banks noted two other seventeenth-century bridges in York. The first is a small bridge that in 1661 was "mentioned as being on the main road just north of the house formerly occupied by Luther Judkins, and probably crossed a ravine at that point." Built in 1670, the other bridge

[19] Albion, 1926, 236; Manning, 1979, 24.
[20] Barry and Peabody, 1982, 10; Churchill, 2007.
[21] Original research compiled by E. A. Churchill from Allen, *Province and Court Records of Maine* vol. 1, 1931.

crossed the northeast branch of the York River and allowed for travel from York to Berwick along the "Country Road." In 1725, the Scotland Bridge, known also as the New Bridge or Swing Bridge, was built in York and the sturdy bridge remained until 1811 when a spring flood destroyed it.[22] The longevity of the Scotland Bridge would be surpassed by Sewall's Bridge, a timber pile bridge that spanned the York River from 1761 to 1934 (see page 54 for detailed information on Sewall's Bridge).

This ferry serviced vehicles traveling along a highway to Andover, Maine. Courtesy of Maine Historic Preservation Commission

Ferries

In the early settlement period, many water crossings were either forded or made with the assistance of a ferry. Reports of ferry use date from the seventeenth century and can be found in the Province and Court records from that time. The earliest documented ferries are recorded from southern Maine, and extend as far north as the Scarborough-Cape Elizabeth area. Ferries during this time could consist of a boat or canoe. The ferry operator typically charged a rate for an individual with a separate rate for horses or cattle. In 1687 John Reynolds, who kept a ferry across the Kennebunk River, charged a man two pence to cross, while his horse cost an extra four pence to swim alongside.[23] The list below is a small representation of the many ferries that operated throughout southern Maine. The dates reflect the earliest known reference to a ferry at these locations.

1647	**Brave Boat Harbor Ferry**	Kittery and York
1649	**Piscataqua River Ferry**	Portsmouth and Kittery
1658	**Spurwink River Ferry**	Scarborough and Cape Elizabeth
1661/1662	**Cape Porpoise River Ferry**	Kennebunk
1661/1662	**Little River Ferry**	Wells
1667/1668	**Spruce Creek Ferry**	Kittery
1673	**Saco River Ferry**	Biddeford and Saco
1683	**Neddick River Ferry**	York Beach

Although the courts would often dictate the location of these ferries, their general or specific originations and destinations, as well as the person responsible for operating the ferry, there were instances when even those carefully laid plans did not necessarily ensure a reasonable level of service. In the case of a ferry at Saco, officials felt compelled to have the inadequate and mismanaged services addressed in and resolved by the regional court:

> *1673—"Wee present the Ferry man at Sacoe for not keeping of a Ferry boate according to law. The Towne orders him to provide two Conows [canoes]."*[24]

[22] Banks, 1935, 292, 296.
[23] Nellie I. Gale, "Some Ferries and Covered Bridges of Maine" (Orono, ME: University of Maine, 1932); Allen, 1958, 267.
[24] Allen, 1931, 268.

Through the years, as roads improved and the volume of traffic increased, ferry operation became more reliable. In Maine, ferry service continued well into the twentieth century. Ferries were widened and became more sturdy, able to accommodate horses and wagons and eventually automobiles. In coastal Maine, steamboats served as ferries to the state's many islands. The last highway ferry crossed the Androscoggin River at Rumford Point. It was replaced by the Martin Memorial truss bridge in 1955.

Today, scheduled ferry service continues to provide connections between mainland portions of the state and some of Maine's offshore islands. The State of Maine runs a year round service to from three mainland ports: Rockland, Lincolnville, and Bass Harbor. Other year round ferry services are offered between Portland and the Casco Bay islands. Most of the state's ferry operators, however, run seasonal routes, including scheduled departures from Bar Harbor, Northeast Harbor, Southwest Harbor, Eastport, Stonington, Port Clyde, and Yarmouth.

Transportation in Maine—1760 to 1900

With the close of the French and Indian War in 1760, greater stability came to the region and significant efforts were put towards improving the transportation infrastructure. Whereas in the past, the growth of the transportation infrastructure had been curtailed by wars and conflicts, during the late eighteenth and nineteenth centuries those types of events actually played a significant role in the development of roads. The upgrade of roads to serve for military transport during the Aroostook War and the need to create a reliable inland transportation system during the Embargo Act and War of 1812 spurred the development of roads across the state.

The need to convey crops, lumber, and other goods to town and the opening of more inland areas for settlement also necessitated additional roadway improvements.[25] Once built, the roads required a certain amount of seasonal repair and general maintenance. Fences and cattle pounds were constructed and repaired to ensure that animals would not interfere with travel. More fundamental road work such as the repair of bridges and the continual improvement of the road's surface through ongoing stump removal, filling of potholes and realignment of dangerous curves was occurring with more regularity and conviction.[26]

Beginning in the eighteenth century, there was a concerted effort towards the construction of improved roadways that would connect the various settlements. While some villages had developed roadway systems within their respective settlements, limited efforts had been put towards road building at an inter-village level.

One of the earliest of these improved roads was the 1754 **Military Road** that connected Augusta and Winslow, following the same general route as the modern day Routes 201 and 100.[27] The **Old Wiscasset Road**, connecting Woolwich to Wiscasset and a precursor to Route 1, was constructed sometime prior to 1760. According to Reverend Henry Thayer: "The old Wiscasset road, earlier than the turnpike, went from the ferry to Nequasset Mills or Church, and then east by present lower and main road to Wiscasset and that road was formerly called 'The King's Highway.' The new town laid a road over the same course in 1760-61,

[25] Churchill, 1995, 70; Rodrigue and Hatuany, 1997.

[26] Banks, 1935, 311; J. W. Eastman and P. E. Rivard, "Transportation and Manufacturing in Maine" in *Maine: The Pine Tree State from Prehistory to the Present*, eds. R. W. Judd, et al. (Orono, ME: The University of Maine Press, 1995), 311.

[27] "Maine Sesquicentennial Observance," *Kennebec Journal*, 1974, 46.

discontinuing a portion of the old roads . . . where General Henry Knox had an overturn of his carriage . . . known as Knox's Corner."[28]

This granite milestone marker aided travelers along the Post Road in Cumberland. Courtesy of Cumberland Historical Society

In 1760, the original purpose of the royally decreed **King's Highway** was finally realized when a continuous road extended from York to Saco. In 1761 the road was upgraded to a military road and was commonly used as a mail delivery route. Mile markers, attributed to an order by Postmaster General Benjamin Franklin, were erected in the 1760s and once lined the roadway. Rare examples of these mile markers are still found in Cumberland. Following the Revolutionary War, this entire stretch of road from Kittery to Saco became known as the **Post Road**. Interestingly, the name King's Highway survives today in Kennebunkport.[29]

The **Lake Megantic Route,** a precursor to Route 27, followed a well-established footpath and portage system developed by the Native Americans and later used by European explorers, Jesuit missionaries, settlers, surveyors, and even the troops of the Benedict Arnold Expedition as they marched to Quebec in 1775. The existing path was improved and its original range extended circa 1777.[30]

The Coos Road marker on Winthrop Street in Hallowell reads: "Here passed the Coos Road opening to the early pioneers the interior of the country between Errol, New Hampshire and Hallowell, Maine."

Construction of the **Coos Road** began in 1792, and provided a route from Hallowell to the New Hampshire border. Charles Vaughn, an early settler in Hallowell, had the route surveyed with the hope of making Hallowell a thriving seaport. The intent was to encourage settlement in western Maine and provide access to inland resources. The road was passable only by foot or horse until 1822 when it was improved to allow for carriage traffic. Modern day Route 17, 133, and 156 follow parts of the Coos Road.[31]

Canals

In addition to roadways, canals were also being constructed in Maine. The primary purpose of a canal was to provide a more direct route between locations, sometimes for travel and navigation, but more often times

[28] Wood, 1919, 130.
[29] Jones, 1953, 15; B. Rodrigue and M. Hatuany, "Maine's FRENCH Communities: Historic Roadways" 1997, www.francomaine.org., Accessed 12 May 2011.
[30] Rodrigue and Hatuany, 1997.
[31] Ibid.; G. Varney, *A Gazetteer of the State of Maine* (Boston: B. B. Russell, 1886), 264.

for the transport of goods. In Maine, these canal ventures were concentrated largely on the commercial movement of lumber from more inland areas to the harbors along the coast for export.

The earliest canals in Maine were built at the turn of the eighteenth century. In 1791, the **New Meadows Canal** was constructed to connect Merrymeeting Bay to the New Meadows River (Bath/Brunswick area) and thereby provide a connection between Casco Bay and the Kennebec and Androscoggin Rivers. Such a connection had obvious appeal to inland timber merchants. In 1792, the first of several variations of the **Mousam River Canal** in Kennebunkport was constructed in an effort to improve navigation at the river's mouth. In 1793, the **Georges River and Knox Canals** were developed and served primarily to move lumber.[32]

Canal development and use in Maine continued throughout the nineteenth century. The economic advantages of long distance transport via canals, as opposed to inland roads, played a major role in canal development throughout the eighteenth and nineteenth centuries. This trend continued until the early to mid nineteenth century when canals were supplanted by an even more economical transporter—the railroads.[33] The following list contains canals that were active in Maine and includes their dates of operation, locations, and primary shipping or functional uses.[34]

1807–1869	**Moose Brook Canal**	Denmark to Saco River	Lumber
1811–c.1838	**Hancock Brook Canal**	Hiram, Hancock Pond to Saco River	Lumber
1815–1836	**Fryeburg Canal**	Fryeburg to Saco River	Flood control
1822	**Burnt Meadow Brook Canal**	Brownfield to Saco River	Lumber
1826	**Ten Mile Brook Canal**	Brownfield to Saco River	Lumber
1828–1845	**Piscataquis Canal**	Howland to Piscataquis River	Lumber Watercraft
1830–1870	**Cumberland and Oxford Canal**	Portland to Fore River	Lumber Freight
1835–1860	**Eastern River Lock and Sluice**	Orland, Eastern River	Lumber Watercraft
1838–1921	**Telos Canal**	Telos Lake to West Branch	Lumber
1840–1872	**Stillwater Canal**	Old Town	Lumber
1846–1869	**Penobscot River Navigation**	Old Town to Winn	Watercraft
1839–1904	**Seboomook Sluiceway**	Seboomook Twp to Moosehead Lake	Lumber

Turnpikes

The beginning of the nineteenth century marked the Turnpike Era in Maine. Within the course of five years, five major toll roads were constructed within the south-central portion of the state. All were built under Massachusetts rule, but were conveyed to Maine when it achieved statehood in 1820.[35] The toll roads were named turnpikes after the shape of the turnstiles located at the gated entrances and exits.

[32] H. L. V. Anderson, *Canals and Inland Waterways of Maine* (Portland, ME: Maine Historical Society, 1982), 23, 26, 31.
[33] Taylor, 1951, 55.
[34] Anderson, 1982.
[35] Wood, 1919, 211; Eastman and Rivard, 1995, 311–313.

How the Embargo Act, War of 1812, and Aroostook War Spurred Road Building in America

Despite gaining sovereignty at the end of the Revolutionary War, the United States still faced several significant political challenges during the early nineteenth century. In retaliation to the seizure of American ships and unfair trading practices by both the English and the French, Jefferson enacted the Embargo Act in 1807. Intended as a display of American independence, it dealt a heavy blow to the New England economy—despite the significant amount of smuggling and illicit trade that persisted. However, it also resulted in Americans establishing inland trade routes and upgrading the land-based transportation systems.[1]

The War of 1812 was declared by America against Great Britain for a number of reasons including British interference in American trade abroad, the Royal Navy's impressment of American citizens, and the British financial support of Native American battles against the settlers. As with the Embargo Act, the blockage of trade along the eastern seaboard had significant economic repercussions for the United States. Instead of relying on water-based routes, Americans were forced to use inland routes to transport goods and services—a task that was hampered by a poorly developed and connected roadway system. The American military was likewise plagued by a lack of infrastructure since it proved difficult to effectively dispatch troops to strategic military sites due to this lack of inland infrastructure. The link between natural defense and functional roadways became evident during that time and spurred an advocacy for road building in America following the war.[2]

The Aroostook War was a bloodless conflict which arose in 1838 between the United States and Great Britain over the placement of the international boundary. After preparation for war and contentious political moves, the modern boundary was agreed upon by both parties and formalized in the Washington Treaty of 1842. In Maine, significant investment was made in transportation systems leading to Aroostook County, including the 1832 Military Road from Bangor to Houlton and the 1832 Aroostook Road. Again, many of these efforts were in response to understanding the role of adequate inland transportation routes in ensuring national security needs.[3]

[1] *J. S. Leamon, et al., "Separation and Statehood" in* Maine: The Pine Tree State from Prehistory to the Present, *eds. R.W. Judd, et al. (Orono, ME: The University of Maine Press, 1995), 181; Smith, 2006, 50; Taylor, 1951, 17.*
[2] *D. R. Hickey,* The War of 1812: A Forgotten Conflict *(Chicago: University of Illinois Press, 1989), 457; J. Latimer,* 1812: War with America *(Cambridge, MA: Belknap Press of Harvard University, 2007) 637; Taylor, 1951, 18.*
[3] *B. Rodrigue, "Soldiers, Spuds, and Spruce: Maine's Military Roads to the Maritimes" in* Voyages: A Maine Franco-American Reader *(Gardiner, ME: Tilbury House, Publishers, 2007), 100, 102.*

Construction on the **Cumberland Turnpike** began in 1802 with the purpose of bypassing the broad Scarborough marsh. The turnpike was located solely within the town of Scarborough and connected the villages of Dunstan and Oak Hill via Scottow's Hill. While the actual distance between the two villages is only 1.5 miles, the distance on the bypass lengthened that to 2.5 miles, an acceptable increase on the part of the traveler as indicated by the toll records.[36] A portion of Route 1 now passes along that same alignment.

The construction of the **Camden Turnpike** also began in 1802. It took six years and nearly $6,000 to complete.[37] The road provided a link between Camden Harbor and Lincolnville Center, bypassing an earlier road that led over Megunticook Mountain and proved perilous for horseback travel, let alone any vehicle. Instead, the new roadway was constructed at the base of the mountain and out into the lake that lay directly at the foot of the mountain itself. Large rocks were dislodged from atop the mountain and allowed to fall directly below. Some of the rocks were moved by brute force, some by the use of explosives. The task continued until a retaining wall of sorts developed along the base. From that point, smaller stones and dirt were used to fill in behind the wall and form the road.[38] The portion of Route 52 from Camden to Lincolnville Center follows the original alignment of the Camden Turnpike.

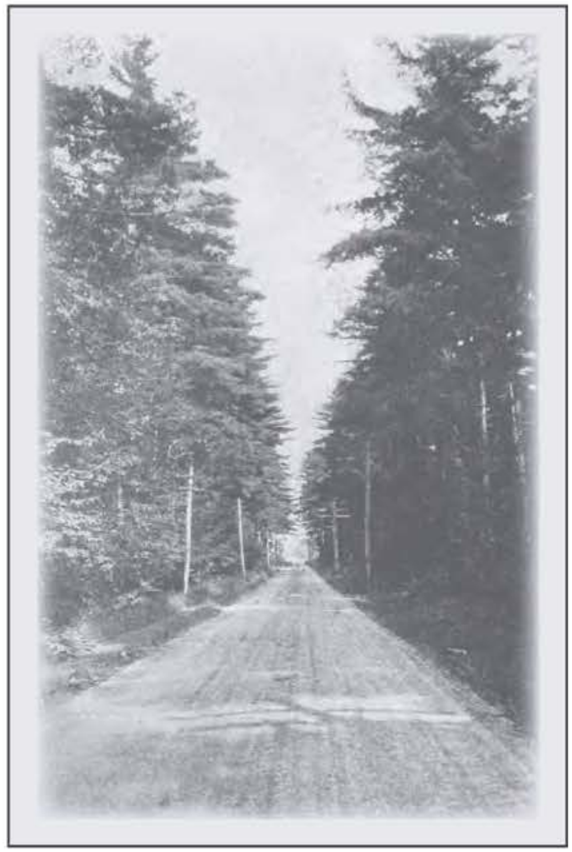
[36] Wood, 1919, 106, 110.
[37] Eastman and Rivard, 1995, 311–312.
[38] Wood, 1919, 104–105.

The **Wiscasset and Woolwich Turnpike** was chartered in 1803 and construction began in 1805. The road began in Wiscasset and terminated in Woolwich near Day's Ferry on the Kennebec River. Day's Ferry itself had been in operation at least 40 years before the turnpike was connected to it.[39] Modern U. S. Route 1 follows the same general alignment of the Wiscasset and Woolwich Turnpike.

A view of the Camden Turnpike along Megunticook Lake. Source: Wood, 1919

The **Bath Turnpike**, also known as **Governor King's Turnpike**, was incorporated in 1805 with construction beginning shortly thereafter. The roadway initiated at Bowdoin College in Brunswick and continued to Bath. It included a bridge crossing the New Meadows River which greatly increased the price of the entire undertaking. The 8-mile long project was built at a cost of approximately $16,800.[40] A portion of modern Route 1 includes this road segment.

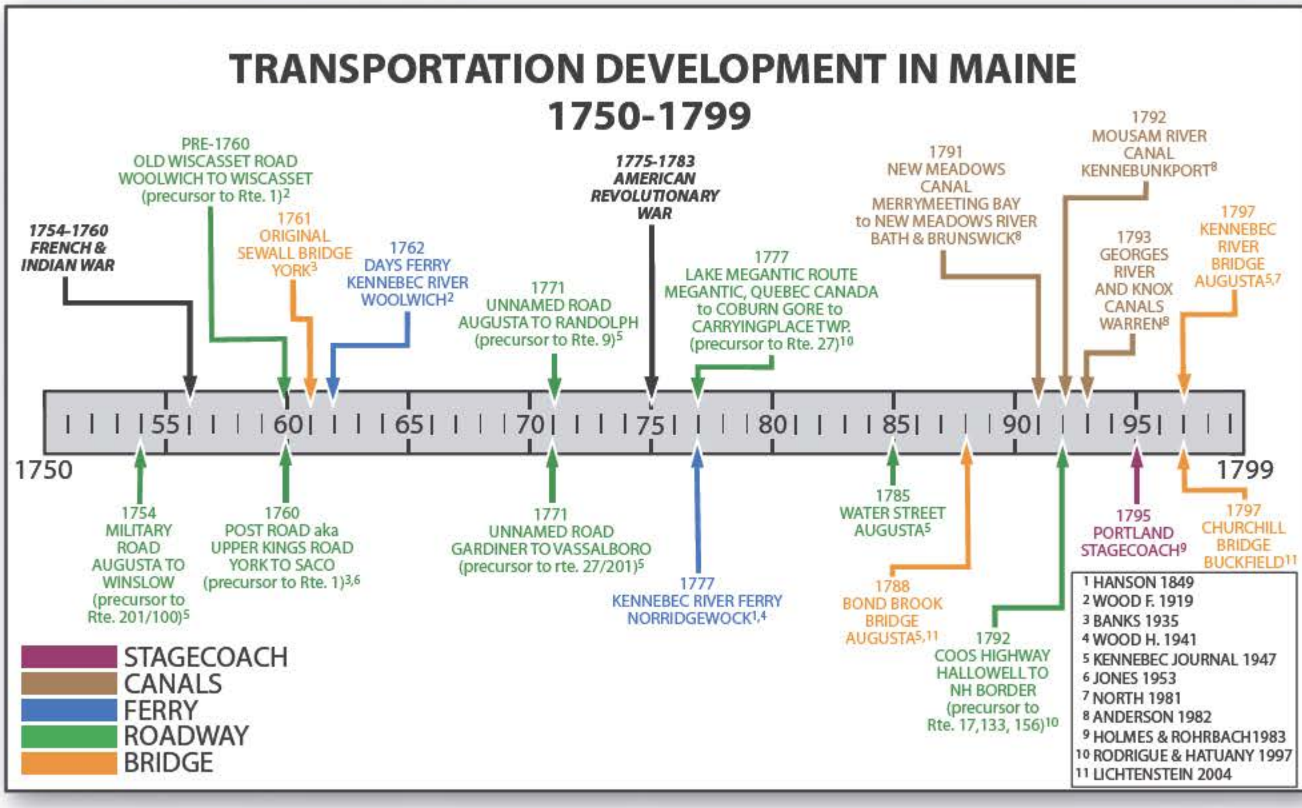
The **Wiscasset and Augusta Turnpike** Company was incorporated in 1803, but construction on the road did not begin until 1807.[41] The road was laid out to begin at the Wiscasset courthouse and end at the Kennebec River toll bridge, built in 1797, in Augusta. With the completion of the Wiscasset and Augusta Turnpike in 1807, a continuous roadway of forty-five miles existed between Augusta and Brunswick, strengthening Augusta's connection to Portland and Boston and likewise making northern destinations more accessible from central Maine.[42] This turnpike was a precursor to Route 27.



The Bath Turnpike runs through the Bowdoin Pines. Source: Wood, 1919

The construction of turnpikes provided improved, relatively well-maintained roadways for the traveler and purveyor of goods alike. Nonetheless, the collection of tolls did not always sit well with users and in an attempt to avoid payment, so-called 'shunpikes' were often created. The shunpikes usually involved a slight detour in the road made before arriving at the tollgate. Such a shunpike seemed to have developed along the Bath Turnpike. Here, several travelers from Brunswick apparently took advantage of the opportunity to leave the official turnpike at Cook's Corner and cross the river at Brown's Ferry via a pre-existing bridge, thereby avoiding having to pay a toll.[43]

[39] Ibid., 130; Eastman and Rivard, 1995, 313.
[40] Wood, 1919, 144.
[41] Eastman and Rivard, 1995, 313.
[42] Wood, 1919, 114.
[43] Ibid, 145



Frequent users of the turnpikes, such as stage coach drivers, often felt the burden of having to pay more regular and heftier tolls than other users. For example, on the Cumberland Turnpike, the rate for a one-horse wagon was 8 cents, but 25 cents for stages.[44] This discrepancy sufficiently enraged one stageline owner to build a several mile bypass of the turnpike, at his own expense, and across which he allowed free travel by all. The road was named "Paine Road" after its founder.[45]

On a national scale, turnpikes turned out to be financial failures. Long-distance travel via turnpikes simply was not economical. In New England, turnpikes met with a little more success, but even here the odds were low that a profit would be made. Out of the nearly 230 turnpikes built in New England, only five or six ever made a satisfactory return on their investments. The lack of profitability and the more economical modes of transport provided by canals and railroads eventually made turnpikes impracticable.[46]

Nonetheless, Mainers continued to have a need for improved roadways—both within settlements as well as between them. By the early nineteenth century, numerous towns within Maine had incorporated and cities such as Augusta and Portland were taking hold. Additionally, in 1820 as part of the Missouri Compromise, Maine separated from Massachusetts and became its own state. Statehood would lead to the need for additional infrastructure to spur economic development, encourage settlement, and even protect its sovereignty from bordering threats during the Aroostook War.[47]

[44] Ibid, 110.
[45] Ibid.
[46] Taylor, 1951, 27, 29.
[47] Rodrigue, 2007, 99–100.

Road Building in the 1700s–1800s

William Allen, a mid nineteenth-century author writing about Norridgewock, describes the slow evolution of road building between early settlements: "The first communication by land to a new settlement is usually by a 'spotted line.' The trees in the direction of the route are marked with an axe, by hewing off a chip on each side, at such distances that the spots can easily be seen from one tree to another, while the underbrush is slightly removed, so that a man can pass on foot with a pack. This work of marking the trees and cutting the bushes, requires a man two days to a mile. The path is sometimes used in this condition two or three years. The next step is to cut out a road so that a pack horse can pass in summer, or teams with sleds in winter, this requires about four days work to a mile. It is then called a sled road, and is used in that state two or three years. Then by expending six days work to a mile in building small bridges and causeways, and clearing out obstructions, it is made passable in a rough manner for carts with small loads. In this rough state the road is used until by the incorporation of the place a more thorough course of making a highway is adopted. After about seven years in the ordinary way the road becomes passable for carriages."[1]

[1] *W. Allen,* The History of Norridgewock *(Portland, ME: Thurston & Company, Printers, 1849), 132–133.*

Nineteenth-Century Roads

As had been done previously, many of the pre-established footpaths and horse trails were improved and made fit for carts and carriages. One such road was the **Canada Road**, a precursor to Route 201. Built between 1817 and 1818, the road extended from Parlin Pond in Jackman to Concord, New Hampshire. As opposed to earlier Maine roads, tree stumps were removed, holes were filled and brush was removed to a width of fifteen feet. The Canada Road served as the primary connection between Lower Canada and Maine from 1820 to 1860, before rail development proved more efficient.[48]

The **Airline Road,** a predecessor to Route 9, extended approximately 90 miles from Bangor to Calais. Originally known as the Schoodic Road or Black's Road, it was subsequently renamed the Airline Road in reference to the relatively high elevation at which the road was built. It was completed in 1822.[49]

Three significant roadways were built within the span of four years in the more northern portions of the state. The 1832 **Military Road** was built with the aid of the federal government to assert the country's sovereignty in that area as border conflict continued with Canada. The road stretched from Bangor to Houlton and allowed for the efficient movement of troops and supplies if the need arose.[50] That road now forms portions of Route 2.

In that same year, the **Aroostook Road**, 58 miles in length, was built to connect the villages of Molunkus and Masardis. Four years later, the **Madawaska Road** was built and covered the 46 miles between Madawaska and Fish River. By the 1840s an early network of roads had begun to link northern Maine to the rest of the state and provided a way to encourage settlement in that region.[51]

Stagecoach Travel

With the improvement of roadways at the turn of the nineteenth century also came the possibility of travel by carriage. Thus was born the era of the stagecoach. In 1785, the federal government employed stage-

[48] Rodrigue and Hatuany, 1997.
[49] Ibid.
[50] Ibid.
[51] Ibid.


During the nineteenth century, the Peabody Tavern in Gilead served travelers along the stagecoach line.

Taverns

With the advent of cross country travel came the need for places to rest and refuel. Although the roads were improving, and stagecoach travel was usually faster than travel by foot, the going was still slow by today's standards. On a good day, a traveler might hope to make a twelve mile journey on these roads.[1] Hence the call for taverns. Taverns provided a place for passengers to rest and eat. Sometimes it would be for a mid-day meal and short rest, other times for an overnight stay with dinner and breakfast. In addition to attending to the needs of the travelers, the taverns would also provide for the driver and his animals.

[1] Banks, 1935.

coaches to carry the mail. They remained the primary carrier for the next sixty years, ensuring regular employment in addition to their business of transporting passengers.[52]

The first stageline in Maine traveled from Portland to Boston and was established in 1795. For nearly a decade, Portland remained the northernmost terminal on the stagecoach line until it was extended to Augusta in 1806 and to Brunswick in 1810.[53]

The stagecoach network continued to branch out across Maine, with the industry reaching its peak in Maine between 1825 and 1845. Stagecoaches ran from Hallowell to Farmington via Winthrop, Dixfield, and Wilton, to Norridgewock via Waterville and Skowhegan, and to Bangor via Belfast. By 1825, the White Mountain route through Conway had been established. By 1832, Portland had twelve separate operating stagecoach lines. A stagecoach route began on the Airline Road, connecting Bangor and Calais in 1858.[54]

The Maine Stage Company and the Portland Stage Company were the dominant staging companies in Maine. Eventually, competition from the burgeoning railroads led to the decline of the stagecoaches in the latter part of the nineteenth century.[55] The Old White Mountain stageline was the last operating line in Maine from 1850 to its final run in 1869; however, stagecoaches continued to be used intermittently to transport summer visitors from the railroad depots to their hotels before the arrival of the automobile.[56]

Railroads

In addition to roadways and canals, railroads provided transportation opportunities across Maine beginning in the early nineteenth century. The 1830s marked the dawn of the Iron Horse in Maine. In 1832, the Maine legislature granted two railroad charters—one to the Old Town Railroad Company and the other to the Cal-

[52] Holmes and Rohrbach, 1983, 79.
[53] Ibid.
[54] L. C. Hatch, *Maine: A History* (New York: The American Historical Society, 1919), 699; Maine State Highway Commission, 1970, 4.
[55] Holmes and Rohrbach, 1983, 79.
[56] Jones, 1953, 29.

ais Railway Company. The Old Town Railroad Company completed their line first in 1836, an eleven mile long railway connecting the towns of Old Town and Bangor for the primary purpose of lumber transport. The first locomotive to run on those tracks was shipped from England, had wooden wheels, burned wood for fuel, and was appropriately named "Pioneer."[57]

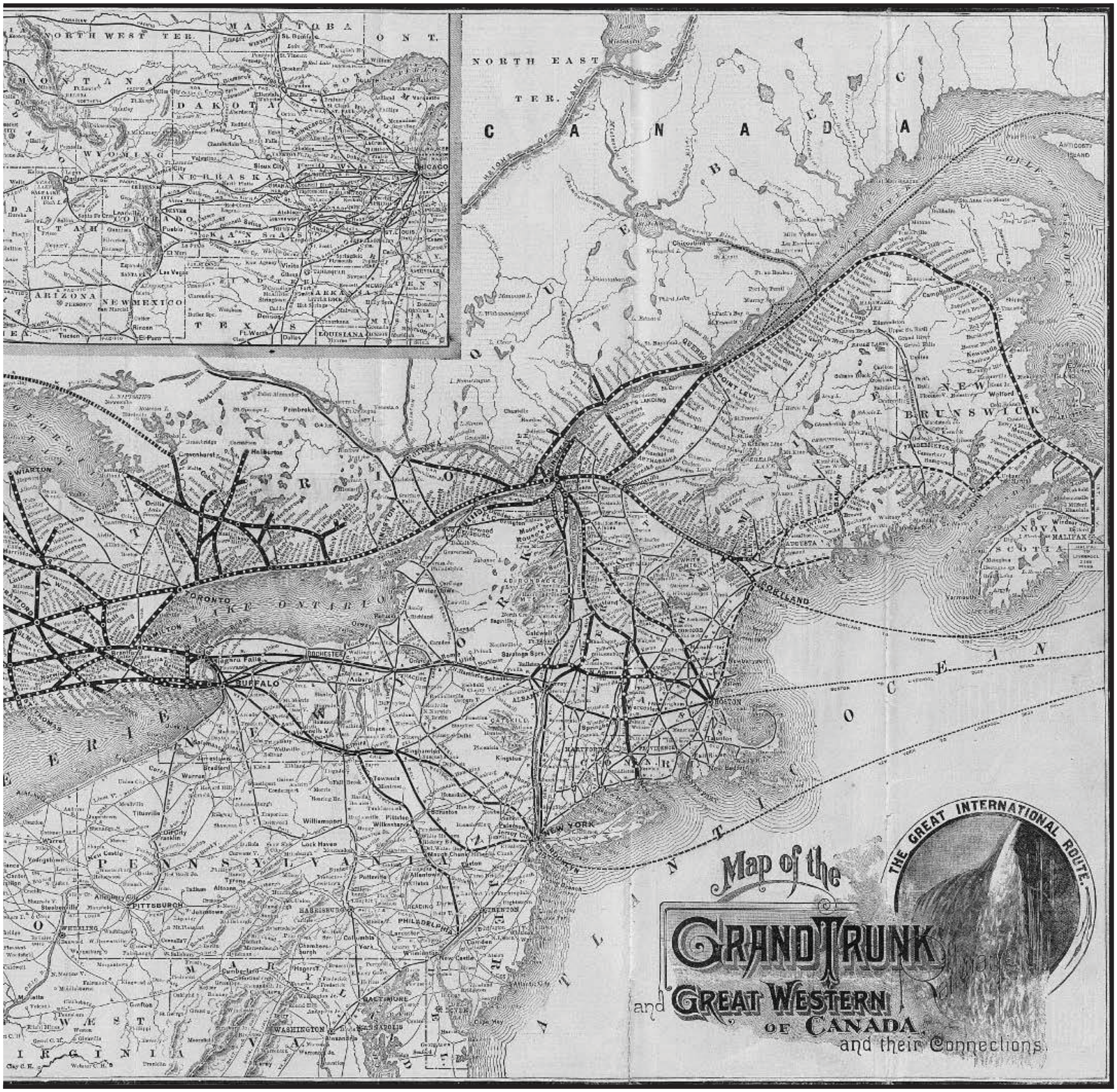
Soon after, the Calais Railway Company finished a two-mile stretch of roadway between Calais and Milltown to allow for lumber transport. However, unlike the Old Town line, the Calais line was operated completely by horse power until 1852 when a steam locomotive was purchased.[58]

Several lines were built during the following decades, such that between 1842 and 1909, there were thirty-one active railroad lines traversing the state.[59] The most historically significant lines are listed below.[60]

1836	**Old Town Railroad**	Old Town to Bangor
1838	**Calais Railway**	Calais to Milltown
1842	**Portland, Saco and Portsmouth Railroad**; **aka Shore Line**	Portland to Boston
1843	**Boston and Maine**	Boston to South Berwick; to Portland in 1873
1843	**Franklin Road**	Whitneyville to Machiasport
1846	**Grand Trunk Railway**	Portland and Lewiston to Montreal
1847	**Moosehead Lake Railway**	Moosehead Lake to Penobscot River; Northeast Carry Twp
1848	**Kennebec and Portland Railroad**	Portland to Skowhegan
1849	**Androscoggin and Kennebec Railroad**	Danville Junction to Waterville
1853	**Atlantic and St. Lawrence Railway (part of Grand Trunk Railway)**	Portland to Montreal
1855	**Penobscot and Kennebec Railroad**	Extending Androscoggin and Kennebec line to Bangor
1862	**Maine Central Railroad**	Danville Junction to Bangor
1867	**Belfast and Moosehead Lake**	Belfast to Burnham Junction
1868	**Knox and Lincoln Railroad**	Woolwich to Rockland
1873	**Somerset Railroad**	Oakland to Rockwood
1876	**Aroostook River Railroad**	Presque Isle to Aroostook Junction, New Brunswick
1882	**Maine Shore Line**	Brewer to Lamoine
1891	**Bangor and Aroostook Railroad**	Searsport to Van Buren, with numerous branch lines
1909	**Aroostook Valley Railroad**	Washburn to Presque Isle

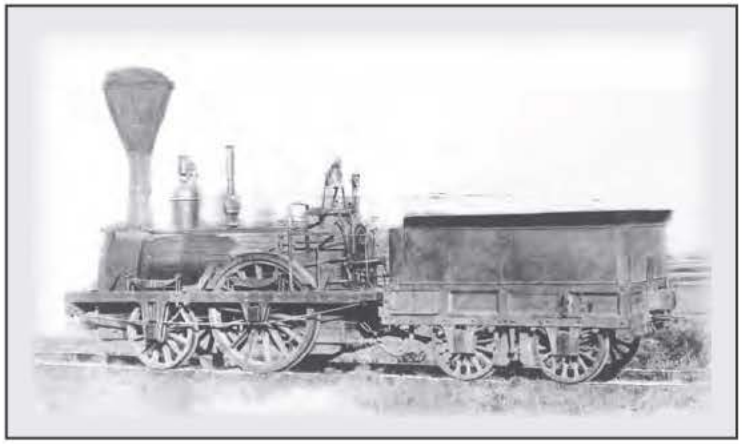
[57] C. J. Corliss, "Railway Development in Maine" in *Along the Rails: A Survey of Maine's Historic Railroad Buildings*, ed. K. F. Mohney (Portland, ME: Maine Preservation, 2000), 15.
[58] Ibid.
[59] State Highway Commission, 1970, 6.
[60] J. Holt, *The Grand Trunk in New England* (Toronto: Railfare Enterprises Unlimited, 1986), 176; Eastman and Rivard, 1995; Corliss, 2000; Lindsell, 2000.


LAKE SUPERIOR
MINNEAPOLIS
MILWAUKEE
MADISON
CHICAGO
DETROIT
TOLEDO
CINCINNATI
LOUISVILLE
BURLINGTON
SAN FRANCISCO



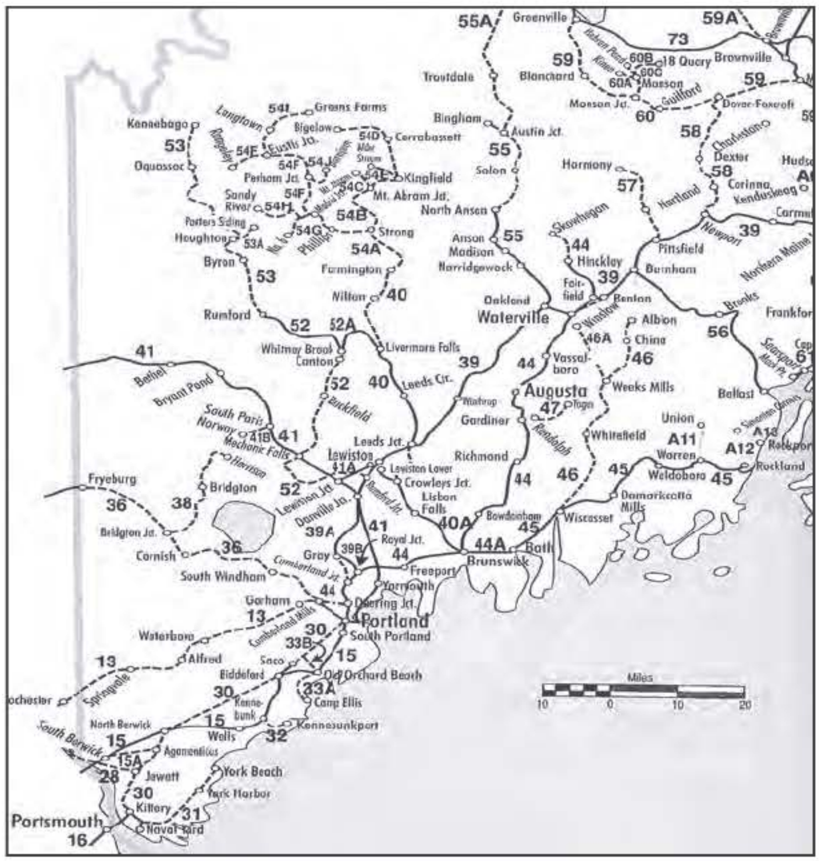
An 1885 map shows the extent of the Grand Trunk Rail Line from eastern Canada to the Great Plains of the United States. The Grand Trunk line connected to many railways in Maine and encouraged the development of Maine industries like wood products, timber, and agriculture. Courtesy of Maine Historic Preservation Commission

During the early development of railroads, the gauge (the width of the railroad tracks) varied greatly among competing lines. The lack of gauge standardization during the early days of railroad development made it difficult to link many of these lines. Different companies employed different widths to such an extent that in 1871, the United States had 20 different gauges of track ranging in size from three to six feet. In Maine, two main gauges dominated the scene—the broad gauge (5 feet 6 inches) and the narrow gauge (4 feet 8 1/2 inches). There was pressure from both sides to have the other convert, but by 1861 gauge standardization in Maine had begun. By 1878, the state's major lines had been converted to narrow gauge, also known as standard gauge. Secondary railroads in the state, however, built lines in a two-foot narrow gauge throughout the 1880s and into the twentieth century.[61]



The "Pioneer," built in 1832, was the first steam locomotive to operate in Maine. Courtesy of Bangor Museum and History Center

Railroads contributed significantly to Maine's economy. Trains facilitated the transport of goods, such as lumber and agricultural products, opened up significant tracts of land to settlement and played a significant role in transporting tourists to wilderness destinations throughout the state.



A modified map shows the locations of major railroads in southwest Maine. Source: Lindsell, 2000

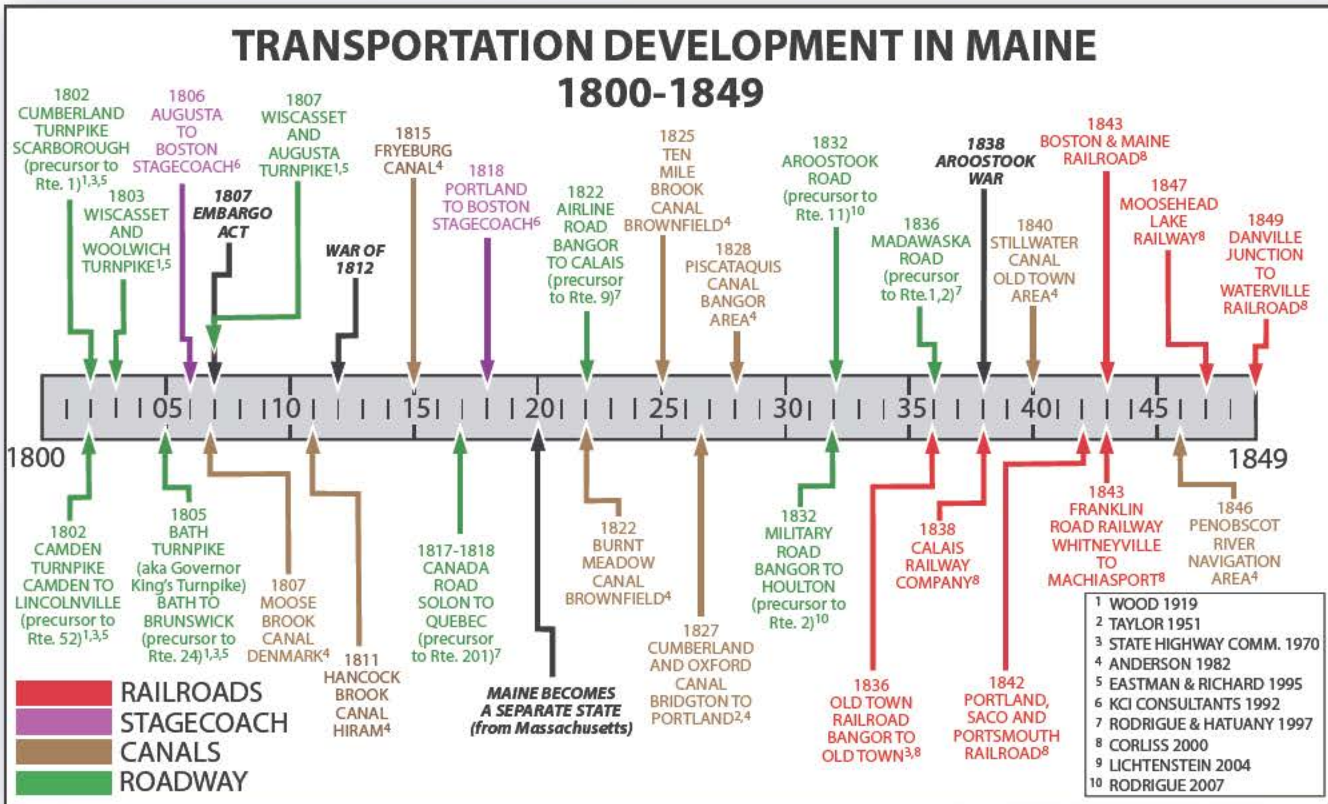
The railroads peak mileage of track occurred in 1924 at 2,380 miles. The improvement of roadways and introduction of the automobile in the twentieth century began to undermine the economic success of the railroads. Some of the railroads fell out of use and were abandoned, while others were purchased and became part of larger conglomerates. Iconic rail lines such as the Bangor and Aroostook Railroad and Boston and Maine Railroad greatly reduced routes throughout the twentieth century to remain competitive. Both rail lines managed to survive much of the twentieth century before being sold to other companies in the 1980s and 1990s.

[61] Corliss, 2000, 21–22, 24–26.

Today, Maine's railroad system is comprised of 1,860 miles of standard gauge track. The majority of rail use is for freight; however, the arrival of the Downeaster Train between Brunswick, Portland, and Boston and various excursion train routes across Maine, such as the Maine Eastern Railroad which runs between Brunswick and Rockland, are part of a trend towards increasing passenger rail travel.[62]

By the end of the nineteenth century, transportation systems in Maine had become well-developed with a network or roads and rails linking citizens within the state to each other and the rest of the region and nation. These transportation systems successfully encouraged the growth of the Maine's industrial pursuits, such as timber, wood products, manufacturing, agriculture, and tourism. From the early footpaths and dependence on rivers for travel, Maine's populace during the eighteenth and nineteenth centuries carved out more established roads and turnpikes, canals, and railroads. The twentieth century, however, would bring technological advancements, professional standards, and a state-run governing body to further promote, build, and improve transportation systems within Maine.

[62] Ibid., 32; Maine Department of Transportation, "History of Railroading in Maine," http://www maine.gov/mdot/freight/railroading-history.php, accessed 6 January 2012.


TRANSPORTATION DEVELOPMENT IN MAINE
1800-1849
1802 CUMBERLAND TURNPIKE SCARBOROUGH (precursor to Rte. 1)1,3,5
1806 AUGUSTA TO BOSTON STAGECOACH6
1807 WISCASSET AND AUGUSTA TURNPIKE1,5
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WAR OF 1812
1815 FRYEBURG CANAL4
1818 PORTLAND TO BOSTON STAGECOACH6
1822 AIRLINE ROAD BANGOR TO CALAIS (precursor to Rte. 9)7
1825 TEN MILE BROOK CANAL BROWNFIELD4
1828 PISCATAQUIS CANAL BANGOR AREA4
1832 AROOSTOOK ROAD (precursor to Rte. 11)10
1836 MADAWASKA ROAD (precursor to Rte.1,2)7
1838 AROOSTOOK WAR
1840 STILLWATER CANAL OLD TOWN AREA4
1843 BOSTON & MAINE RAILROAD8
1847 MOOSEHEAD LAKE RAILWAY8
1849 DANVILLE JUNCTION TO WATERVILLE RAILROAD8
1800
1849
1802 CAMDEN TURNPIKE CAMDEN TO LINCOLNVILLE (precursor to Rte. 52)1,3,5
1805 BATH TURNPIKE (aka Governor King's Turnpike) BATH TO BRUNSWICK (precursor to Rte. 24)1,3,5
1807 MOOSE BROOK CANAL DENMARK4
1811 HANCOCK BROOK CANAL HIRAM4
1817-1818 CANADA ROAD SOLON TO QUEBEC (precursor to Rte. 201)7
MAINE BECOMES A SEPARATE STATE (from Massachusetts)
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1827 CUMBERLAND AND OXFORD CANAL BRIDGTON TO PORTLAND2,4
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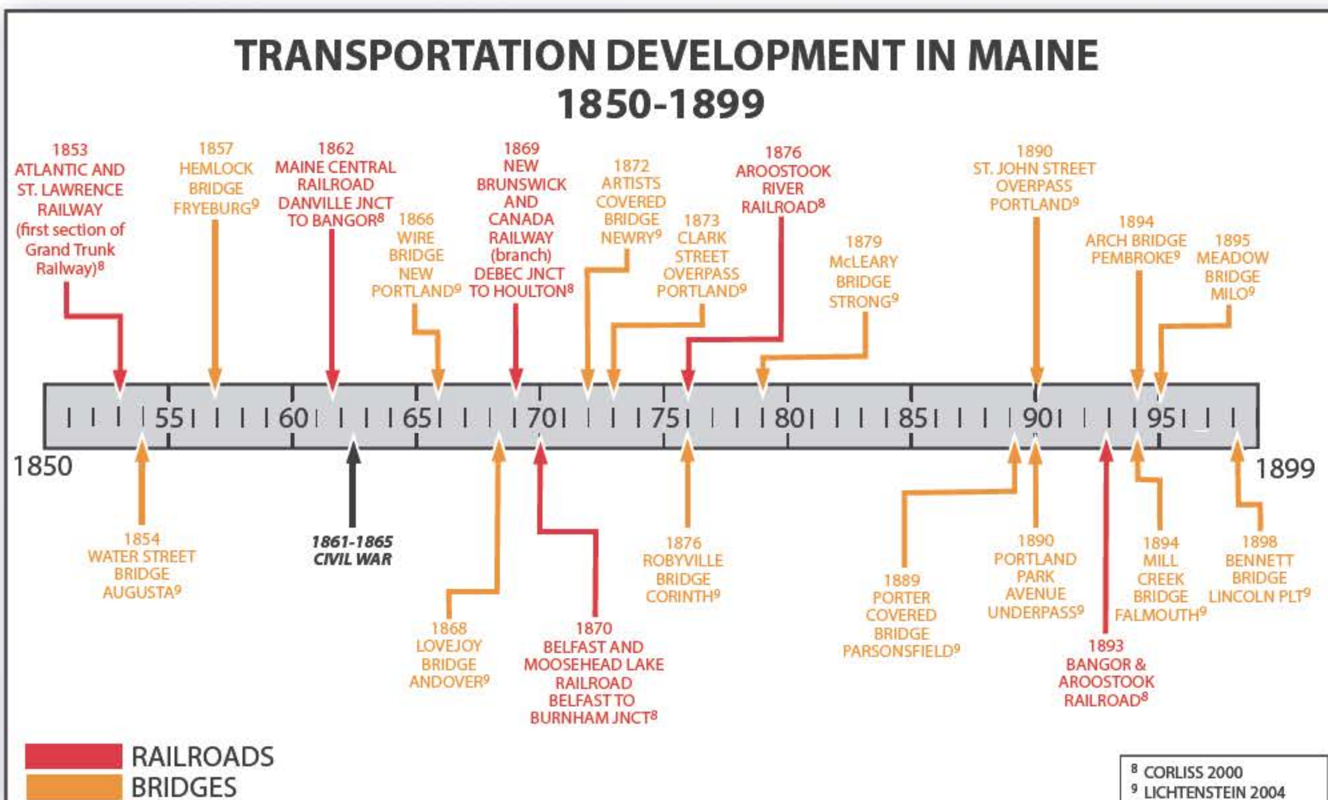
1836 OLD TOWN RAILROAD BANGOR TO OLD TOWN3,8
1838 CALAIS RAILWAY COMPANY8
1842 PORTLAND, SACO AND PORTSMOUTH RAILROAD8
1843 FRANKLIN ROAD RAILWAY WHITNEYVILLE TO MACHIASPORT8
1846 PENOBSCOT RIVER NAVIGATION AREA4
RAILROADS
STAGECOACH
CANALS
ROADWAY
1 WOOD 1919
2 TAYLOR 1951
3 STATE HIGHWAY COMM. 1970
4 ANDERSON 1982
5 EASTMAN & RICHARD 1995
6 KCI CONSULTANTS 1992
7 RODRIGUE & HATUANY 1997
8 CORLISS 2000
9 LICHTENSTEIN 2004
10 RODRIGUE 2007


TRANSPORTATION DEVELOPMENT IN MAINE
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1853 ATLANTIC AND ST. LAWRENCE RAILWAY (first section of Grand Trunk Railway)8
1857 HEMLOCK BRIDGE FRYEBURG9
1862 MAINE CENTRAL RAILROAD DANVILLE JNCT TO BANGOR8
1866 WIRE BRIDGE NEW PORTLAND9
1869 NEW BRUNSWICK AND CANADA RAILWAY (branch) DEBEC JNCT TO HOULTON8
1872 ARTISTS COVERED BRIDGE NEWRY9
1873 CLARK STREET OVERPASS PORTLAND9
1876 AROOSTOOK RIVER RAILROAD8
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1890 ST. JOHN STREET OVERPASS PORTLAND9
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RAILROADS
BRIDGES
8 CORLISS 2000
9 LICHTENSTEIN 2004

CHAPTER 2

Transportation in Maine Post-1900

Previous: Work crews pave a bridge across the Penobscot River connecting Verona Island to Bucksport in 1932.

Chapter 2

Transportation in Maine Post-1900

Margaret Bishop Parker
Stuart P. Dixon
Gabrielle M. Lanier
Lisa Churchill-Dickson

Early Highways in Maine—The State Initiatives

While Maine's railroad lines become more extensive and reliable, its roads were becoming worse, largely due to a general lack of planning and regular maintenance. The 1822 timber bridge across the Piscataqua River in Kittery was described as late as 1920 as a "quivering old wooden toll bridge."[1] Dirt roads in Maine typically became soft during regular rains and quagmires during the long spring thaw. Farmers needing to move crops quickly to market were often stymied by poor road conditions.

The Good Roads Movement that began in the late nineteenth century increasingly focused national attention on the deplorable condition of existing roads. The movement gained its most significant impetus in the 1880s and 1890s from large numbers of ardent and outspoken bicyclists. By 1884, bicycling had become a national craze, and cyclists took to the rural roads in increasing numbers. Once they encountered the deplorable condition of most of the rural roads, however, cyclists around the country, especially the League of American Wheelmen, launched a concerted public relations campaign to promote national public awareness of the need for better roads.[2]

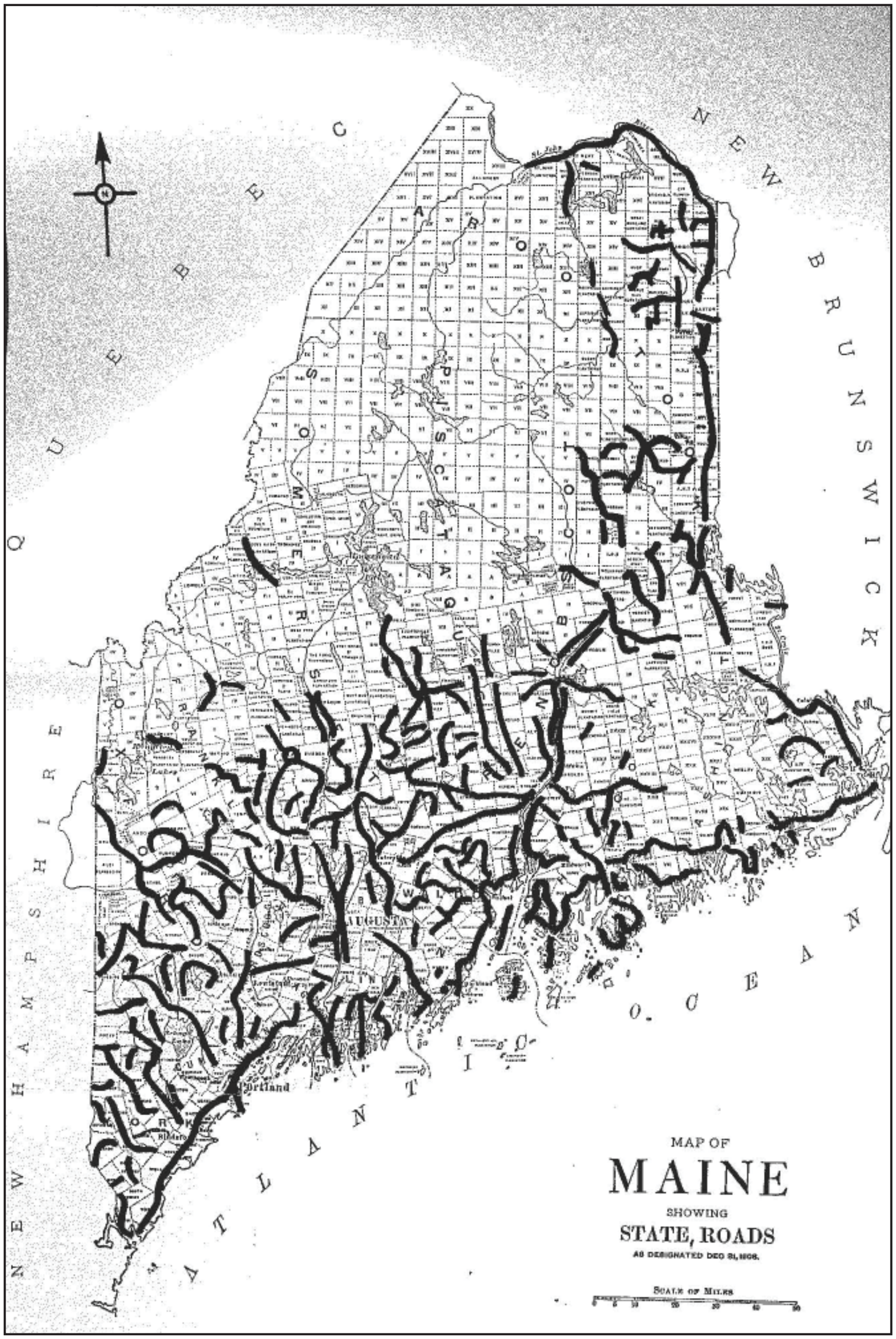
By the early twentieth century, as automobiles were becoming more common and trucks were beginning to be used for widespread distribution of both agricultural and manufactured goods, roads finally became a priority of the state government. Maine became increasingly aware of the need for state involvement in road building and maintenance as the need for a statewide highway system in Maine became apparent. In his inaugural address of 1901, Governor John F. Hill underscored the need for a statewide, state-funded highway system. The first official designation of a "state road" was described by law as the primary thoroughfare through a town.[3]

From an appropriation of $15,000, the state provided up to $100 for each town to use on their roads. To qualify for state aid, towns had to spend $100 on the portion of the state road that ran through the town, and the state would reimburse them. Twelve towns managed to build 2.5 miles of road with the funding boost provided by this state appropriation. By 1903, the total appropriation had been raised to $40,000. In 1905, the Office of Highway Commissioner was created.[4]

Paul D. Sargent, who was chosen as Maine's first Commissioner of Highways in 1905, adopted a systematic approach to statewide highway improvement. Sargent made uniformity, regular maintenance, and steady improvement of the state's roads his overriding goals. He suggested ways of improving country roads by

[1] Maine State Highway Commission, *A History of Maine Roads: 1600–1970* (Augusta, ME: Maine State Highway Commission, 1970), 5.
[2] Federal Highway Administration, *America's Highways 1776–1976: A History of the Federal-Aid Program* (Washington D.C.: United States Department of Transportation, 1976), 37–38.
[3] Maine State Highway Commission, 1970, 8; Federal Highway Administration, 1976, 43–44.
[4] Maine State Highway Commission, 1970, 9.

building new sand and clay roads and by landscaping, straightening, and widening existing roads. He advocated a system of regular maintenance that would be implemented by individuals with professional training in road work.[5]



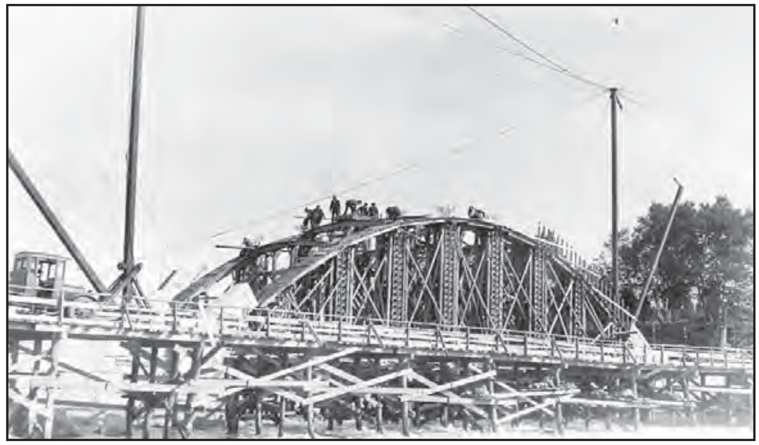
The State Highway Map of Maine from 1908 shows the fragmented and disconnected nature of major roadways at that time.

Maine's 73rd Legislature created the State Highway Department in 1907. By 1909, Commissioner Sargent was publicly advocating the development of the state's system of primary roadways in order to halt further highway deterioration and encourage the future development of Maine's tourist and summer resort industry. The automobile, on which the future of Maine's tourist industry depended, was wreaking havoc on existing state roads that had endured years of less destructive horse-drawn traffic. The dust raised by speeding automobiles was the main culprit; consequently, roads began to be surfaced with tar and asphalt with increasing frequency.[6]

A three-man State Highway Commission was created in 1913 to replace the State Highway Department. The newly-created organization, which consisted of Lyman H. Nelson, Philip J. Deering, William M. Ayer, and twelve additional employees, constituted a central coordinating agency with the authority to build and maintain a statewide highway system. Paul Sargent was chosen as the Chief Engineer of the State Highway Commission. The Commission immediately began to plan and survey for an interconnected statewide highway system. Although there were 1,342 miles of highway in the state system in 1914, few of these roads were connected. A map of Maine showing state roads as designated December

[5] Ibid., 9–10.
[6] Ibid., 11.

31, 1908 depicts the nature of the state's "highway system" and illustrates the need that existed for a network of connected roads.



Crews build a wooden framework in preparation for pouring the concrete for the tied thru arch during construction of the Blue Hill Falls Bridge in 1926.

Prior to the formation of the State Highway Commission, road construction had served local needs and had been controlled by the towns and cities. Roads seldom connected neighboring communities and were often of inconsistent design and construction. The Highway Commission aimed to serve both local and interstate travelers with its planned statewide highway system, and gradually implemented many of the elements and practices that form integral parts of the commission.[7]

The practice of regular highway patrol maintenance was initiated in 1916. Patrol maintenance involved placing designated portions of roadway under regular and systematic superintendence and maintenance. In 1916, the first year when any extensive patrol maintenance took place, 3,379 miles of roadways through 423 towns were superintended by 373 patrolmen.[8]

By the early twentieth century, motorized cars and trucks had become more common place; therefore many nineteenth-century bridges that had been designed to carry wagons and carriage could not accommodate these new forms of conveyance. Furthermore, the State Highway Commission had to step up maintenance as a result of the increase in the use of automobiles by tourists. Ancillary development resulting from both tourism and motor traffic entailed construction of motels and motor courts.[9]

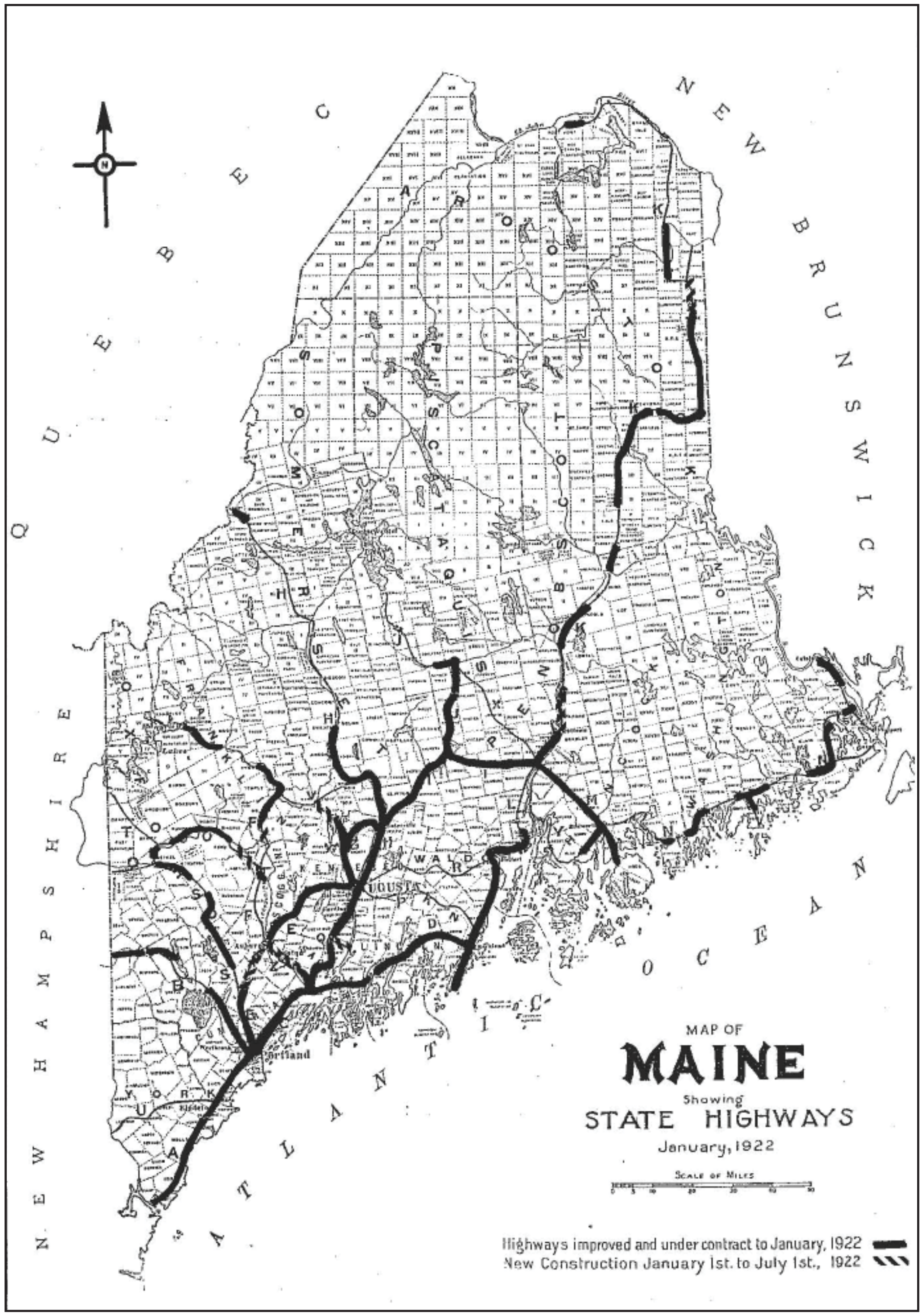
In 1915, Maine enacted the Bridge Act, a state law providing state and county aid for bridges constructed on main thoroughfares. This law was designed to promote proper bridge construction and to "put bridge building on state and state aid highways . . . on a thoroughly businesslike basis." The law provided for a division of the cost of the bridge between the counties and the state. Still, this law provided only for new construction. State aid for maintenance still had to be obtained by special resolves. An annual appropriation of $100,000 was initially provided to cover the cost of bridge construction begun under the 1915 Bridge Act, but by 1919, income from bond issues began to be apportioned for such efforts. In 1917, the first bridges were built under the new law.[10]

The Highway Commission was given the right by law to acquire private property by eminent domain for obtaining rights-of-way in 1913. In 1916 the United States Congress enacted a law that permitted states to draw federal aid for highways, but the money could only be secured on a matching funds basis. In Maine, adequate monies to provide the matching funds were provided by $8 million of new highway and bridge bonds authorized by the state legislature. Responsibility for highway costs was gradually transferred to the

[7] Ibid., 13.
[8] Ibid., 14.
[9] N. R. Lipfert, et al., "New Industries in an Age of Adjustment" in *Maine: The Pine Tree State from Prehistory to the Present*, ed., R. W. Judd, et al. (Orono, ME: University of Maine Press, 1995), 437–438.
[10] Maine State Highway Commission, 1970, 14–15; R. A. Wentzel, "Bridge Maintenance" (Augusta, ME: Maine State Highway Commission, c. 1965).

highway user through gasoline taxes and registration and license fees. In 1931, a General Highway Fund was established to provide funds for the building and maintenance of state and state aid highways, and interstate, intrastate, and international bridges. This law was repealed in 1937, when a new law was enacted authorizing the State Highway Commission to accept federal funds for improving secondary roads.[11]

During World War I, highway and other construction languished due to a widespread labor shortage. The Federal War Department authorized the construction of a highway along the Maine coast from Portsmouth to Calais, connecting through Portland, Brunswick, Rockland, Belfast, Bar Harbor, and Machias (current Route 1), and also requested the immediate completion of an interior route connecting Brunswick, Augusta, Waterville, and Bangor. Accordingly, Congress distributed road-building equipment including road machinery and motor vehicles to state highway departments. In 1921, the state built a garage and machine shop near the State House in Augusta to house and repair this equipment.[12]



The State Highway map of Maine in 1922 reveals an established and connected roadway system.

A 1922 map of state roads illustrates the progress that the State Highway Commission had made in connecting roads into a logical network extending into all but the most remote portions of Maine. This map also shows new construction initiated in the southwestern region of the state.

[11] Maine State Highway Commission, 1970, 15–18.
[12] Ibid., 18–19.

Llewellyn N. Edwards (1873-1952)

Llewellyn N. Edwards

Llewellyn Nathaniel Edwards was Maine's first state bridge engineer of record, serving from 1921 to 1928. He was born in Otisfield, Maine, the son of an apple grower. He received his Bachelor's degree in Civil Engineering in 1898, his Master's degree in Civil Engineering degree in 1901, and his doctorate in Engineering in 1927, all from the University of Maine. He began his career as a draftsman for the Boston Bridge Works and then held positions of increasing responsibility at the Boston & Maine Railroad, the Chicago & Northwestern Railway, the Grand Trunk Railway System of Canada, the City of Toronto, and the U.S. Bureau of Public Roads, where he wrote a technical pamphlet on the design and construction of bridge foundations. He then accepted the appointment at the Maine State Highway Commission.[1]

During Edwards' tenure at the State Highway Commission, he oversaw increasing uniformity in bridge design due to the evolution of bridge technology. While he was the state bridge engineer, the Bridge Division either designed or oversaw the construction of approximately 330 structures, and seventy-five percent of those were reinforced concrete slab or T-beam bridges, the most durable and economical for most spans up to sixty feet long. Many of the rest were steel truss bridges for spans over seventy-five feet long.

Edwards' commitment to providing the state of Maine with reliable, economical bridges did not preclude him from building less common bridge types when the site warranted it. He oversaw the construction of four handsome concrete thru arch bridges—the Blue Hill Falls Bridge in Blue Hill, the Chestnut Street Bridge in Lewiston, the Covered Bridge in Norridgewock, and the Fairbanks Bridge in Farmington (only the Blue Hill Falls Bridge and Chestnut Street Bridge remain). Edwards will most likely be best remembered for the most unique bridge of all: the Bailey Island Bridge in Harpswell, a cribwork bridge unlike any other in the world. His granite slab cribwork design fit the needs of a challenging site, providing a beautiful bridge to allow access to a previously isolated island.[2]

Edwards designed the one-of-a-kind Bailey Island Bridge, his most enduring and iconic structure.

After leaving the State Highway Commission, Edwards returned to Bureau of Public Roads, this time as a researcher where he explored the properties of concrete and wrote several technical guides. In 1934 he published an article "The Evolution of Early American Bridges," which eventually culminated in The Record of History and Evolution of Early American Bridge, *one of the few histories of bridge construction in the United States. He retired in 1943 and passed away in 1952 at the age of 79. His extensive papers are housed at the Smithsonian Institution and at the University of Maine's Fogler Library. The University of Maine honored Edwards when it built a wing on Boardman Hall. The Dr. Llewellyn N. Edwards Wing houses the departments of civil and mechanical engineering.*[3]

[1] Edwards, 1959, v, Lichtenstein, 2004, III-1, 11.
[2] Lichtenstein, 2004, III-1, 14, 16.
[3] Ibid., III-6–7; Llewellyn N. Edwards Papers, Special Collections, Raymond H. Fogler Library, University of Maine.

According to the 1924 Annual Report of the State Highway Commission, bridge construction work under the 1915 Bridge Act was hampered by the lack of funds to cover the state's portion of the cost of construction. A flood in May 1923 destroyed a large number of bridges (no specific number was noted in the report) and resulted in the filing of numerous petitions for aid. Several large bridge structures were reconstructed during 1924. Although the number of bridges placed under construction did not drop dramatically because of the limited funds available, the report noted that most of the structures consisted of relatively small projects, most less than 50 feet long.[13]

As the century progressed, the State Highway Commission became concerned with more than the construction and maintenance of roads and bridges. In 1919, state highway routes began to be marked with distinctive color bands and punctuated with highway warning signs. Numbered route markers began to appear on Maine roads by 1925, and in the same year, the State Highway Commission issued the first official Maine road map. The U.S. system of road markers, which standardized route markers and guide signs throughout the country, was officially adopted in 1926. The State Highway Commission also began counting traffic in 1926 in order to determine use statistics and surface requirements. An effort to keep Maine roads passable throughout the winter began in the 1920s, although salt was not used to control ice and snow until the 1950s.[14]

By 1929 the State Highway Commission maintained a 20,000-mile network of "trunk" highways, major roads that linked various regions of the state together.[15] Farmers were more interested in the development and improvement of "market roads" which led from the farm to the nearest village or railhead. The state faced similar pressure from both industrialists who demanded better intercity routes and tourist industry advocates who requested improvement of the coastal routes. During the 1920s, the state used limited funds from state bond issues and automobile license fees to expand the road system. The impact of the increase in automobile usage was felt by railroads, streetcars, and steamboats. For example, railroad passenger service dropped from 4 million in 1920 to 1.9 million in 1927, and to 375,000 in 1933; freight revenues declined by almost half between 1920 and 1933. Transportation improvements focused on the highways, which were increasingly supported by both state and federal funding.[16]

The Legislature amended the Bridge Act in 1929, limiting its application to bridges on the state, state-aid, or third-class highway systems. This amendment implied that state funds should only be used on bridges with a regional significance to traffic movement and that bridges serving localities should be the responsibility of those municipalities. The Legislature also amended the law to provide that towns with a population of 4,000 or less, the state would be responsible for the cost of bridges built on state highways. By 1931, the State Highway Commission was required to maintain all bridges on the state highway system located in municipalities with populations of 10,000 or less. Two years later the state was required to maintain all bridges on state highways regardless of the size of the community.[17]

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[13] Ibid., 78.
[14] Ibid., 19–21.
[15] Condon, et al., "Maine in Depression and War" in *Maine: The Pine Tree State from Prehistory to the Present,* ed., R. W. Judd, et al. (Orono, ME: University of Maine Press, 1995), 509.
[16] Ibid., 509–510.
[17] *Acts and Resolves as Passed by the Eighty-fourth Legislature of the State of Maine, 1929* (Augusta: Kennebec Journal Company, 1929), 50–52; *Acts and Resolves as Passed by the Eighty-fifth Legislature of the State of Maine, 1931* (Augusta: Kennebec Journal Company, 1931), 72; *Acts and Resolves as Passed by the Eighty-sixth Legislature of the State of Maine, 1931–1933* (Augusta: Kennebec Journal Company, 1933), 268.

Chapter 2

Federal Aid and Relief Programs

During the Depression, Maine turned to the federal government for relief from the growing unemployment of the state's residents. The first relief program to be passed by Congress was the Civilian Conservation Corps (CCC), established in April 1933. In return for food, lodging, and $30 per month, young men (and later young women) worked on various conservation-related projects. The nearly 16,000 youths who belonged to the CCC in Maine between 1933 and 1944 were supervised primarily by the Maine Forest Service. In addition to planting trees, completing much of Maine's section of the Appalachian Trail, working at the eradication of pests, and constructing campgrounds, the CCC built 400 miles of roads.[18]

Another relief scheme started in 1933 was the Federal Emergency Relief Program, which granted funds to a state authority. The authority provided grants to localities with some of the funds and also supervised a number of work-relief projects, ranging from construction to sewing garments and preserving historical records. The Federal Emergency Relief Program and the Works Progress Administration, established in 1935, contributed local labor and expertise to build roads and bridges throughout the state.[19]

Beginning in 1933, the State Highway Commission annual reports began noting bridge construction projects that were financed wholly or in part with federal funds. Thirteen bridges benefited from U.S. Public Works money in 1933. Throughout the 1930s and 1940s, funding for the construction, repair, or reconstruction of numerous bridges received federal aid either from financial subsidies or labor contributions. Financial programs included U.S. Public Works projects, U.S. Works Program Grade Crossing projects, U.S. Public Works Administration projects, and U.S. Works Program Flood Replacement projects. As noted above, labor for the construction of some bridges was provided by the Works Progress Administration.

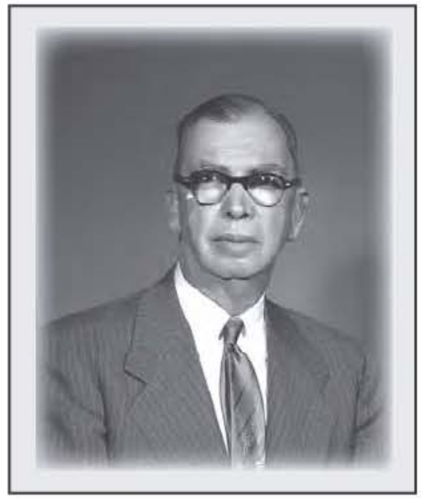
The 1936 Annual Report includes a table listing the twenty-six bridges which were severely damaged as the result of the extensive flood of March 1936. The report notes that the reconstruction of these bridges were U.S. Works Program Flood Relief projects and were handled under the jurisdiction of the Bureau of Public Roads, U.S. Department of Agriculture. All bridges were placed under construction in 1936 and are listed below and on page 43.[20]

Town	**Bridge Name**	**Bridge Type**	**Length (Ft.)**	**Waterway**
Auburn-Lewiston	South Bridge	Warren thru	723	Androscoggin River
Bangor	Bulls Eye	Warren thru	210	Kenduskeag Stream
Biddeford-Saco	New County Road	Warren thru	365	Saco River
Biddeford-Saco	Somesville	Stringer	344	Saco River
Brownfield	Covered	Warren thru	329	Saco River
Canton	Schoolhouse	T-beam	28	Whitney Brook
Clinton	Sebasticook	Warren thru	184	Sebasticook River
Columbia	Lowes Iron	Stringer	72	Pleasant River
Columbia	Saco	Stringer	62	Pleasant River
Detroit	Village	Warren thru	88	East Branch Sebasticook River
Dresden	Middle	Warren thru	260	Eastern River
Frankfort	Boyd	Stringer	32	Meadow Stream
Frankfort-Monroe	Lord	Stringer	72	Marsh Stream

[18] Condon, et al., 1995, 517.
[19] Ibid.
[20] Maine State Highway Commission, *Annual Report*, 1936, 95.

Max L. Wilder (1894-1962)

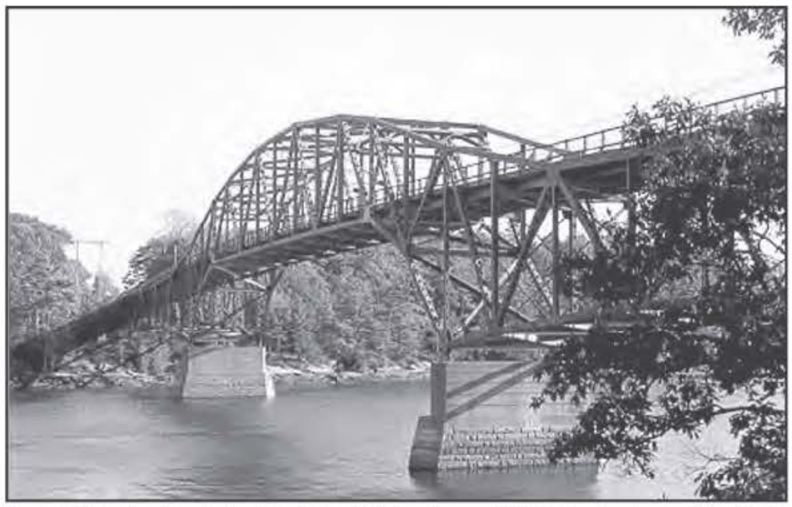
Max Lincoln Wilder was the second state bridge engineer in Maine, serving from 1929 to 1962. Wilder was born in Augusta in 1894 and received his bachelor's degree in Civil Engineering from the University of Maine in 1914. Paul D. Sargent, Maine's first Commissioner of Highways and first Chief Engineer of the Maine State Highway Commission, recruited Wilder as one of the first engineers in the Commission, shortly after he graduated from college.



Max L. Wilder

Wilder became the second state bridge engineer in 1929. Wilder started in the position on the threshold of the Great Depression and oversaw the Bridge Division through most of the tumultuous events of the twentieth century, including the Depression and the New Deal programs; the floods of 1936, which damaged or destroyed an estimated 150 bridges in Maine; the Second World War; post-war economic growth; and the expansion of the bridge program.

Despite these upheavals and their impact on the state bridge-building program, Wilder provided the division with an extraordinary level of stability. Like his predecessor Llewellyn Edwards, Wilder relied on conservative bridge designs throughout most of his time as the leader of the bridge division and kept up with national standards of bridge construction, although his term was not without innovation. He designed the only three cantilever truss bridges in the state in the late 1940s and early 1950s in Augusta, Arrowsic, and Caribou. Moreover, some nationally-prominent engineers designed notable bridges on his watch, including David B. Steinman, who designed the Waldo-Hancock (1931) and Deer Isle-Sedgwick bridges (1939), and J. A. L. Waddell and Shortridge Hardesty, who designed the Carlton Bridge (1927) in Bath, a vertical lift span bridge (now bypassed). In addition, Wilder supervised one of the first bridge preservation efforts undertaken by a state agency in the United States, the rehabilitation of Sewall's Bridge in York in the early 1930s.



Max Wilder designed the 1950 Max Wilder Memorial Bridge in Arrowsic, which was named after him posthumously in 1963.

Max Wilder was an engaging writer and dynamic speaker about bridges and other transportation issues. The Maine Better Transportation Association (MBTA) has memorialized his abilities as a communicator in their Max L. Wilder Award, given to the individual who is voted the best speaker at the annual Maine Transportation Conference.[1]

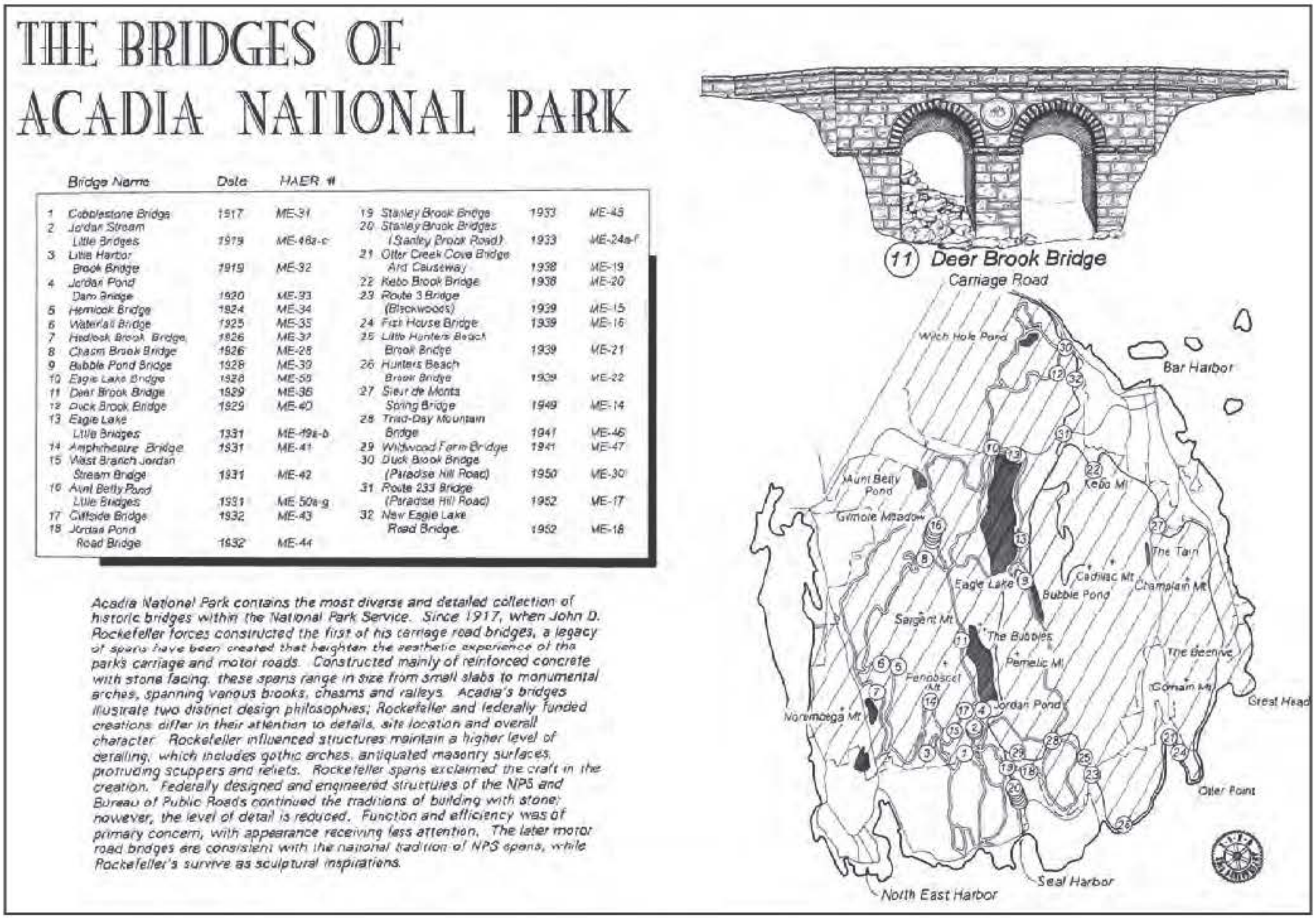
[1] *Lichtenstein, 2004, III-1, 3, 8, 17–30; "MBTA Celebrates 70: The Whys of Transportation,"* Maine Trails Magazine, *October-November, 2009.*

Town	Bridge Name	Bridge Type	Length (Ft.)	Waterway
Gardiner	Lower Rolling Dam	T-beam	29	Rolling Dam Stream
Hollis-Buxton	West Buxton	Warren thru	607	Saco River
Limington-Standish	Steep Falls	Warren thru	226	Saco River
Lisbon-Durham	Durham	Warren thru	363	Androscoggin River
Milford	First Otter Stream	Stringer	66	Otter Stream
Milford	Second Otter Stream	Warren	210	Otter Stream
Naples	Edes Falls	Stringer	70	Crooked River
Rumford	Morse	Tied thru arch	279	Androscoggin River
Sumner-Hartford	Hodgdon	Stringer	73	East Branch Nezinscot River
Warren	Starrett	Stringer	95	St. George River
Windsor	York	Stringer	55	West Branch Sheepscot River
Winslow-Waterville	Ticonic	Girder	517	Kennebec River
Yarmouth	Davis Landing	Concrete slab	17	West Branch Cousins River

In 1937, a law was passed to provide for a survey of state highways in order to gather information on traffic, road use, and road conditions. The result was the formation of the Planning Division within the State Highway Commission, which was responsible for compiling this information into accessible reports and producing an annually updated road map. A Traffic Division, formed in 1938, was responsible for signage, pavement markings, traffic studies, and surveys of hazardous, and an Accounting Division, charged with controlling the Commission's funds, was established in 1940.[21] The 1940 Annual Report stated that the State-Wide Highway Planning Survey begun in 1937 was suspended in June 1940 due to the lack of funds. The planning survey, 89 percent complete at the time of its suspension, collected data on traffic trends. The report stated, "It is apparent that demands from Federal agencies, State agencies and others for information gathered by this survey will make it necessary to eventually carry the highway planning as a continuing activity."[22] Although bridges were not specifically mentioned in the description of the planning survey and its related activities, the gathering of data on traffic, road use, road conditions, signage, and surveys of hazardous locations probably included the identification of bridges as well as roads. For example, recognition of heavy traffic over a particular road may have contributed to the recommendation to repair, strengthen, or replace a bridge (or bridges) on that road.

While the Great Depression was gripping most of the country, privately-funded development was occurring on Mount Desert Island as part of the newly-formed Acadia National Park. Between 1914 and 1940, John D. Rockefeller, Jr. conceived, planned, and funded a carriage road system. This project reflected the ethic of using private wealth for public enjoyment and conservation and illustrated Rockefeller's belief that modern infrastructure could be built without spoiling the natural surroundings. The interest in building carriage roads resulted from the public's passion for pleasure driving, a new form of recreation that came about during the first several decades of the twentieth century. The early 1900s saw the trend of park design move toward the picturesque style, which dictated curved walks and roads to fit these elements into the landscape. Rockefeller hired local Maine engineers Charles P. Simpson, his son, Paul D. Simpson, and Walter G. Hill to survey and supervise the road construction. Architects William Welles Bosworth and Charles Stoughton designed most of the bridges.[23] Many of the bridges, such as Hemlock, Waterfall and Duck Brook, were

[21] Maine State Highway Commission, 1970, 22.
[22] Maine State Highway Commission, *Annual Report*, 1940, 23.
[23] W. D. Rieley and R. S. Brouse, "Historic Resource Study for the Carriage Road System for Acadia National Park, Mount Desert Island, Maine." North Atlantic Region, National Park Service, U. S. Department of the Interior, 1989, 2–3, 8.



THE BRIDGES OF ACADIA NATIONAL PARK

	Bridge Name	Date	HAER #
1	Cobblestone Bridge	1917	ME-31
2	Jordan Stream Little Bridges	1919	ME-48a-c
3	Little Harbor Brook Bridge	1919	ME-32
4	Jordan Pond Dam Bridge	1920	ME-33
5	Hemlock Bridge	1924	ME-34
6	Waterfall Bridge	1925	ME-35
7	Hadlock Brook Bridge	1926	ME-37
8	Chasm Brook Bridge	1926	ME-28
9	Bubble Pond Bridge	1928	ME-39
10	Eagle Lake Bridge	1928	ME-55
11	Deer Brook Bridge	1929	ME-36
12	Duck Brook Bridge	1929	ME-40
13	Eagle Lake Little Bridges	1931	ME-49a-b
14	Amphitheatre Bridge	1931	ME-41
15	West Branch Jordan Stream Bridge	1931	ME-42
16	Aunt Betty Pond Little Bridges	1931	ME-50a-g
17	Cliffside Bridge	1932	ME-43
18	Jordan Pond Road Bridge	1932	ME-44
19	Stanley Brook Bridge	1933	ME-45
20	Stanley Brook Bridges (Stanley Brook Road)	1933	ME-24a-f
21	Otter Creek Cove Bridge And Causeway	1938	ME-19
22	Kebo Brook Bridge	1938	ME-20
23	Route 3 Bridge (Blackwoods)	1939	ME-15
24	Fish House Bridge	1939	ME-16
25	Little Hunters Beach Brook Bridge	1939	ME-21
26	Hunters Beach Brook Bridge	1939	ME-22
27	Sieur de Monts Spring Bridge	1949	ME-14
28	Triad-Day Mountain Bridge	1941	ME-46
29	Wildwood Farm Bridge	1941	ME-47
30	Duck Brook Bridge (Paradise Hill Road)	1950	ME-30
31	Route 233 Bridge (Paradise Hill Road)	1952	ME-17
32	New Eagle Lake Road Bridge	1952	ME-18

Acadia National Park contains the most diverse and detailed collection of historic bridges within the National Park Service. Since 1917, when John D. Rockefeller forces constructed the first of his carriage road bridges, a legacy of spans have been created that heighten the aesthetic experience of the park's carriage and motor roads. Constructed mainly of reinforced concrete with stone facing, these spans range in size from small slabs to monumental arches, spanning various brooks, chasms and valleys. Acadia's bridges illustrate two distinct design philosophies; Rockefeller and federally funded creations differ in their attention to details, site location and overall character. Rockefeller influenced structures maintain a higher level of detailing, which includes gothic arches, antiquated masonry surfaces, protruding scuppers and reliefs. Rockefeller spans exclaimed the craft in the creation. Federally designed and engineered structures of the NPS and Bureau of Public Roads continued the traditions of building with stone; however, the level of detail is reduced. Function and efficiency was of primary concern, with appearance receiving less attention. The later motor road bridges are consistent with the national tradition of NPS spans, while Rockefeller's survive as sculptural inspirations.

The bridges of Acadia National Park have been documented by the Historic American Engineering Record (HAER). Courtesy of HAER, National Park Service, Joe Korzeniewski, 1995.

granite-faced structures with concrete cores. The system also included three rustic timber bridges (Jordan Stream Bridge path, east side of Eagle Lake, and Chasm Brook) which were built on stone or concrete piers with heavy steel beams under the planking and adz-hewn timber rails.[24]

During the late 1930s, another phase of road-building took place in Acadia National Park. With the help of federal funding and in conjunction with Rockefeller, the National Park Service, and the Department of Agriculture's Bureau of Public Roads, a motor road system was constructed.[25] Most of the roads were designed by the National Park Service with the assistance of Kidde Construction Company, White Engineering Company, and landscape architect Frederick Law Olmsted, Jr. The motor road system utilized bridges to cross streams throughout the park and to eliminate "at grade" intersections of the Motor Roads with state and county roads and carriage roads. The bridges were constructed of concrete faced with stone; two early bridges included Kebo Brook, built c.1938, and Otter Cove Causeway, built in 1939. Other bridges were constructed in the same style after World War II, including the Duck Brook and Paradise Road bridges built in 1952.[26]

[24] Ibid., 272–275.
[25] H. E. Foulds and L. G. Meier, "Compliance Documentation for the Historic Motor Roads, Acadia National Park," (Washington, D.C.: Federal Highway Administration, 1993), 42.
[26] Ibid., 45, 62.

Maine Transportation Systems in the Post-War Era

A riveter works on the Deer Isle-Sedgwick suspension bridge in 1939.

During World War II, much Highway Commission activity was curtailed by lack of funds, materials, and labor. In 1942, only twelve bridges were placed under construction.[27] Restrictions were even tighter in 1943, when just three bridge projects (one replacement as a result of flood damage and two reconstruction projects for traffic problems) were approved and undertaken. War damage insurance was taken out on five bridges and guards were placed on the Waldo-Hancock Bridge, Carlton Bridge between Bath and Woolwich, Badger Island Bridge on Route 1 in Kittery, and Memorial Bridge over the Piscataqua River, in conjunction with the New Hampshire Highway Department. Guards on all but the Carlton Bridge were removed in February 1944.[28] Other activities carried out by the State Highway Commission during the war years included the construction of flight strips, roads and bridges to provide access to military and naval reservations, industrial defense plants, and sources of raw materials.[29]

Although restrictions on bridge construction relaxed after the war, the number of projects remained small as a result of a dramatic rise in unit costs to nearly seventy percent over pre-war costs. Despite rising costs, a surge in highway construction and a concerted effort to make up for deferred maintenance was initiated in the post-war years. Flood conditions and other damage caused by the hurricanes of August and September 1954 resulted in the reconstruction of fourteen bridges; however, the specific bridges were not named in the report.[30]

The Maine Turnpike

The inability of Route 1 to accommodate the increasing tourist traffic in southern Maine led to the development of the Maine Turnpike. In 1941, the Maine State Legislature created the Maine Turnpike Authority (MTA) to "construct, operate and maintain a turnpike at such location as shall be approved by the State Highway Commission."[31] In 1947, MTA opened forty-five miles of controlled access four-lane highway from Kittery to Portland. Eight years later, in 1955, the second leg of the Turnpike was opened to extend the road to Augusta. The total length of the turnpike is 106 miles, stretching from Kittery to Augusta. The MTA is still in existence today and continues to operate as an independent entity.

[27] Maine State Highway Commission, *Annual Report*, 1942, 32.
[28] Maine State Highway Commission, *Annual Report*, 1943, 44–48; Maine State Highway Commission, *Annual Report,* 1945, 55.
[29] Maine State Highway Commission, 1943, 10.
[30] Maine State Highway Commission, *Annual Report*, 1947, 57; Maine State Highway Commission, *Annual Report*, 1955, 41.
[31] Maine State Highway Commission, 1970, 23–26, 29–30.

The Interstate

Passenger cars pause to pay a toll to cross the Joshua L. Chamberlain Bridge between Bangor and Brewer. The bridge remained a toll bridge into the 1960s. Courtesy of Bangor Museum and History Center

In 1956, the National Interstate and Defense Highway System, which permitted federal funds to be allocated for interstate highways such as the section of I-95 that traverses Maine, was enacted. The Interstate Highways were intended to connect the principal metropolitan areas, cities, and industrial centers of the eastern United States. The first link in the Maine system included a nine-mile section from Freeport to Brunswick which opened in November 1957. The focus then shifted to constructing portions of the road from Augusta northward to the Canadian border. Eight sections of the road were put in service during the following decade, culminating in the opening of the Medway to Oakfield section (forty-one miles long) in November 1967. Two portions of the road (Augusta to Fairfield in 1961 and Bangor to Newport in 1965) were selected in a contest as "America's most scenic highway." The contest also recognized the State Highway Commission's imaginative way of designing a road that would blend with the landscape and capitalize on the area's natural beauty. During the 1970s, the focus shifted to constructing interstate sections in the southern portions of the state and widening two-lane sections to four lanes.[32]

The Maine Department of Transportation

Division offices of the State Highway Commission were established throughout the state beginning with the first office in Presque Isle in 1948. Augusta continued to serve as the administrative headquarters for the Commission. In 1951, offices were established at six other locations: Ellsworth, Bangor, Fairfield, Rockland, Scarborough, and Dixfield. Shortly thereafter, a radio network was installed to link division offices, headquarters in Augusta, and mobile equipment. In 1953 the chairmanship of the State Highway Commission was made a full-time chief administrative position with a seven-year term.[33] The Maine State Highway Commission, which had been officially formed in 1913, changed its name to the Maine Department of Transportation on July 1, 1972.

The Environmental Movement

During the 1960s and 1970s, there was a growing awareness of the environmental impacts associated with all types of development, especially transportation. Several keystone environmental laws were drafted and passed during this time, forcing a fundamental change in the planning and development of all federally-funded undertakings or actions subject to federal approval. The National Historic Preservation Act of 1966, U.S. Department of Transportation Act of 1966, National Environmental Policy Act of 1970, Clean Air Act

[32] Ibid., 29–30.
[33] Ibid., 26.

of 1970, Endangered Species Act of 1973, and Clean Water Act of 1977, to name a few, introduced a regulatory stringency to the environmental impact analysis that was formerly lacking. Under these new regulations, transportation agencies had to lay out the purpose and need of the project, engage potential stakeholders early on in the planning process, and ensure that reasonable efforts had been undertaken to avoid, minimize, or mitigate harm to the protected resources.

In 1956, vehicles approach and exit the 1931 Waldo-Hancock Bridge in Prospect.

Both the National Historic Preservation Act and Section 4(f) of the Department of Transportation Act of 1966 provide protection to historically-significant resources. Consideration of historic status must be applied both to those resources that are bordering the travel way, as well as those that are integral parts of the transportation system itself, such as toll booths, railroad stations, and bridges.

Unlike other historic resources, there is an expectation that a bridge—even a historic bridge—will eventually need to be either rehabilitated or replaced to meet the needs of the traveling public. Before replacing a historic bridge, the transportation agency must demonstrate that there is no feasible and prudent alternative that avoids and minimizes harm to the structure. If the analysis determines that the bridge must be replaced, then the agency must develop mitigation that is commensurate with the level of impact and the value of the resource impacted.

This book, *Historic Bridges of Maine,* was developed as part of the mitigation package for the replacement of the former Waldo-Hancock Bridge. The bridge was a significant example of its type and design both in-state and nationally, and played a vital role in the development of the tourism industry in mid-coast Maine. Recognizing the significance of the structure, as well as the inability to adequately repair it, the Federal Highway Administration, MaineDOT, and the State Historic Preservation Officer worked together to develop an appropriate level of mitigation for its replacement.

Transportation Infrastructure in Present Day Maine

Maine's modern transportation infrastructure still relies heavily on highways and roads; there are approximately 22,762 miles of public roads in the state. However, other modes of travel and transport have recently received a boost through the passage of the Intermodal Safety and Transportation Efficiency Act (ISTEA) in 1991. The ISTEA and subsequent transportation bills set aside funds which encouraged the development of pedestrian trails and bikeways, as well as investment in other modes of transport including rail, shipping, and buses.

Over the last twenty years, the MaineDOT has participated in the development of approximately 180 miles of off-road, dedicated pedestrian trails and bikeways throughout the state. The MaineDOT has also been involved with purchasing abandoned or unused rail lines with the goal of reestablishing freight and/or passenger services along those lines. Examples include the Rockland Branch, Calais Branch, and the "Lower Road" rail line which runs from Brunswick to Augusta.

Investment in airport development and the expansion of bussing infrastructure have increased significantly during the same period. As have the investments in waterborne transport and shipping services. In addition to running the Maine Ferry Service, MaineDOT was also instrumental in establishing a high speed ferry, The Cat, as well as building several deep sea cargo ports along the coast.

Despite the effort to diversify, the majority of the modern day transportation system in Maine still relies heavily upon petroleum-fueled, road-based vehicles to transport people and goods. Roadway bridges play a significant part in maintaining a smooth connection across the terrain and ensuring continuity in travel and transport. How the structure and function of those bridges evolved, and their role in the overall development of the state's infrastructure, is the subject of the next chapter.

CHAPTER 3

Bridge Building in Maine

Previous: The Chisholm Park Bridge, an open spandrel reinforced concrete arch bridge in Rumford, is shown under construction in 1930.

Bridge Building in Maine

Mary McCahon
J. Patrick Harshbarger
Sara K. Martin

The story of bridge-building in Maine is the story of how bridge-builders, be they laypersons or professionally trained engineers, found ways to construct crossings over waterways and terrain. Further, it is the story of how the profession of engineering evolved from its beginnings in the nineteenth century until the present day; responded to the standardization of technology, materials, and practices; and created ever-more complex and stable structures in more difficult environments. It reveals how Mainers solved local problems with local materials and expertise and also how they used national and international trends and applied them to regional engineering challenges. Mostly, the story details how these bridge-builders devised ingenious solution to challenging problems.

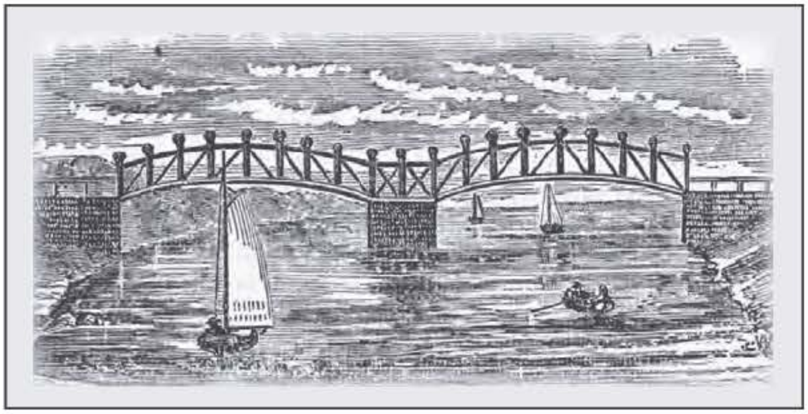
While historical and engineering accounts provide a broad outline for bridge construction in the United States, a close examination of the bridges in Maine provides documentation from which to build a narrative of their history. In 1903, the Maine Assessor's Department undertook a bridge inventory. The Maine Department of Transportation conducted two inventories of the existing bridges in the state, one in 1924 and one from 1999 to 2001, to gather information about bridges in Maine. The latter two surveys—the General Bridge Survey of 1924 and the Maine Department of Transportation Historic Bridge Survey—detail concrete evidence of the types and locations of bridges built in Maine, lending a glimpse into the bridge-building history of Maine from the eighteenth century through the mid-twentieth century. The availability of materials, as well as the evolving ability to manipulate them and the technical expertise to create new forms, led to the development of new bridge types. The surveys show that while Maine's bridge builders often followed national trends, sometimes they led the way, and other times they created genuinely unique solutions to complex problems.

One example of how local ingenuity provided a unique solution to crossing a significant waterway is the construction of the Kennebec River Bridge in 1797. Timothy Palmer, an early designer of timber trusses, designed the bridge. Like earlier bridges, Palmer's Augusta bridge used a variety of locally available building materials. It was comprised of two 210-foot spans with a single stone pier between the spans that rested on a wooden foundation that had a floor of heavy timbers and was filled with stone ballasts; the abutments were also built of stone. The framework of the bridge was painted white and upright timbers were capped with large balls. Construction of the bridge began in May 1797 and cost $27,000 (nearly $350,000 in current dollars). The bridge helped lead to the expansion of the town and coincided with Augusta's appointment as the county seat of Kennebec County and thus the beginnings of its eventual designation as the state capitol.[1]

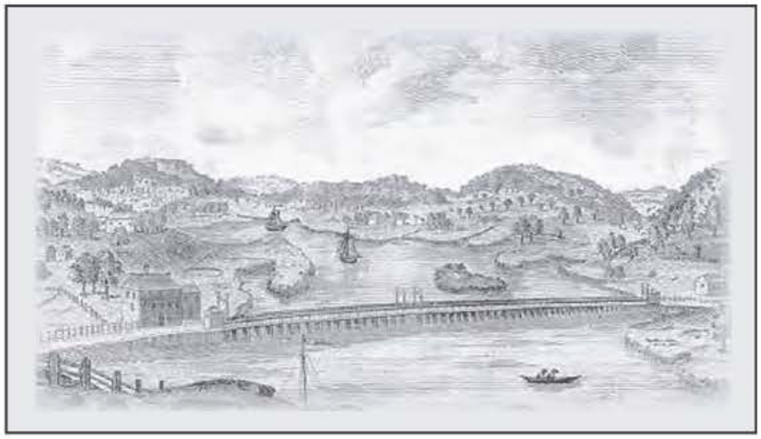
Furthermore, the bridge's place in the economic growth of Augusta and its impact on local residents is emblematic of the affect bridges can have on their surrounding communities. In her diary, Martha Ballard, a midwife from Hallowell, Maine, chronicled the construction of the Kennebec River Bridge, the first bridge

[1] KCI Engineering Consultants, "Maine Statewide Historic Bridge Inventory: Final Phase I Survey Plan" (Augusta, ME: Maine Department of Transportation, 1997), II-21–22; L. T. Ulrich, *A Midwife's Tale: The Life of Martha Ballard, Based on Her Diary, 1785–1812* (New York: Vintage Books, 1990), 227.

to cross the Kennebec River in Augusta in the late eighteenth century. On September 9, 1797, amidst an entry about caring for an infant with a cold and a visit to her son, Ballard wrote, "The middle pier of the Kennebec Bridge was finished and there were seven discharges of the field piece and three cheers." A couple of months later she describes the dedication of the bridge, where the celebration nearly turned dangerous: "The Kennebec Bridge was dedicated. Mr. Ballard and son Cyrus attended. David Wall, James Savage & Asa Fletcher were burnt some by the cartridges taking fire through carelessness." Ephraim Ballard, Martha's husband, was undoubtedly interested in attending the dedication, as he had done survey work for the bridge before work on it began.[2]



The first bridge to span the Kennebec River in Augusta was built in 1797. Source: James W. North, History of Augusta, Maine.



Samuel Hill created this 1790 engraving of the "Bridge over the Mystic River." The bridge was built in 1630 in Medford, Massachusetts. Courtesy of Library of Congress

Early Timber Bridges

Early Maine colonists were preoccupied with providing for their daily needs and preparing for Maine's long, cold winters within their settlements rather than constructing roads between villages, so their early bridges were simple. Moreover, the political climate of the region, including conflict among settlers and the French and their native allies, precluded much permanent road or bridge building. In addition, Maine's rich water and timber resources made the region's rivers and streams the primary mode for transportation, especially for moving lumber from the interior to coastal ports. As the population grew and market towns were established, road networks between settlements increased, requiring bridges to cross waterways.[3]

The first documented timber bridges constructed in the English colonies were built in the seventeenth century. The first of these—and possibly the first recorded bridge constructed in North America by European setters—was a toll bridge across the Mystic River in Medford, Massachusetts in 1630. At least three early Maine bridges were built in York. The first documented reference to one of the bridges was in 1653, which noted a small bridge already in place over the northwestern branch of the York River. The others were built in 1661 and 1664. All of these early bridges were utilitarian.[4]

[2] Ulrich, 1990, 227. The Kennebec River Bridge was dedicated on November 21, 1797. The quotes have been edited for spelling.
[3] L. N. Edwards, *A Record of History and Evolution of Early American Bridges* (Orono, ME: University Press, 1959), 20–21; KCI, 1997, II-8; R. W. Judd, et al., eds., *Maine: The Pine Tree State from Prehistory to the Present* (Orono, ME: The University of Maine, 1995), 52–70, 97–142, 310–319.
[4] KCI, 1997, II-18–19; Edwards, 1959, 26–27; C. E. Banks, *History of York, Maine*, vol. II (Boston: The Calkins Press, 1931) 2, 292–293, 296.

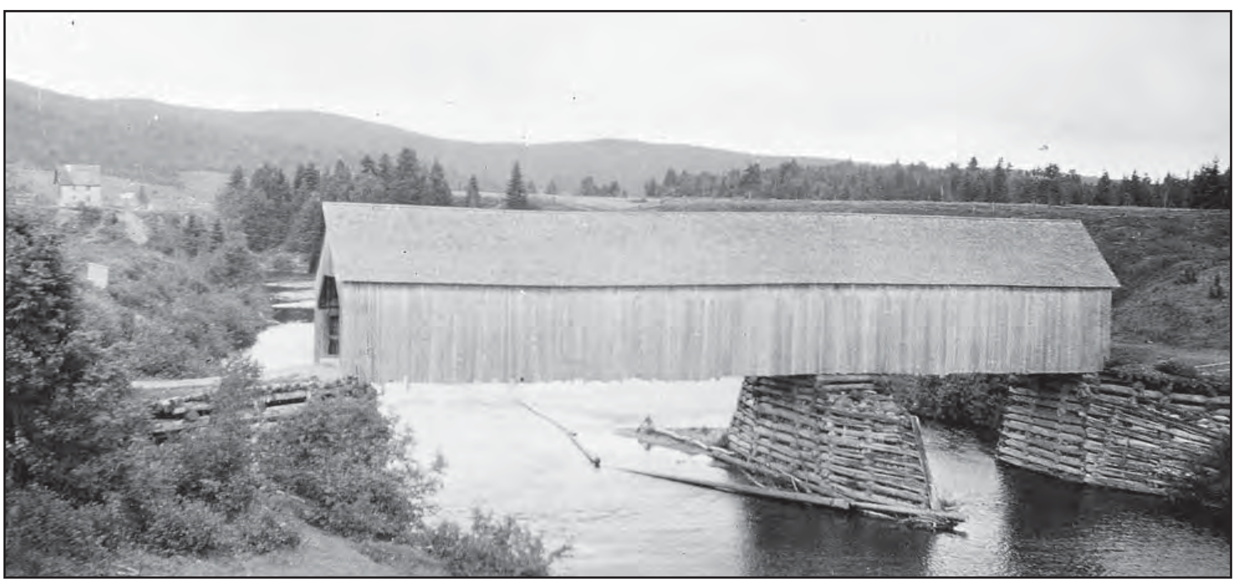
Timber Abutments and Piers

Earley's Bridge, built in 1937 in Willimantic, is a steel stringer bridge supported by a timber crib abutment.

Although stone was more commonly used for substructures, craftsmen often used a variety of materials when constructing bridges, including timber. Though timber crib abutments typically supported a wood stringer span, this substructure type was also used to support other varieties, from wood truss bridges to steel stringers, as seen in the Little Black River Bridge in Allagash Plantation and Earley's Bridge in Willimantic.[1]

Timber piles embedded into the riverbed were the crudest type of bridge supports. The next step in bridge construction was the construction of wooden abutments. These featured a face and two wing walls laid horizontally, forming a partial crib, with anchor timbers driven into the approach embankment. The interior of the crib was commonly filled with fieldstone and earth. Early wooden piers employed the same construction methods found in crib abutment construction. Cribs were often filled with stone ballast and other materials that would not be scoured away by water currents, so that they would remain strong and stable. Although most piers were completely filled with stone to resist freshets, ice floes, and water-borne debris, some piers were occasionally filled only with sufficient ballast to anchor the pier, thereby allowing the force of floodwaters to carry them away. More substantial piers consisting of hewn logs with dovetail-notched interlocking corners, transverse struts, and diagonal braces evolved from simple timber cribbing over time.[2]

Due to the short life of timber in a wet environment, and the fact that timber piers are more susceptible to being washed out by flooding than stone, wood cribbing tended to be replaced by stone as the nineteenth century progressed. Nonetheless, timber cribbing continued to be used in bridge substructure construction well into the twentieth century as an efficient and inexpensive—though somewhat transitory—construction option, especially in rural areas where timber was the easiest material to transport to a remote crossing.



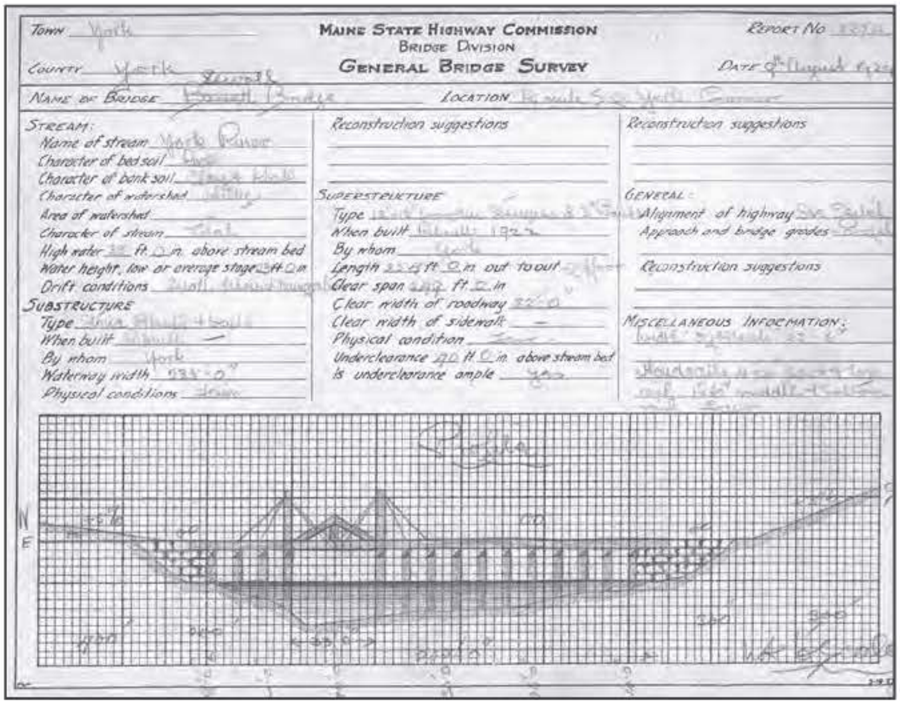
The Little Black River Bridge, shown here in 1924, in Allagash Plantation was a wooden truss bridge supported by a wood stringer span and timber crib piers and abutments. It was replaced in 1956.

[1] *Maine State Highway Commission, "General Bridge Survey" (Augusta, ME: Maine State Highway Commission, 1924).*

[2] *Edwards, 1959, 23–27; Allen, 1957, 34.*

Sewall's Bridge

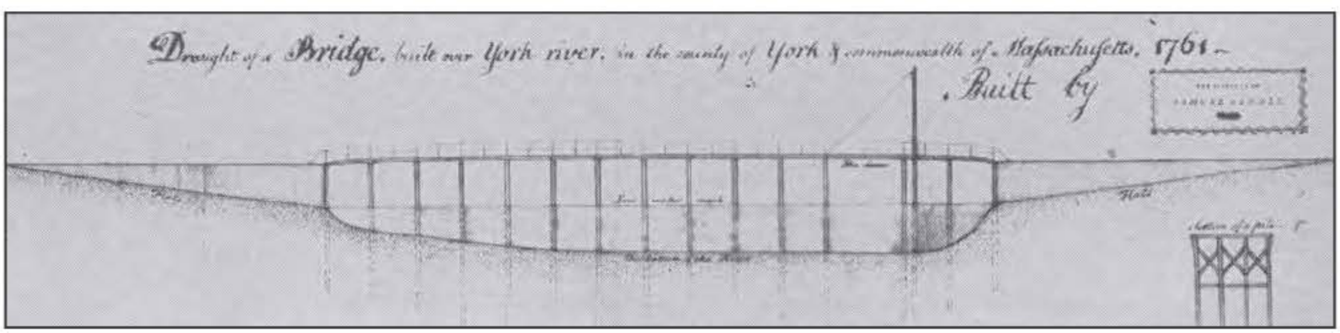
In 1761 Major Samuel Sewall, a civil engineer, designed and built the first bridge across the York River in York. The Sewall family had operated a ferry across the York River during the eighteenth century, and Sewall desired a safer way to cross the river. He decided to build a timber pile bridge. He determined the necessary length for each timber pile by probing the river bottom with a long pole tipped with iron. Sewall dropped heavy oak logs onto the timber piles to drive them into the river bottom. The bridge totaled 270 feet in length and was 25 feet wide supported by thirteen timber piles. The bridge featured a drawbridge, which had a counterweight to lift the span.[1] Uniquely, Sewall's Bridge was the first timber pile trestle structure designed in the United States based on a survey of its site and with a surviving construction record.



In 1924 MaineDOT inventoried many of its bridges, including Sewall's Bridge. The form includes basic information about the bridge's construction and design and a profile sketch.

Sewall's Bridge stood for almost 175 years, an unprecedented length of time for a timber pile structure. In the 1930s York's residents responded with concern to the notice that Sewall's Bridge would be replaced and fought to see it faithfully reconstructed. The Maine State Highway Commission agreed and built a structure closely resembling Sewall's design: a fixed span with steel stringers, a timber pile substructure, timber stringer superstructure, and wood plank deck. The bridge was completed in 1934.

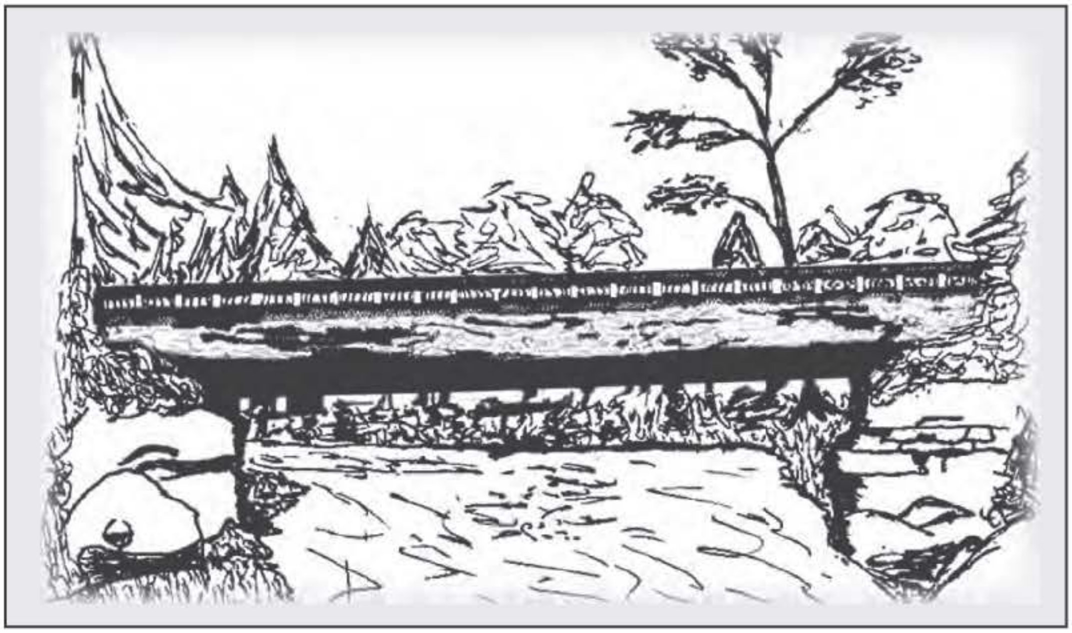
The bridge is considered the first historic preservation bridge project undertaken by a state agency in the United States. The American Society of Civil Engineers designated Sewall's Bridge a Maine Historic Civil Engineering Landmark in 1986.[2] In 2011 Sewall's Bridge received additional rehabilitation sensitive to its design.



Major Samuel Sewall drew and colored this detail plan of his bridge over the York River in York. The original bridge was built in 1761 and replaced in 1934 with a bridge faithful to Sewall's design. Courtesy of the Old York Historical Society

[1] *W. W. Clayton, History of York County, Maine (Philadelphia: Everts & Peck, 1880), 227; S. Morse, "Sewall's Bridge has storied history," 3 November 2011. http://www.seacoastonline.com, accessed 26 March 2012.*

[2] *MaineDOT, "Sewall's Bridge York, Maine," http://www.maine.gov/mdot/historicbridges/otherbridges/sewallsbridge.htm, accessed 26 March 2012.*



Timber bridge type schematic. Illustration by Kevin Riley, MaineDOT

Most of the earliest bridges were simply designed and built using local, easily-gathered materials. The forests of Maine provided plenty of timber that colonists used to build pedestrian bridges of timber beams over streams and other small waterways. Colonists created wider surfaces by fastening two or more logs together and covering their upper surface with planks. Settlers built horse bridges by expanding on this basic design by placing parallel beams five to seven feet apart. They then placed smaller timbers or heavy planking on top of these principal beams to create a flat surface to make it easier for horses to pass. Cart bridges were the next improvement in bridge design, built with increasing frequency after the mid-eighteenth century. They were constructed with three to five parallel beams with transverse pieces hewn on their tops to create a relatively smooth bridge deck. They often had rails on either side of the bridge, which was typically ten to twelve feet wide, allowing a driver to walk alongside the team of oxen pulling the cart. Where these beam-type bridges were impractical to build, settlers constructed "boom" or "floating" bridges, where logs were hewn to create a flat surface for the bridge and joined together by dowels or mortises. They were floated on the water's surface, able to sustain pedestrian and equestrian traffic with their inherent buoyancy.[5]

After the end of the Revolutionary War, settlement of inland areas accelerated. With increased settlement came an expansion in commerce, which roughly coincided with the beginnings of the Industrial Revolution in New England and created a need for new transportation networks, including new bridges. The larger volume of traffic created the need for more permanent bridges to carry heavier loads. State and local governments began taking over the responsibility for bridge-building, often financing them through lotteries or the authorization of private toll bridges.[6]

Early timber pile trestle bridges, which were more stable than earlier makeshift bridges, spanned mud flats, bogs, and shallow water. The earliest recorded timber pile trestle bridge in the American colonies was Sewall's Bridge in York, Maine, built in 1761. Major Samuel Sewall dramatically increased the sophistication of timber bridge design, and engineered a span which lasted for nearly 175 years.[7]

[5] KCI, 1997, II-18; Edwards, 1959, 22–23, 27–28.
[6] KCI, 1997, II-18.
[7] Edwards, 1959, 21, 26–27; KCI, 1997, II-19; Banks, 1931, 2, 293–295.

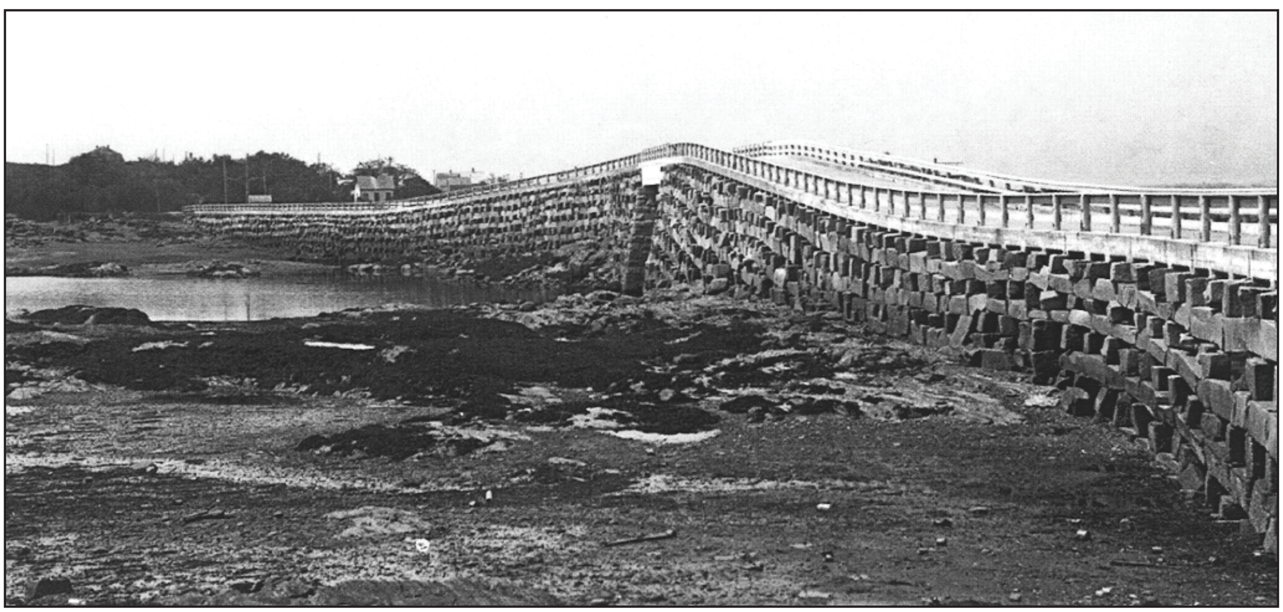
Bailey Island Bridge

The Bailey Island Bridge in Harpswell is a granite cribwork bridge, the only structure of its kind in the world. It was designed by one of Maine's premier bridge engineers to solve the unique issues of its site and topography. The Bailey Island Bridge connects the Casco Bay islands of Bailey Island and Orr's Island, both located in the Town of Harpswell. Spanning Will's Gut, a strait between the islands, the Bailey Island Bridge is a modern example of dry-laid stonework. It was completed in 1928 following decades of controversy between the fishermen of Bailey and the rest of the residents in Harpswell over whether the bridge should be built at all.

The first State Highway Commission bridge engineer, Llewellyn N. Edwards, designed the bridge. Edwards tackled daunting environmental challenges in the design of this bridge, as it had to span a long crossing that contains both strong tidal currents and winter ice. His design, inspired by the crude log crib piers found on logging roads and coastal wharves, took advantage of the strength of Maine granite and the idiosyncrasies of the strait. The quarried stone was laid directly on top of natural ledge outcroppings that curve across the strait between the islands. The bridge is constructed of granite slabs, which are typically twelve feet in length and two feet square in cross-section. These substantial slabs were laid in an open crib pattern, with rows of headers laid layer upon layer across stretchers that run along the nearly twelve hundred foot length of the structure.

Edwards' design brilliantly solved the engineering dilemma of the site, creating a bridge that was both elegant and cost-effective. Edwards chose the open construction of the substructure to allow tidal waters to flow freely through it without accelerating the current. The stone slabs, some of which weigh up to five tons, are heavy enough to withstand the buffeting of waves and ice floes common in the area, even though they are held in place by nothing more than gravity and friction. By taking advantage of the natural ledge as foundation for the bridge, using local granite from quarries in nearby Yarmouth and the local work force to finish the job, Edwards was able to provide a bridge that cost less than a typical steel truss or concrete bridge. In addition, a fifty-two foot long T-beam span in the center of the structure allowed motorized fishing boats sufficient clearance at high tide to travel under the bridge, thus circumventing the need for a moveable span at that crossing, resulting in considerable cost savings.[1]

In recognition of the ingenuity displayed by its design and construction, the Bailey Island Bridge is a Historic Civil Engineering Landmark and listed in the National Register of Historic Places.



The Bailey Island Bridge, shown here shortly after completion, exemplifies innovative bridge engineering; it utilizes open granite cribwork and is the only bridge of its type in the world.

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[1] *Edwards, 1959, 185–187; Lichtenstein, 2004, II-15–16; Bridge #2033, Bailey Island Bridge, Harpswell, Maine Department of Transportation, Historic Bridge Survey, 2001; B. Hansen, "Stacking Stones: The Bailey Island Bridge,"* Civil Engineering *79:1 (January 2009), 34–35.*

The Maine State Highway Commission's General Bridge Survey of 1924 gathered information about the substructure and superstructure type of 6,800 bridges in the state. Over 1,500 bridges were founded on timber cribbing, making timber the second most plentiful substructure type after stone, which was found in over 4,300 bridges. While the number of timber bridges has dwindled since the 1924 survey, several bridges with timber crib abutments located in rural areas have been maintained.

The 1797 Churchill Bridge near Buckfield is a rare stone slab bridge. Courtesy of Maine Historic Preservation Commission

Stone Slab Bridges

Maine settlers used stone in addition to timber to construct bridges, using the plentiful stones left behind by glacial activity. The earliest stone bridge types included post-and-lintel, or stone slab, bridges. Post-and-lintel bridges are a simple structure, wherein a single large, flat stone (the slab, or lintel), is laid over a pair of vertical stones (the posts). Most of the surviving stone bridges in Maine are of the post-and-lintel type, as they could be built fairly quickly over small spans. Stone was also used in combination with wood, generally for abutments, piers, and retaining walls.[8]

Stone slab construction was most often used to span small streams and continued to serve that purpose in many areas of Maine until new technologies emerged in the early twentieth century, particularly formed concrete box and corrugated metal pipe culverts. The General Bridge Survey of 1924 reveals that 494 of the 6,800 surveyed—seven percent—were constructed of stone and most of those used the post-and-lintel technique. By 2004, according to the Historic Bridge Survey, only nine remained. Most were bypassed or demolished as part of the state's efforts to improve highways in the mid-twentieth century. Two extant bridges, both listed in the National Register of Historic Places, help illuminate the patterns of early stone bridge construction in Maine. The Churchill Bridge near Buckfield was constructed in 1797 to cross Bicknell Brook. It was built of dry-laid fieldstone abutments with a five-foot clear-span monolithic slab. Thompson's Bridge, also known as Allen's Mill Bridge, was built in approximately 1808 in Industry. It consists of dry-laid rubble abutments with a short granite slab span. Both the Churchill Bridge and Thompson's Bridge have been bypassed by state roads. Other stone slab bridges include the McLeary Bridge in Strong (c. 1879 and classified as a culvert) and Watson's Bridge in Waterford (1890). The McLeary Bridge and Watson's Bridge are on state highways and have been identified as eligible for the National Register by the Historic Bridge Survey.[9]

While most early bridge builders used only one material for construction, others combined timber and stone. The Grist Mill Bridge, likely built in the 1790s in Lebanon, Maine, was constructed with both timber and stone: dry-laid rubblestone abutments and a single stone pier support timber girders. Towns and individual property owners probably erected simple spans such as the Grist Mill Bridge more frequently than any other type because they could use locally-available materials and were relatively easy to construct.[10]

[8] KCI, 1997, II-18.

[9] Ibid., 19; Edwards, 1959, 34; Lichtenstein Consulting Engineers, "Historic Bridge Survey: Phase II Final Report and Historic Context" (Augusta, ME: Maine Department of Transportation, 2004), 38.

[10] Ibid.

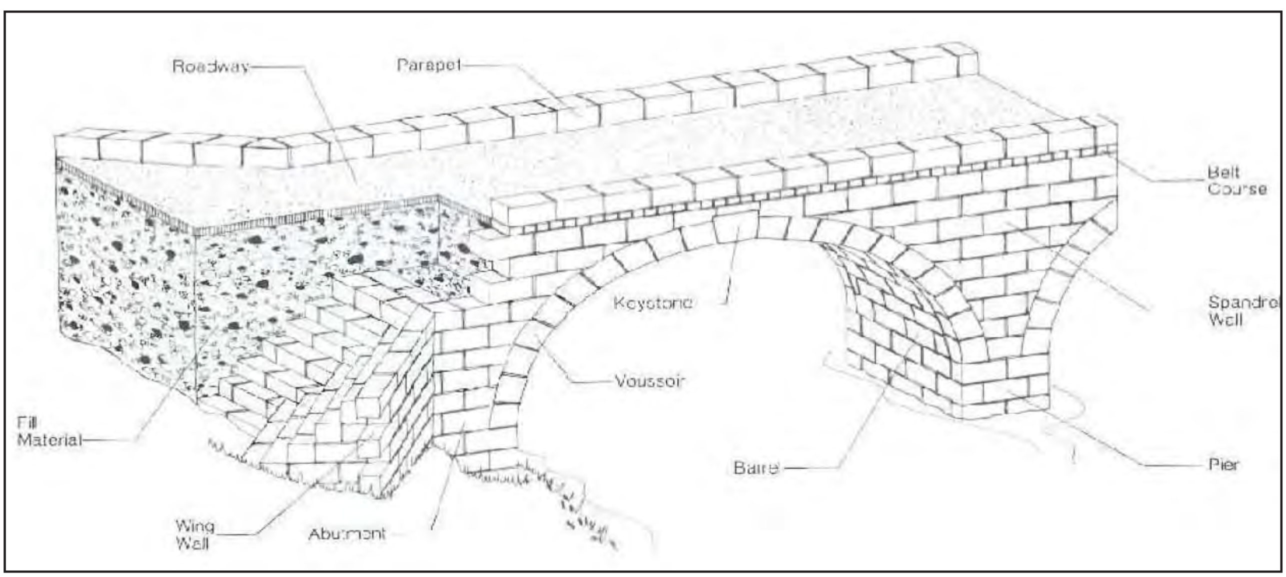
Arch Bridges

Arch bridges are curved construction with the convex side upward. Regardless of size, shape, or material, the principle behind the arch bridge type remains the same: the arch ring compresses under vertical loads and the outward thrust at the base of the arch must be balanced by equal reactions at the abutments. The arch shape can be semicircular, elliptical, or segmental.[11]

Stone Arch Bridges

Stone arch bridges have been used since ancient times, brought to this country by European colonists. The most primitive stone arch bridge is a corbelled arch. Corbelled arch bridges are constructed by laying large flat stones on top of one another in a cantilevered fashion to create an arched opening. As stone arch technology improved, it became well-suited for the compressive strength inherent in natural rock and it was the only technique available for permanent, substantial structures prior to the introduction of the truss bridge during the first half of the nineteenth century. Stone arch bridges continued to be built for railroad and highway use through the first decades of the twentieth century.

The principle behind stone arch construction is that the shaped stone blocks of the arch ring compress together under vertical loads. Historically, the stone arch was constructed by building the abutments and wingwalls, then erecting a wooden, arch-shaped form, known as "falsework" or "centering." The arch ring, spandrel walls, and parapets were constructed, then the structure was backfilled with fill material (usually stones, large rocks, and earth). Finally, builders removed the falsework, allowing the arch to compress into a locked and stable unit that supported itself through compression. Stone arch bridges were usually laid up with mortared joints, although some were dry laid (no mortar between the stones). Until the late nineteenth century, the mortar was a soft, plastic, lime-based mortar, rather than a hard Portland or artificial cement. Portland cement came into common use in the 1880s and 1890s.



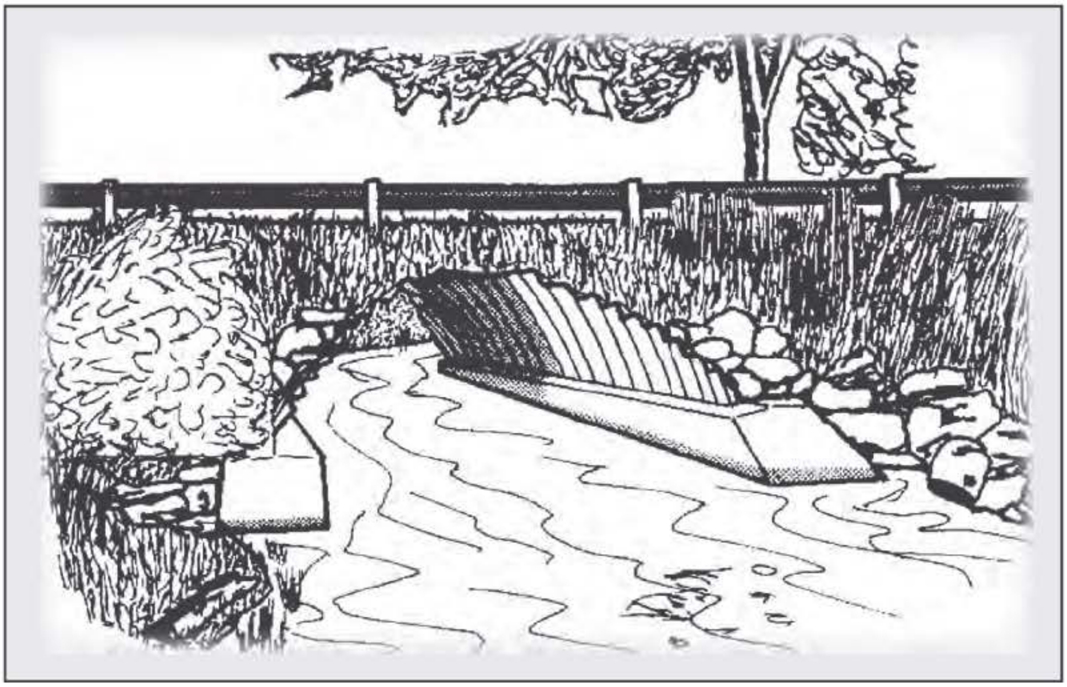
Stone arch bridge nomenclature. Pennsylvania Department of Tranportation and Lichtenstein, 2004

[11] The Arch Bridges section was adapted from the "Historic Bridge Survey: Phase II" completed by Lichtenstein Consulting Engineers for the MaineDOT in 2004 and reprinted here with slight modifications, II-15–22.

The c.1790 Grist Mill Bridge in Lebanon is built on rubble stone piers. In 1993 its timber superstructure was replaced in-kind. It is listed in the National Register of Historic Places.

The 1854 Water Street Bridge in Augusta is the oldest extant example of a stone arch bridge in Maine.

The Arch Bridge, built in 1894 in Pembroke, features a double arch constructed with ashlar stone. One wingwall was constructed with rubble stone.

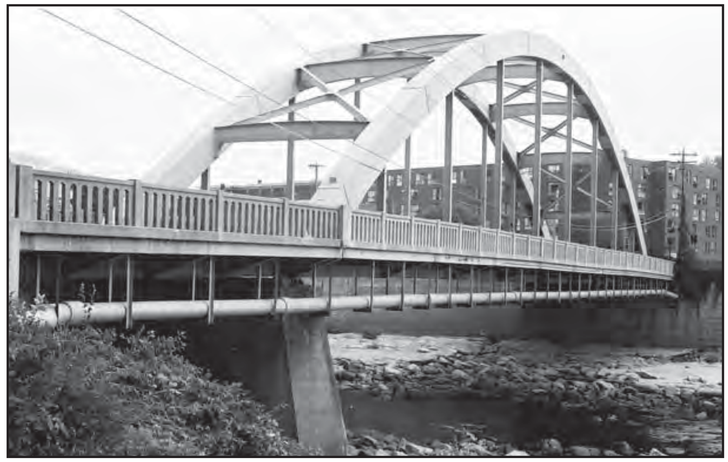


Multi-plate steel arch on spread footings. Illustration by Kevin Riley, MaineDOT

At least twelve stone arch highway bridges remain in service on public roads in Maine. They are most often composed of granite blocks, an abundant natural resource that was quarried because of its suitability as a building material. The oldest documented extant stone arch bridge in Maine is the 1854 Water Street Bridge in August. Like many of the state's arch bridges, it is laid up in ashlar (i.e., squared) stone. The Clark Street Overpass (c. 1873) in Portland, the Arch Bridge (1894) in Pembroke, and the Vaughan Memorial Bridge (1905) in Hallowell are among the most intact and well-crafted stone arch bridges in Maine. The Clark Street Overpass was built by the Boston and Maine Railroad as part of the development of its Portland terminal. The Vaughan Memorial Bridge was built by the Vaughan family, one of the town's founding families, as a gift to the town as a memorial to William Manning Vaughan (1807-1891). The c.1905 Arch Bridge in Bristol is the only stone arch bridge in Maine listed in the National Register of Historic Places.

Steel Arch Bridges

Metal has been used for arch bridges since the famous 1779 cast-iron arch over the River Severn at Coalbrookdale in England. The first American iron arch bridge was the 1839 Dunlap's Creek Bridge at Brownsville, Pennsylvania, on the National Road. Steel was introduced for arch bridges in the United States during the 1870s. The Morse Bridge, built in 1935 in Rumford, is the only example of a steel arch bridge that is not the more common structural steel plate corrugated arch. The Morse Bridge has a 230 foot-long, three-hinge, steel tied thru arch main span. The bridge works under the same basic principles as the reinforced concrete tied thru arch bridge type/design, but the material is different. The steel tied thru arch technology was developed in Europe during the last half of the nineteenth century. The first important long-span steel tied thru arch bridge in the United States was the 780 feet long West End-North Side Bridge built from 1930–1932 over the Ohio River in Pittsburgh. During the 1930s, American engineers increasingly considered tied steel thru arch bridges as an important alternative to other bridge types, especially for bridges in the range of two-hundred to eight-hundred foot spans. The type/design was usually chosen for reasons of economy, appearance, and because conditions at the bridge site restricted water flow. The three-hinge variation is a common steel bridge design that was developed for deck arch bridges in about 1870 and later applied to thru arch bridges.



The 1935 Morse Bridge in Rumford is the only example in Maine of a steel tied thru arch. It also bears a concrete arcade railing.

Reinforced Concrete Arch Bridges

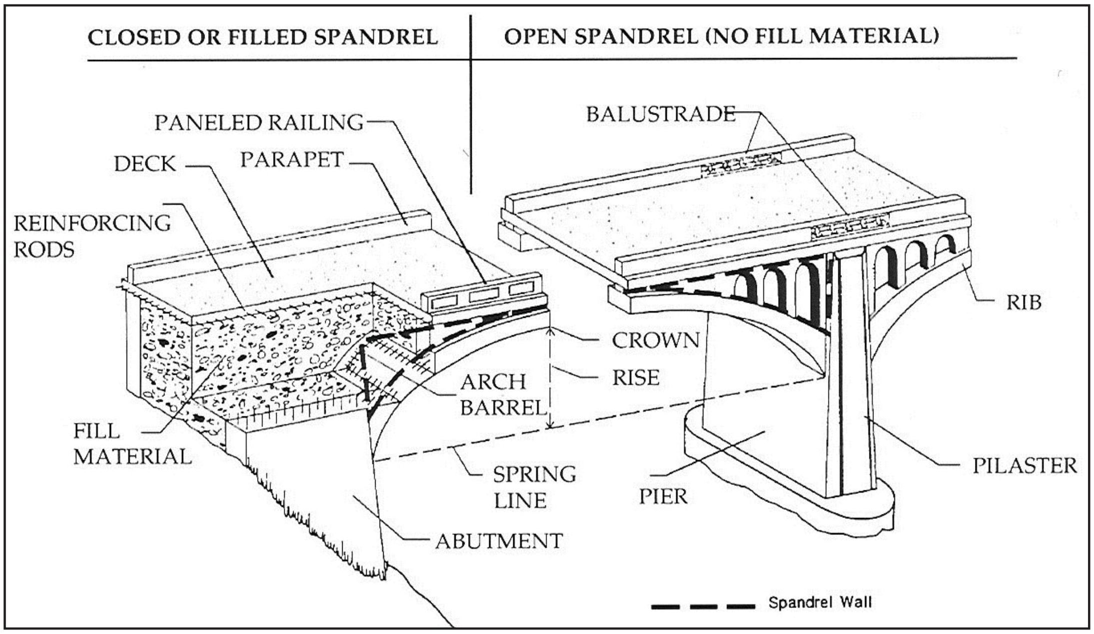
The same principles that govern traditional stone arch construction rule the erection of reinforced concrete arches, only that rather than shaped blocks compressed together under vertical loads as in a stone arch, reinforced concrete arches are monolithic structures with the reinforcement distributed in the tension zones of the arch ring. In traditional stone arch or plain [unreinforced] concrete arch bridges, the sheer bulk of material is used to absorb the tensile stresses, but reinforced concrete arches use reinforcing bars to perform the same function. Reinforced concrete arches are in many ways a more efficient design, since a lesser volume of material can do the work formerly done by the additional mass.

The 1902 Pope Memorial Bridge in East Machias is Maine's oldest reinforced concrete deck arch bridge.

In the 1880s and 1890s, the earliest reinforced concrete bridges built in the United States were closed spandrel deck arches where the arch ring supported the spandrel walls that hold back the fill between the arch ring and the roadway. During the early period of the reinforced concrete arch technology, a trial-and-error approach prevailed with a variety of competing ideas about the appropriate shape, volume, and placement of reinforcing metal. A number of engineers patented and marketed different arch reinforcing systems, but by far the two most common systems in North America were versions of either the Melan or Ransome systems.

Josef Melan, an Austrian engineer, invented the Melan system in 1892 and patented it in this country in 1893. The Melan system utilized steel beams embedded in the concrete. Really more a steel arch with concrete encasing than a true reinforced concrete structure, the Melan system was able to support greater capacity for longer span lengths than earlier systems. Edwin Thacher, an engineer, was the leading proponent of the Melan system in the United States. He designed the first major Melan-type arch, a three-span structure, over the Kansas River at Topeka beginning in 1894. He established the Concrete-Steel Engineering Company of New York City in 1901 and the firm went on to design more than two hundred Melan arch bridges prior to 1912. There are no extant Melan arches in Maine. The Old Wesserunset Bridge in Skowhegan, built in 1903, appears to be a Melan-type arch but it has been significantly altered and has lost its integrity of original design. Unfortunately, there are no surviving plans that document its construction.

Ernest Ransome first used the system of twisted reinforcing bars that came to bear his name in the early 1880s. Versions of the Ransome system eclipsed the Melan system during the first decade of the twentieth



Reinforced concrete arch nomenclature. Pennsylvania Department of Tranportation and Lichtenstein, 2004

century. Ransome, a California concrete block builder and manufacturer, received a patent for the commonly used square twisted reinforcing bar in 1884. He patented the reinforcing system after experimenting in search of a factory-building material that offered superior resistance to earthquake, explosion, and fire. He later applied the twisted reinforcing bars to arch bridges, and his 1889 Alvord Lake Bridge in San Francisco's Golden Gate Park is considered America's first concrete arch with steel reinforcing bars. The Ransome system offered important advantages: the twisted bar provided a much better bond between the steel and concrete, and twisting the bar cold raised the steel's yield point considerably. The bars could be offered in a range of sizes, thus providing greater control over the available cross section and thereby eliminating unnecessary metal.

Although Ransome is widely acknowledged as the inventor of what became the most popular concrete reinforcing system, other engineers and builders were responsible for promoting reinforced concrete arch bridges using the twisted reinforcing bars through engineering periodicals, textbooks, and advertising that reached a national audience of engineers and contractors receptive to the economic and structural advantages of the material. By 1910, reinforced concrete deck arch construction had become a widely accepted practice throughout the United States. Builders and engineers in Maine were in step with national trends. The Historic Bridge Survey identified at least thirty-three extant examples from 1902 to 1953. The oldest extant example is the 1902 Pope Memorial Bridge in East Machias. Examples of technology after 1910 are the Hartford Street Bridge in Rumford (c. 1915) and the Centennial Bridge in Kingfield (1916). These bridges exhibit typical period details such as paneled concrete parapets or concrete balustrades and plain or minimally detailed spandrel walls. The State Highway Commission oversaw the construction of a number of reinforced concrete deck arch bridges for towns in the 1910s, and beginning in the latter part of that decade, the Commission also designed many examples in-house. An example of the Bridge Division's work that includes many of the standard details is the 1924 Carrabassett Bridge in New Portland.

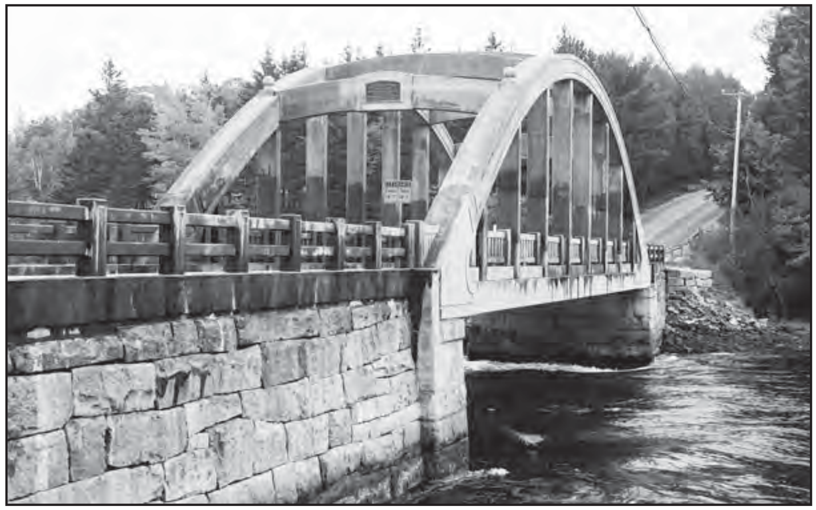
In the first decades of the twentieth century, engineers developed other reinforced concrete arch bridge types, most notably **open spandrel arches** and **thru arches**. Open spandrel arch bridges differed from closed spandrel arch bridges in that spandrel columns were used to support a deck slab rather than walls holding back earth fill. Open spandrel arch bridges were built nationally from about 1907 through the 1930s. Although they offered economy of material in comparison to closed spandrel arches of similar size and a lessening of dead load, they also required more complicated formwork. Thus, they were best suited to long-span crossings where a graceful yet powerful bridge was desired and the economy of material could be used to best advantage. Many open spandrel arch bridges have arch rings composed of individual ribs, resulting in further economy of material. Maine has one notable ribbed open spandrel arch bridge, the Chisholm Park Bridge in Rumford, completed in 1930. Like many open spandrel arch bridges nationally, it is in a setting where the aesthetics of the design and its architectural features are shown off to best advantage.

The Maine Bridge Division designed the 1923 Carrabassett Bridge in New Portland. The bridge is one of the earliest examples of a reinforced concrete bridge at this length.

The Chisholm Park Bridge in Rumford is an open spandrel arch highway bridge. It was built from 1929 to 1930.

Reinforced concrete thru arch bridges appeared in the United States during the early 1910s, with the best-known variation a patented design by James B. Marsh of Des Moines, Iowa. The thru arch usually consisted of two parallel arch ribs that were tied by reinforced concrete girders, which resist the thrust of the arch. The structural action is similar to an archer's bow and the bridge type is sometimes also called a bowstring arch for that reason. The design reduces the size of the required substructure. Thru arches were often located in settings where an aesthetic arch bridge was desired but conditions did not permit massive abutments or low vertical clearances.

Many thru arches were built throughout the Midwest in the 1910s and 1920s, but they were never greatly popular on the East Coast. Maine's state bridge engineer, Llewellyn Edwards, however, chose the reinforced concrete tied thru arch design for the state bridge division's signature work. Although the state highway department built only three examples during his tenure from 1921 to 1928, they were exceptionally proportioned and well-detailed examples that ranked among the most graceful in the nation. The Blue Hill Falls Bridge, built in Blue Hill in 1926, is the earliest of Maine's four examples. The 1927 Chestnut Street Bridge is located over a power canal adjacent to Lewiston's textile mills. The bridge was originally known as the Wiseman Bridge, named after Lewiston's mayor at that time, Robert Wiseman. The Covered Bridge in Norridgewock, built in 1928 and replaced in 2011, was the longest multi-span example in Maine. The Fairbanks Bridge in Farmington was the latest one, built in 1930 after Edward's tenure with the state highway department. The three span bridge was destroyed by the flood of 1987.



The 1926 Blue Hill Falls Bridge in Blue Hill features significant decorative details. This concrete tied thru arch bridge is complimented by its natural setting along the rocky coastline.

Lewiston's Chestnut Street Bridge, shown here under construction in 1927, is a single span concrete tied thru arch bridge.

The 1928 Covered Bridge in Norridgewock was one of two multi-span tied thru arch bridges in Maine. The bridge was replaced in 2011 with a modern concrete tied thru arch bridge.

Acadia National Park's Reinforced Concrete Arch Bridges

This signature, stone-faced, reinforced concrete arch bridge is in Acadia National Park. John D. Rockefeller, Jr. had the bridge built as part of a system of grade-separated carriage and motor roads.

Among Maine's significant reinforced concrete arch bridges are the collection built for Acadia National Park's carriage roads and motor roads by John D. Rockefeller, Jr. He developed the park on his own land and later donated it to the federal government as part of his effort to offer the public an alternative way to experience the natural beauty of a Maine coastal island.

A significant feature of Rockefeller's planning for the park was a system of carriage roads reserved for pedestrians, horse riders, and carriages. The carriage roads were separated from the motor roads, which themselves were sited to fit gracefully to the island's topography. Where carriage roads and motor roads intersected or crossed streams, Rockefeller directed his designers—including Wells Boswell, Charles Stoughton, and the Olmsted Brothers—to create reinforced concrete arch or reinforced concrete rigid frame bridges faced with native stone. The application of stone veneer to reinforced concrete bridges was a technique that was in use from the first decade of the twentieth century.

The Acadia National Park bridges have a high quality of stone craftsmanship used to great effect in harmony with the natural landscape. The road and bridge system is considered a masterpiece of the intersection of engineering and landscape architecture. It has had a significant influence on the design of parks throughout the United States.[1]

[1] *L. G. Meier and L. Terzis, "Historic Resources of Acadia National Park Multiple Property Listing," National Register of Historic Places Nomination Form, 2005; R. A. Thayer,* Acadia's Carriage Roads: A Passage into the Heart of the National Park *(Camden, ME: Down East Books, 2002), 13.*

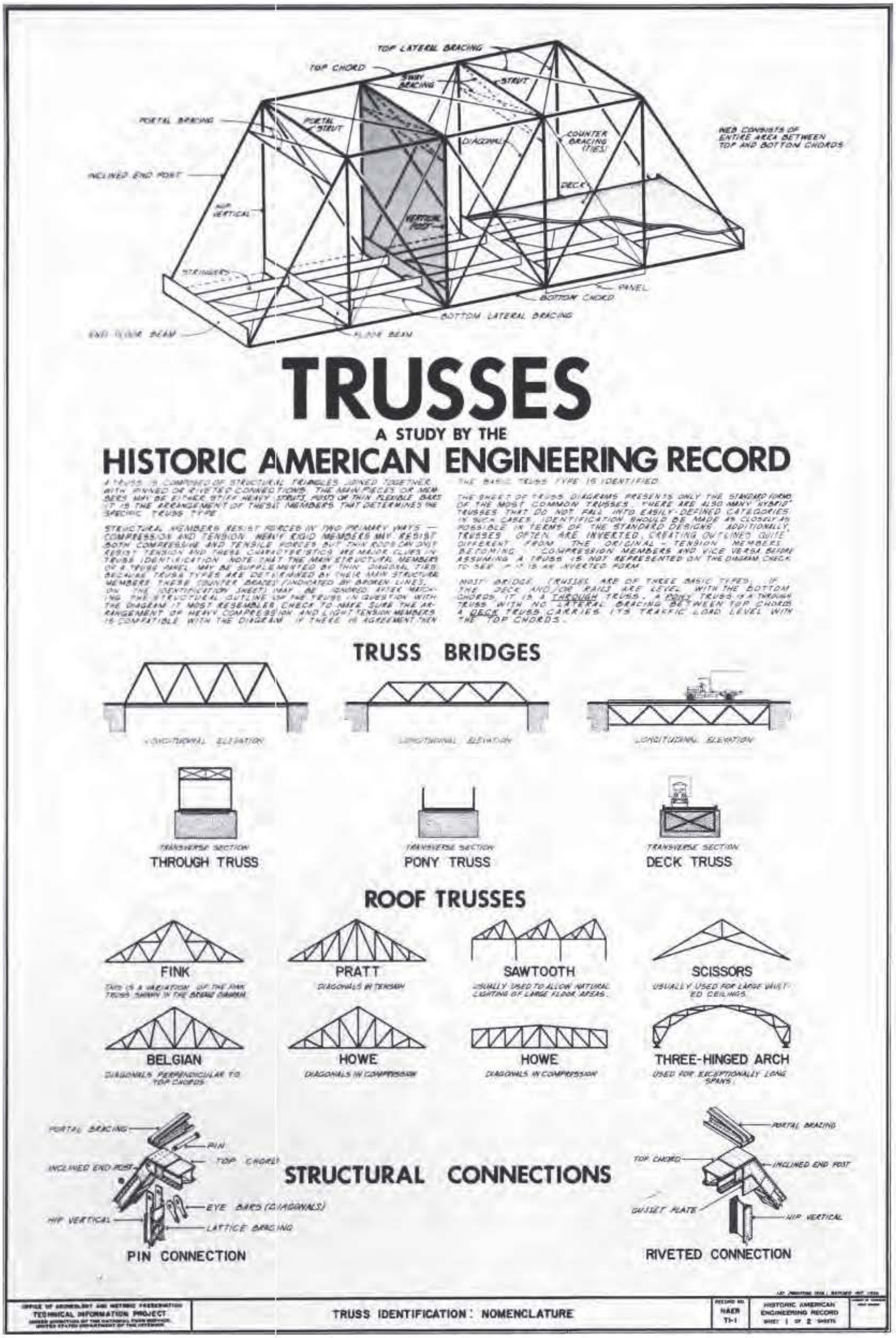
By 1930, the great era of reinforced concrete arch bridges had ended nationally and in Maine. Afterward, reinforced concrete arch bridges were built less frequently as plain utilitarian structures because of their comparatively high cost of construction and material in comparison to steel and other reinforced concrete bridge types, such as T-beams, slabs, and rigid frames. They did, however, continue to be built in small numbers in urban or park-like settings where a traditional arch bridge was desired.

Truss Bridges

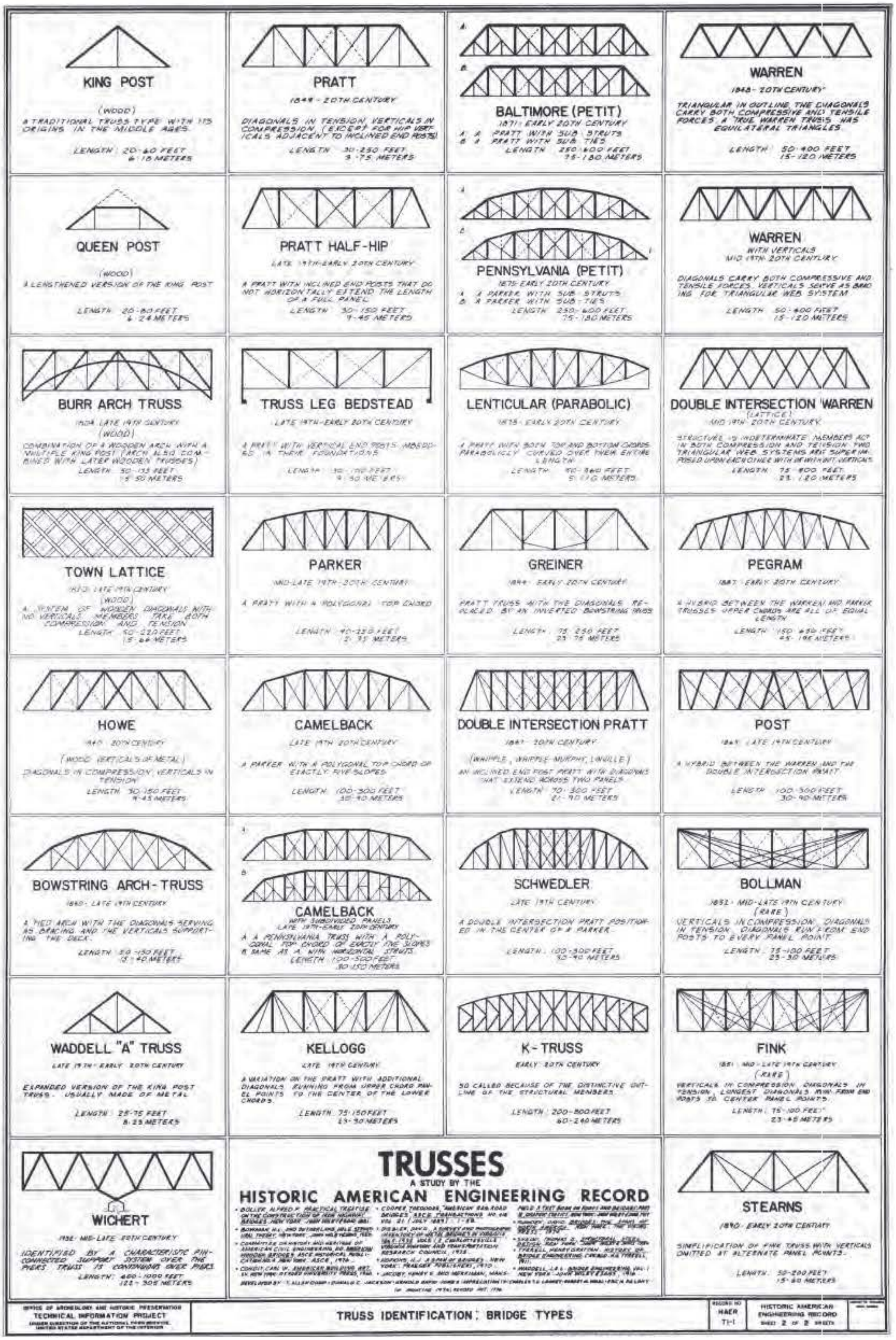
The easing of tensions following the end of the French and Indian wars in 1763 attracted Massachusetts settlers to Maine, almost doubling the population in the decade between 1765 to 1775 from 23,000 to 47,000, primarily to York, Cumberland, and Lincoln counties in the southern part of the state. Similarly, 120 townships were settled in the quarter century before the beginning of the American Revolution, compared to the twenty-one townships that had been established in the early eighteenth century. The period following the Revolutionary War also witnessed an increase in population and settlement to interior areas of the region, away from the coast and major waterways, requiring an increase in road and bridge-building to accommodate increased commerce from interior towns.[12]

The longer spans and heavier loads required in the late eighteenth and early nineteenth centuries required more stable structures than the rudimentary bridges of the earlier colonial era. By the third decade of the nineteenth century, towns were taxing their citizens to erect bridges to respond to the need to connect inland

[12] Judd, et al., 1995, 144, 311; KCI, 1997, II-21.Lichtenstein, 2004, II-2; Edwards, 1959, 37–38.



Truss bridge types and nomenclature. Source: Historic American American Engineering Record, National Park Service, 1976


KING POST
PRATT
BALTIMORE (PETIT)
WARREN
QUEEN POST
PRATT HALF-HIP
PENNSYLVANIA (PETIT)
WARREN
BURR ARCH TRUSS
TRUSS LEG BEDSTEAD
LENTICULAR (PARABOLIC)
DOUBLE INTERSECTION WARREN
TOWN LATTICE
PARKER
GREINER
PEGRAM
HOWE
CAMELBACK
DOUBLE INTERSECTION PRATT
POST
BOWSTRING ARCH-TRUSS
CAMELBACK
SCHWEDLER
BOLLMAN
WADDELL "A" TRUSS
KELLOGG
K-TRUSS
FINK
WICHERT
TRUSSES
A STUDY BY THE
HISTORIC AMERICAN ENGINEERING RECORD
STEARNS
TECHNICAL INFORMATION PROJECT
TRUSS IDENTIFICATION: BRIDGE TYPES
HAER
HISTORIC AMERICAN ENGINEERING RECORD

villages to larger market towns. Truss bridges, comprised of triangles where each member carries either tension or compression, met the needs of the burgeoning population. The vertical members bear the loads that are then transmitted by the diagonals to the horizontal members and to the bearings. Truss technology has been used since at least the third century B. C., but around the turn of the nineteenth century, bridge designers repeated the truss pattern several times within a span, allowing it to extend over much greater lengths.[13]

There are many different versions of truss design, but they all use the same engineering principals of transmitting loads through the vertical, diagonal, and horizontal members. Truss types and designs differ according to how their members are configured, which affects how they accommodate tensile and compressive forces. There are three basic truss types: the thru truss, the pony truss, and the deck truss. In a **thru truss** bridge, the roadway travels between the truss members on the deck and floor system connected to the bottom chords at the panel points. Lateral bracing connects the top chords of the trusses helping to brace it against wind. Thru trusses are usually used for spans that are more than one hundred feet long. A **pony truss** is very similar to a thru truss, except that it does not have lateral bracing between the top chords. Pony trusses are commonly used for shorter spans than thru trusses, generally from forty-five to one hundred feet long. The road is above the trusses in a **deck truss** and the deck system is on the top chords.[14]

Wood Truss Bridges

Master carpenters used Maine's abundant hardwood forests to construct wooden truss bridges. Timothy Palmer, one of the pioneers of wooden bridge design and the leading timber bridge builder in the United States by 1800, was a carpenter and self-taught engineer from Newbury, Massachusetts. He designed one of the earliest wood truss bridges in America, the Piscataqua River Bridge between Maine and New Hampshire in 1794. It was a 2,362-foot footbridge over the Great Bay near Portsmouth, New Hampshire. It was a wooden arch-truss bridge that incorporated both wooden arch and truss structures, locking the frames of the two bridge systems together, ensuring the transfer of stresses from the span to the substructure, making larger spans possible.[15] Palmer also designed the first covered bridge in America, the Middle Ferry Bridge over the Schuylkill River in Philadelphia, Pennsylvania in 1805.

The Historic Bridge Survey includes eight wooden truss bridges. Seven of the eight are covered bridges, built between 1857 and 1911. Covered bridges—defined as a wooden bridge with a wood-framed roof—were built by skilled craftsman throughout the nineteenth century in Maine to protect the wooden trusses and arches from the elements. The roofs of these bridges generally extended five or more feet beyond their floor and were supported by inclined posts. This configuration protected the bridge's flooring and substructure from the dampness of rain and snow, thereby staving off the decay of the timbers. Ephraim Ballard and Benjamin Brown designed and built the first covered bridge in Maine in 1818 to replace Palmer's 1797 bridge across the Kennebec in Augusta. Approximately 150 covered bridges were built in Maine in the nineteenth century.[16]

Despite the clear advantage of covering a wooden truss, exposed wood truss bridges continued to be built in the state after the 1820s. The majority of these (286 were identified in the 1924 bridge survey) were short-span crossings designed with a single **kingpost** or **queenpost** truss system. In addition to those uncovered

[13] Judd, et al., 311; Lichtenstein, 2004, II-1.
[14] Lichtenstein, 2004, II-1–2.
[15] Ibid, 2; Edwards, 1959, 40.
[16] KCI, 1997, II-22; Lichtenstein, 2004, II-3; Edwards, 1959, 53–54; J. Conwill, *Maine's Covered Bridges* (Charleston, SC: Arcadia Press, 2003), 7–8, 49.

Preservation and Reconstruction of Maine's Covered Bridges

The Maine Assessor's Department bridge survey of 1903 indicated that covered bridges were a popular bridge type into the 1880s and 1890s. The construction of covered bridges for highway use ended in Maine around 1903 with the construction of the Watson Bridge in Littleton. Although susceptible to both floods and fire, sixty-two covered bridges remained in 1924, but their numbers slowly declined. In 1932, only thirty-five bridges existed and in 1956, just ten remained. With few extant covered bridges, concerned citizens began to advocate for their preservation. Their efforts paid off in 1959 when the Legislature enacted a law that allocated funds for the preservation of covered bridges within the state. In 1961 MaineDOT undertook major rehabilitation of the ten remaining covered bridges.

The 1876 Porter-Parsonsfield Bridge spans the Ossipee River and was built jointly by the towns of Porter and Parsonfields. Today, it is only open to pedestrians.

Located in Bangor, the Morse Covered Bridge was built in 1873, but destroyed by fire in 1983.

Since the 1960s, three bridges were lost to fire, flood, and vandalism, but two were reconstructed. Babb's Bridge, a queenpost truss that crossed the Presumpscot River in South Windham, was originally constructed in 1840. Vandals burned it in 1973 and it was meticulously reconstructed three years later. Low's Bridge, a Long truss, was originally built in 1857 to span the Piscataquis River between Guilford and Sangerville. It was washed away by a flood on April 1, 1987 and a new bridge patterned after the original was built on the existing abutments in 1990. The Morse Bridge, a Howe truss, over the Kenduskeag Stream in Bangor was removed in 1962. MaineDOT, however, carefully dismantled and stored the bridge instead of demolishing it. Three years later it was reconstructed as a pedestrian crossing at Coe Park in Bangor. Unfortunately, it was destroyed by arson in 1983 and was not rebuilt.

The MaineDOT has endeavored to protect the remaining seven covered bridges in an effort to ensure that their beauty and craftsmanship are preserved for future generations. All of Maine's covered bridges are listed in the National Register.[1]

[1] *Conwill, 2003, 8;* Woodsmen and Whigs: Historic Images of Bangor, Maine *(Bangor, ME: Bangor Historical Society, 1991), 68.*

truss bridges that stood on their own, a number of covered truss bridges across the state were accompanied by an uncovered approach span. Some bridges of this form, typically either constructed as an approach span to a covered bridge or as a span eventually intended to be covered in some manner, were constructed with carefully cut and joined timbers. The vast majority of open wooden truss spans that continued to be built in rural areas into the twentieth century were rustic structures made from peeled logs. The framing members of these simple trusses were typically lapped and bolted together, with steel rods used in the place of timber for uprights.[17]

Complex trusses that were left uncovered continued to be constructed until the late-nineteenth century, as in the case of the Red Bridge at Houlton, generally for financial reasons or for bridges that were never meant to be permanent. Some uncovered wooden truss bridges were built in response to the war effort during

[17] Conwill, 2003, 7; R. S. Allen, *Covered Bridges of the Northeast* (Brattleboro, VT: Stephen Greene Press, 1957), 7–8.

World War II. For example, the Allagash Bridge in Allagash Plantation was designed and built in a pattern common to steel truss bridges. However, due to the shortage of steel in 1944, heavy timbers were used in its construction. The only open wooden truss bridge that appeared in the Historic Bridge Survey was a Howe pony truss at the Hobb's Railroad Overpass in Berwick, built in 1942. Railroad companies constructed wood overpass bridges into the mid-twentieth century because they were more economical to build and because the railroads had ready access to creosoted lumber, rendering it less vulnerable to the elements than untreated wood. Similar to the Allagash Bridge, the railroad company probably decided to use a wood truss for Hobb's Railroad Overpass Bridge because of steel and concrete shortages in World War II. Unfortunately, there are no longer any more uncovered wood truss bridges in Maine, as the Hobb's Railroad Overpass Bridge was replaced in 2002.[18]

A wide variety of truss designs have been used in Maine. Their differences come from the way they accommodate tensile and compressive forces. They are most often named for the engineer or craftsman who originated or patented the design. The first bridges in Maine were built of wooden structural members and then were built of iron and steel as those materials became more widely available.[19]

Town (Lattice) Truss

The lattice truss was probably first developed around 1813 by an unidentified craftsman working near Otter Creek, Vermont. However, Connecticut architect Ithiel Town received a patent for his design of a lattice truss in 1820 and is credited with its creation. Composed of closely spaced diagonal plank members attached to parallel chords, the Town truss proved to be extremely strong. The truss could be inexpensively built from wooden pegs and lumber available from local sawmills. Town promoted his truss as a structural system constructed entirely without iron. Though iron had been wrought for centuries in Europe and had been incorporated into various bridge designs in England since the mid-eighteenth century, American designers rejected it as a structural material due to its stiffness, weight, propensity to rust, and to fail without warning. Town trusses became popular in New England for their all-timber construction, which offered a considerable savings over bridges designed with expensive iron components. In addition, the Town truss could be prefabricated on land for subsequent positioning over the crossing. The lattice truss was frequently used for both highway and railroad bridges. None of the surviving covered bridges in Maine were constructed with a lattice truss, though fifteen Town truss bridges existed in the state during the nineteenth and early twentieth centuries, including the Norridgewock Bridge across the Kennebec River.[20]

The Town truss, though one of the lesser-used truss types in the state of Maine, was often used as the support system for some of the most distinctive and innovative wooden bridge forms. Commonly called "double-barrel" bridges, covered crossings constructed with two travel lanes could once be found across the state, with as many as twelve estimated to have existed at one point. Double barrel bridges were often designed with two trusses on the exterior of the span, like all covered bridges, as well as a third divider truss in the center of the bridge's width. Less frequently, the divider between the two lanes was simply a framed partition intended to keep drivers in their lane more than to carry any load. Most often, these bridges were constructed at crossings where a toll was charged, perhaps as a method for controlling traffic on the bridge.[21]

[18] Lichtenstein, 2004, II-3.
[19] Lichtenstein, 2004, II-2.
[20] Edwards, 1959, 56–60; Allen, 1957, 9.
[21] Conwill, 2003, 98; Allen, 1957, 9.

Long Truss


The Red Bridge in Houlton, pictured here in 1924, consisted of stacked timber piles and an uncovered wooden deck.


The Big Stillwater Bridge was an example of a double-barrel covered bridge which utilized the Town truss system. This bridge was located near Orono and was replaced in 1951.

The Long truss was patented by Colonel Stephen H. Long of the U.S. Topographical Engineers (a predecessor to the Army Corps of Engineers) in 1829, who designed "the second step toward simplicity and concentration of parts in wooden bridge truss types."[22] Colonel Long is credited as being the first American engineer after Benjamin Latrobe to have applied mathematical theory and calculation to bridge design. Long, a native of Hopkinton, New Hampshire, was a graduate of the United States Military Academy at West Point, one of the first engineering programs in the country. Thus, Colonel Long can be considered the first professionally trained bridge engineer to practice in Maine. He designed a refinement of the lattice truss during his detail with the Baltimore and Ohio Railroad. Instead of using a closely spaced plank web, Long calculated the stresses in the individual members in a truss of a given length and sized them according to the load they would carry. Long's truss was designed with pre-stressed counterbraces that function in compression to distribute stresses evenly along upper and lower chords. The Long truss was used predominantly in Aroostook, Penobscot, Piscataquis, and Washington counties. Federal troops constructed many covered bridges on the Military Road in Houlton during the Aroostook War in 1839, which may have influenced the preference for the Long truss in northern and Downeast Maine, providing a model for other bridge builders in the area. The 1924 bridge survey documented seventeen Long Truss bridges. One of Maine's surviving historic covered bridges, the Robyville Bridge in Corinth, uses a Long truss.[23]

Paddleford Truss

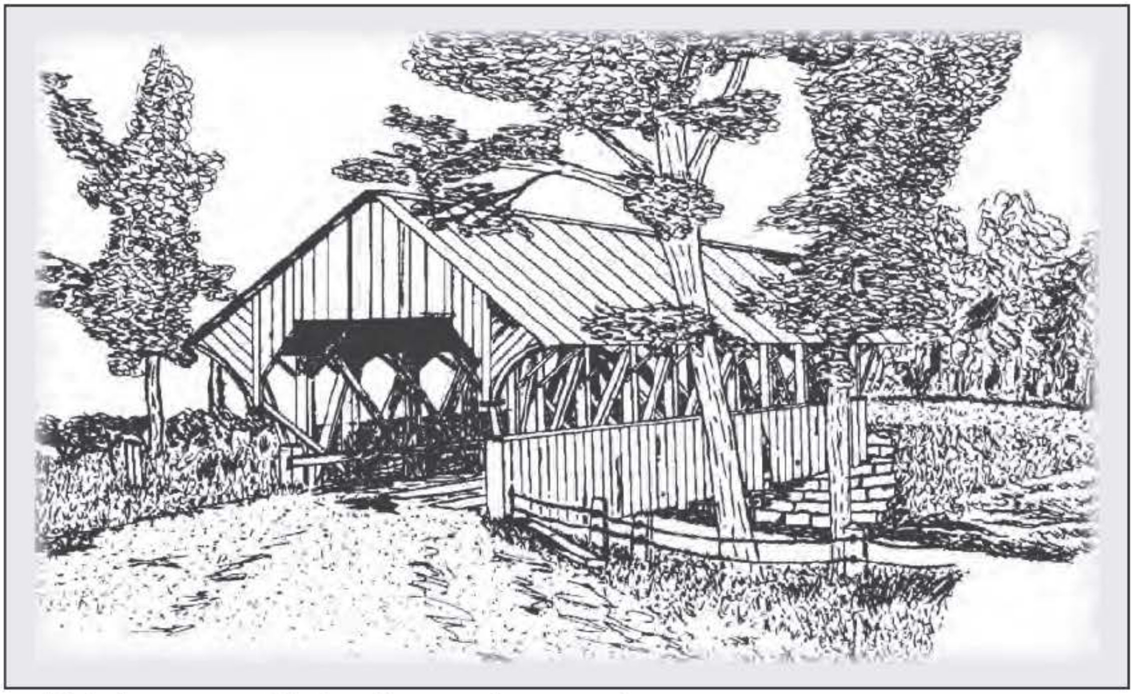
A further variation on the basic lattice truss, the Paddleford truss is a structural system used in the majority of Maine's remaining covered bridges. New Hampshire engineer Peter Paddleford designed this truss in 1844 to improve upon Long's truss. This truss design is constructed with a series of upright posts, braces, and counterbraces that function together to distribute stresses to the bridge chords. The chords, posts, and braces are lapped together and fastened and the counterbraces are locked onto the other framing members, utilizing numerous joints to minimize shear stresses while taking advantage of the great tensile strength inherent in timber to spread loading stresses across the superstructure. The counterbraces are also longer than those seen in many other truss designs, crossing three truss panels to better distribute the loads carried by the structure. Paddleford's truss was most popular in New Hampshire, where fourteen examples remain

[22] Edwards, 1959, 61.
[23] Edwards, 1959, 55, 61–63; Allen, 1957, 8–9; Conwill, 2003, 108.

The 1876 Robyville Bridge in Corinth spans 73 feet across the Kenduskeag Stream and is the only covered bridge in the state completely covered in shingles. The Long truss bridge is a Maine Historic Civil Engineering Landmark.

The 1857 Hemlock Bridge in East Fryeburg spans the Old Course of the Saco River. The 109-foot long Paddleford truss bridge carries local traffic and is the oldest extant covered bridge in Maine.

Located in Littleton, the c.1903 Watson Bridge spans the Meduxnekeag Stream and is the only extant Howe truss covered bridge in Maine. This bridge is a Maine Historic Civil Engineering Landmark.



Paddleford truss covered bridge. Illustration by Kevin Riley, MaineDOT

today. The truss design was also popular in Orleans and Caledonia Counties in eastern Vermont and Oxford, Cumberland, and York Counties in western Maine, the areas closest to Paddleford's home in Littleton, New Hampshire. Paddleford's design was used in the construction of thirty-four of the covered bridges that remained in 1924, several of which were constructed by Peter Paddleford himself.[24]

While the Paddleford truss is the most widespread existing wood truss design in Maine, it is rare in other states except New Hampshire. Five of the remaining seven covered bridges in Maine were constructed according to Paddleford's design: the Hemlock Bridge (1857) near East Fryeburg; the Porter-Parsonsfield Bridge (1876) connecting the two towns; the Lovejoy Bridge (1868) in South Andover; the Artist's Covered Bridge (1872) in Newry; and the Bennett Bridge (1901) in Lincoln Plantation. The Artist's Covered Bridge (also known as the Sunday River Bridge) received its name based on its reputation as the most photographed and painted covered bridge in the state.[25]

Howe Truss

William Howe was born in Spenser, Massachusetts, to a family of inventors. Howe developed a truss with double upright posts meant to hold the compressive stresses of counterbraces that were designed to be cambered by the application of wedges, similar to Colonel Long's pre-stressing method. Howe patented his design in 1840 with further refinements in 1846, in which he substituted iron tie rods for the double wooden uprights. Howe's refined design, with its use of both wood and wrought iron, was a key transitional form between early wood trusses and the metal trusses of the later nineteenth and early twentieth centuries. The incorporation of iron support members into the Howe truss made it slightly less susceptible to deterioration and fire than traditional timber trusses. The Howe truss gained popularity for use in railroad bridges throughout the United States because of its durability and strength and because of the convenience of its

[24] Allen, 1957, 42–43.
[25] Conwill, 2003, 67, 71, 73–74, 85–86, 91–92.

regularized panel division and lateral rigidity provided by the iron ties, which made it inherently modular and easy to transport to the site. The Howe truss was primarily used for railroad bridges within Maine. Though it was generally not used for the construction of highway bridges, examples did exist, such as the former Bangor Toll Bridge in Bangor and the Gardiner-Randolph Bridge between those two towns. One example remains today, the Watson Bridge in Littleton.[26]

Metal Truss Bridges

Beginning in the two decades before the Civil War, iron was increasingly used for the fabrication and construction of bridges. Rail transportation required the construction of sturdier bridges as railways had to contend with higher traffic speeds, greater wheel concentration, increased vibrations and lateral forces, and longer spans than highway traffic, which was comprised of pedestrian and animal traffic for most of the nineteenth century. A number of factors contributed to the wider acceptance of all-metal structures during the later nineteenth century, including a decrease in the price of wrought iron; improvements in the manufacture of wrought iron, including smelting and rolling technologies; the growing scarcity of timber; the lower cost of erecting factory-fabricated materials in the field; and the risk of fire to wooden bridges and the resulting transportation delays. However, many people still continued to distrust all-metal structures, based on past weakness under certain loading conditions and susceptibility to vibration.[27]

In 1840 Squire Whipple and Earl Trumbull, both of New York, designed and built separate bridges to span the Erie Canal. The superstructures of both bridges were built entirely of iron. Whipple and Trumbull took patents out on their designs, but Squire Whipple's work is more familiar because he wrote a treatise about using iron for bridges that was widely used throughout the nineteenth century. His bridge designs and his published work contributed to the expansion of the railroad industry. The iron bowstring truss that Whipple designed—built to cross the Erie Canal in Utica, New York—featured wrought iron lower chords held in tension by the arched cast iron upper chord. Whipple wrote about this bridge, "The design and intent were to construct an iron-truss bridge to be used in connection with a wooden floor system, the truss to have sufficient stability to stand of itself, without any dependence upon the wood, so that the latter could be renewed from time to time as might be required, without disturbance or danger to the iron work. . . ." Squire Whipple attained his Bachelor of Arts degree from Union College in Schenectady, New York, which gave him theoretical as well as practical knowledge for engineering bridges.[28]

The move to iron truss bridges brought about a cultural shift in the bridge design and construction process. Not only did the construction of the first bridges with iron superstructures signal the beginning of the long transition in the materials used in bridge-building from wood to metal (which was not complete until well into the twentieth century), it also forecast a transition in the occupation of bridge builders from craftsmen to professional engineers. Unlike the designers of earlier wood truss construction, iron truss bridges were designed by engineers who had been college-educated in engineering programs, often at the newly formed land-grant universities like the Maine State College of Agriculture and the Mechanic Arts (now the University of Maine), founded in 1863 for the purpose of educating farmers and engineers. They applied modern techniques to bridge-building, including stress analysis, plans, specifications, testing, and inspection. The way in which bridge designs were conceived and constructed changed as well. Starting in the last third of the nineteenth century, patent holders formed bridge companies to build and market their truss designs.

[26] Allen, 1957, 9, 17–19; Conwill, 2003, 17–18, 51, 103–104; Edwards, 1959, 69–70; Zelz and Zoidis, 1991, 68; S. J. and R. T. Leon, *Encyclopedia of Bridges and Tunnels* (New York: Facts on File, 2002), 162.
[27] Edwards, 1959, 63, 95–98.
[28] KCI, 1997, II-25; Edwards, 1959, 70–71. The quotation by Squire Whipple is found in Edwards.

They ranged in size from large iron and steel companies that owned fabrication companies to distribute their bridge designs to regional contractors. The move toward fabrication and erection companies marketing their own proprietary truss designs minimized regional variation in bridge design and diminished the role local craftsmen could play in designing bridges. In this new system, the truss type and form utilized for any given bridge was defined by the length of the crossing, the number of piers constructed to support the bridge, and the patents for which individual truss fabricators had licenses. Moreover, these new companies became vertically integrated fairly quickly, as new iron rolling mills were built solely to supply rolled iron structural members to bridge building companies, such as the company created by Squire Whipple in partnership with his son, the S. & J. M. Whipple Company.[29]

This interior view of the Old Iron Bridge in Houlton displays intricate decorative finials along the intial portal.

The East Dover Bridge in Dover-Foxcroft exemplified the Lenticular truss, a popular iron bridge type in the 1870s through 1890s.

The use of iron and steel in the construction of bridges accelerated in the years following the end of the Civil War. In the 1870s, iron manufacturers started using rolled iron, which increased the variety of shapes and sizes they could produce. The use of rolled iron became prevalent in bridges as well as buildings associated with bridges and manufacturing companies, including railroad stations, train sheds, warehouses, and mill buildings.

Iron truss bridges started to arrive on Maine highways in the last quarter of the nineteenth century. In West Buxton, an 1869 fire burned part of the covered bridge over the Saco River. Instead of demolishing the entire bridge, the town replaced the missing part of the bridge with an iron bridge. Another early iron bridge was located in Westbrook and built in 1871. One of the more unique iron bridges in Maine crossed the Cathance River in Bowdoinham and caught the notice of Llewellyn Edwards, who wrote about it in the 1930s. The rare cast iron bridge was originally built in 1866 and used in either Connecticut or Massachusetts before it was relocated to Maine in 1895. It stood until the 1950s.[30]

Changes in steel production led to its use in bridge construction. In 1874, principal bridge members were fabricated for the first time for use in the Eads Bridge in St. Louis, Missouri, made possible by smelting alloy steel by the crucible process. At the time of its construction, it was the largest steel structure in the world and one of the most attractive, prompting Walt Whitman to call it a "structure of perfection and unsurpass-

[29] Edwards, 1959, 71; KCI, 1997, II-27; Lichtenstein, 2004, II-3–4; J. L. Garvin, "Metal Truss Bridges," New Hampshire Division of Historical Resources, 1998; D. C. Smith, *The First Century: A History of the University of Maine, 1865–1965* (Orono, ME: University of Maine Press, 1979), 1–3, 65.

[30] J. D. Libby, *Buxton* (Charleston, SC: Arcadia Publishing, 2009), 58; G. A. Knoblock, *Historic Iron and Steel Bridges in Maine, New Hampshire, and Vermont* (Jefferson, NC: McFarland & Co, Publishers, 2012), 28, 34–35.

able beauty." The use of steel allowed engineers to build much larger bridges than previously possible.[31] By the turn of the twentieth century, most metal truss bridges were constructed with steel.

The Boston Bridge Works built the 1890 St. John Street Underpass in Portland to carry the Maine Central Railroad. The bridge is an example of a rivet-connected Baltimore thru truss.

Metal truss highway bridges became less popular in the 1920s with the increased use of the automobile. Many were replaced as part of a bridge replacement program, as they were thought to be too narrow and unsafe for cars and trucks. The bridge survey of 1924 documented a wide variety of metal truss bridges, but there were only three nineteenth-century examples in the 2000 survey: the Overpass Bridge in Yarmouth (1888), the St. John Street Underpass in Portland (1890), and the Grants Railroad Overpass in Berwick (1890). The St. John Street Underpass is the only one that remains on the Maine landscape, as the other two were disassembled and relocated in 2001–02 to Maine railroad museums.[32]

The 1936 North Turner West Bridge in Turner, replaced in 2008, was an example of a Pratt highway thru truss.

Pratt Truss

In 1844 Thomas and Caleb Pratt patented an improved truss form. An adaptation of the Howe truss, the Pratt truss was originally designed to use both timber and iron elements, with rigid vertical timber truss members to resist compression forces and diagonal iron members to distribute tensile forces. The Pratt truss was easily converted into an all-metal design and quickly became the most commonly used metal truss type in the late nineteenth century due to the simplicity of its design, its strength, and its economical use of materials. The Pratt truss eventually became the basis for the Baltimore, Parker, Pegram, Pennsylvania, Kellogg, and Lenticular trusses, which generally either modified the manner of panel subdivision or utilized polygonal upper chords. These truss forms were designed during the late-nineteenth century and continued to be used into the twentieth century. The lenticular iron truss was particularly popular in Maine at that time, and examples of this span were found in the communities of Bingham, Buxton, Clinton, Dover, Fairfield, Houlton, and Yarmouth.[33]

Approximately 130 Pratt truss and Pratt truss variations were found in Maine in 1924, seventy-six of which followed the original Pratt truss design. Examples of the Pratt truss in Maine that remain today are most often found in the Baltimore, Pennsylvania, or Parker truss forms. Still, instances of the design patented by the Pratt brothers were constructed in Maine over the years. The Bangor and Aroostook Railroad Bridge in Ashland is a pin-connected Pratt deck truss constructed in 1902. This bridge and numerous other truss bridges that remain on Maine's rail systems illustrate the importance of iron and steel truss bridges to the

[31] KCI, 1997, II-26; P. McQuire, "Smitten by St. Louis's Other Arches," *Wall Street Journal*, 5-6 February 2011.
[32] KCI, 1997, II-4.
[33] Edwards, 1959, 74; KCI, 1997, II-25–26; Lichtenstein, 2004, II-4; Knoblock, 2012, 35.

Once located in Fort Kent, the three-span 1929 International Bridge was an example of the Pennsylvania truss.

expansion of the railroads through the latter half of the nineteenth century. Along with railroad trusses are numerous highway truss bridges, such as the North Turner West Bridge in Turner.[34]

Pennsylvania Truss

The Pennsylvania Railroad designed the Pennsylvania Truss, occasionally called the "Petit truss" after the engineer credited with its conception around 1875. It is a derivative of the Pratt truss and easily recognized by its polygonal upper chord and distinctive panel separation with intermediate diagonal bracing and half-verticals that extend from the upper chord. Though the truss was widely used by the Pennsylvania Railroad, it also became popular for use on highways. The State Highway Commission used it extensively in the early twentieth century. The New Sharon Bridge in New Sharon and the International Bridges at Van Buren and Madawaska were all exceptional, early examples of Pennsylvania truss bridges constructed in Maine. The Gardiner-Randolph Bridge over the Kennebec was an interesting combination of bridge types in 1924. In earlier years, the bridge had been a typical three-span bridge with two covered spans to either side of an uncovered wood truss swing span. The covered spans in the center of the river and the swing span had been washed away during the flood of 1896 and were replaced with two Pennsylvania truss spans and a Pratt truss swing span. The covered spans to either side of the metal trusses remained until 1926 and were replaced with Pennsylvania truss spans.[35]

Parker Truss

Charles H. Parker designed the Parker truss in the 1870s, which is used primarily for highway crossings. A Parker truss with exactly five slopes is called a "camelback" truss, due to its segmented upper chord that curves like the back of a camel. The division of its panels is nearly identical to the standard Pratt truss design, except that it has a polygonal upper chord. The Androscoggin River Bridge in Gilead, constructed in 1921, exemplifies the Parker camelback truss type.[36]

Warren Truss

James Warren and Willoughby Monzani, two British engineers, patented the Warren truss in 1848, which was widely used in Maine and the rest of the United States. The Warren truss has a triangular pattern outline

[34] Lichtenstein, 2004, II-4–5.
[35] Edwards, 1959, 84–85.
[36] Edwards, 1959; 74; Lichtenstein, 2004, V-10.

created by diagonals that are alternately placed in either tension or compression. By 1880, most metal truss long-span highway bridges were assembled on site with pinned connections, as the bridge components could be shipped to the site and constructed in the field, making them more economical to build than riveted bridges. Riveted connections began to replace pinned connections when improvements were made to pneumatic riveting equipment around the turn of the twentieth century. Increased speed, higher traffic volume, and heavier loads, especially seen on railroad bridges, also led to the increased demand for the sturdier riveted structures. The straightforward design of the Warren truss lent itself to these more rigid connections, making it a popular bridge type in the early twentieth century. The Ryefield Bridge spanning between Harrison and Otisfield is the only example of a double-intersection Warren thru truss in the state. The Frank J. Wood Bridge, built in 1931-1932 between Topsham and Brunswick, is a good example of a triple-span, riveted Warren thru truss structure.[37]

Gilead's Androscoggin River Bridge, built in 1921, is an exceptional example of a Parker camelback truss bridge.

The 1921 Ryefield Bridge between Harrison and Otisfield is the only extant example of a double-intersection Warren thru truss bridge in Maine. The bridge is listed in the National Register.

Significant Early Twentieth-Century Truss Bridges

By 1900, the design of metal truss bridges was less innovative and more standardized, so that only a few types of truss bridges were built in Maine after the turn of the twentieth century. In addition, other bridge types emerged during the early years of the new century that were more economical to build and required less maintenance than steel truss bridges. These two factors led to a decline in both the total number of metal truss bridges constructed after the turn of the twentieth century.[38]

The uniformity of metal truss bridges after the turn of the twentieth century was due to the availability of economical steel in the last decade of the nineteenth century, the formation of large bridge companies and the evolution of the engineering profession. Steel is superior to iron for truss bridges because of its higher tensile strength. Like many industries in the late nineteenth and early twentieth centuries, large bridge companies either bought smaller companies or drove them out of business. These large corporations, such as the American Bridge Company (a subsidiary of U.S. Steel), liked to manufacture a limited number of bridge designs in order to keep costs down and production levels high. Moreover, as the engineering profession matured, engineering societies, such as the American Society of Civil Engineers, emerged that nurtured the professional development of engineers and created standards for designs and materials. All of the state's

[37] Edwards, 1959, 104–105; KCI, 1997, II-26–27; Lichtenstein, 2004, II-4, V-10.
[38] KCI, 1997, II-5–8.

steel truss bridges constructed after 1920 are rivet-connected Warren, Pratt, or variations on the Pratt design.[39]

The 1912 Gambo Falls Bridge in Windham is an example of a rivet-connected Warren pony truss bridge.

Most of Maine's extant steel truss bridges were built after 1900 and most of these were built according to standardized designs. The bridges built before 1920 are historically and technologically significant because they represent once-common truss designs but are now the only surviving examples. They include the Gambo Falls Bridge in Windham, a rivet-connected Warren truss bridge and the Free/Black Bridge in Brunswick, a Pratt truss bridge.[40]

The 1916 New Sharon Bridge in New Sharon was the last pin-connected bridge in Maine. The former National Register-listed bridge was a Pennsylvania thru truss.

As metal truss bridge designs became more standardized, engineers created new types of bridges that cost less to build and maintain. Steel stringer bridges and reinforced concrete bridge types began to compete with truss technology, especially after 1913, when the State Highway Commission started developing the state highway system. The construction of truss bridges began to gradually decline after this—the Bridge Division of the Maine State Highway Commission only designed eighty-five steel truss bridges between 1920 and 1955, less than seven percent of the total.[41]

The first two state bridge engineers, Llewellyn Edwards and Max Wilder, who served as the state bridge engineers for most of the first half of the twentieth century, helped develop standards for the American Association of State Highway Officials (AASHO), which along with the American Society of Testing Materials (ASTM), coordinated national highway policy and created standard bridge design and material specifications that were applied nationwide. The truss bridges built through most of the twentieth century were built according to these standards, and were therefore not uncommon or unique; rather, they were a proven bridge type that was known to perform well under certain conditions. After 1920 the Maine State Bridge Division designed metal truss bridges that ranged in span length from 75 to 300 feet because the truss bridges offered some advantages for these longer-length bridges. Reinforced concrete bridge types need more form work and additional time to cure, which could be a hindrance given Maine's short summers. Metal truss bridges could be constructed less expensively and in less time. Local conditions could also lead to the use of steel truss bridges, such as an active stream or the decision to reuse the substructure of another bridge.[42]

[39] Lichtenstein, 2004, II-5, 7.
[40] Lichtenstein, 2004, II-6.
[41] Lichtenstein, 2004, II-5–6.
[42] Lichtenstein, 2004, II-6–7.

Madawaska's International Bridge, built in 1921, is an early example of a bridge that served as a prototype for dozens of metal truss bridges in the early twentieth century.

The former 1929 Piscataquis Bridge in Howland was one of three early examples of the use of rolled section members in the verticals and diagonals in rivet-connected steel truss bridges.

The 1937 West Buxton Bridge, a Warren thru truss, in Buxton is one of two early examples of a continuous design truss bridge.


The 1901 Songo Lock Draw Bridge is sixty-feet long moveable bridge. It has a hand-operated center-bearing bobtail swing span.

Historically significant bridges built in the early twentieth century were either built shortly after the Bridge Division was founded in 1916 and are the earliest extant prototypes of the many similar truss bridges that followed or illustrate some fine-tuning in the design of those bridge types. Two of the early bridges that served as models for future truss bridges are the International Bridge in Madawaska and the Androscoggin River Bridge in Gilead, both built in 1921. An important refinement in steel truss bridge design was the substitution of rolled section members for built-up members in the verticals and diagonals in rivet-connected truss bridges, made possible by the lower cost of rolled sections and improvements in metallurgy. The state highway commission used this improvement in most of their truss bridges after 1929. There were three examples of the earliest use of rolled sections, each designed by the Bridge Division in 1929: the International Bridge in Fort Kent, Piscataquis Bridge in Howland, and Mill Pond Bridge in Salem Township.[43]

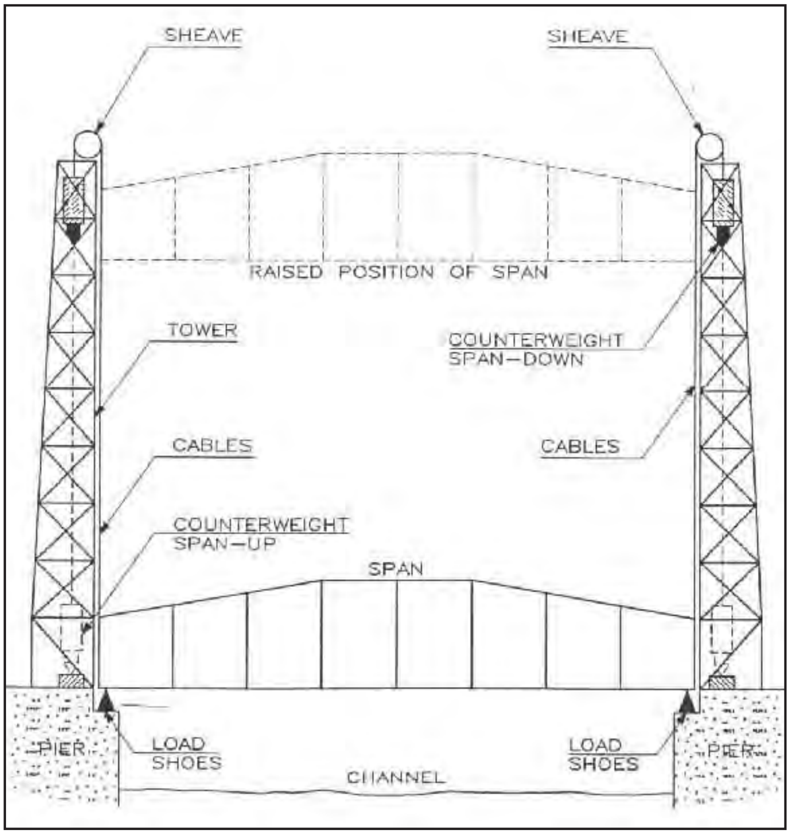
In the 1930s, the Bridge Division began using another refinement in their truss bridges called "continuous design," where the superstructure extends beyond one pier, reducing deck joints and requiring less material. Because of difficulties in analyzing the stresses, many engineers did not initially favor this method, but advances in engineering theory made calculations more precise and continuous designs were in widespread use in the 1930s in Maine and across the nation. The West Buxton Bridge in Buxton is a good example of a continuous design bridge built in 1937.[44]

As other bridge types—especially continuous-design steel girder-floorbeam and stringer bridges—became more economical to build over longer spans, the Bridge Division designed fewer truss bridges and their appearance on the landscape declined after 1945. However, State bridge engineer Max Wilder designed the only cantilever truss bridges in the state in the years following World War II to span three of the longer crossings in these years: the Augusta Memorial Bridge in Augusta (1949), the Max L. Wilder Memorial Bridge in Arrowsic (1950), and the Aroostook River Bridge in Caribou (1952). A cantilever truss is supported on one end, which is balanced by the previous span. While cantilever truss bridges have been in existence since the nineteenth century, Wilder's application of them in these situations were successful uses of this type of design.[45]

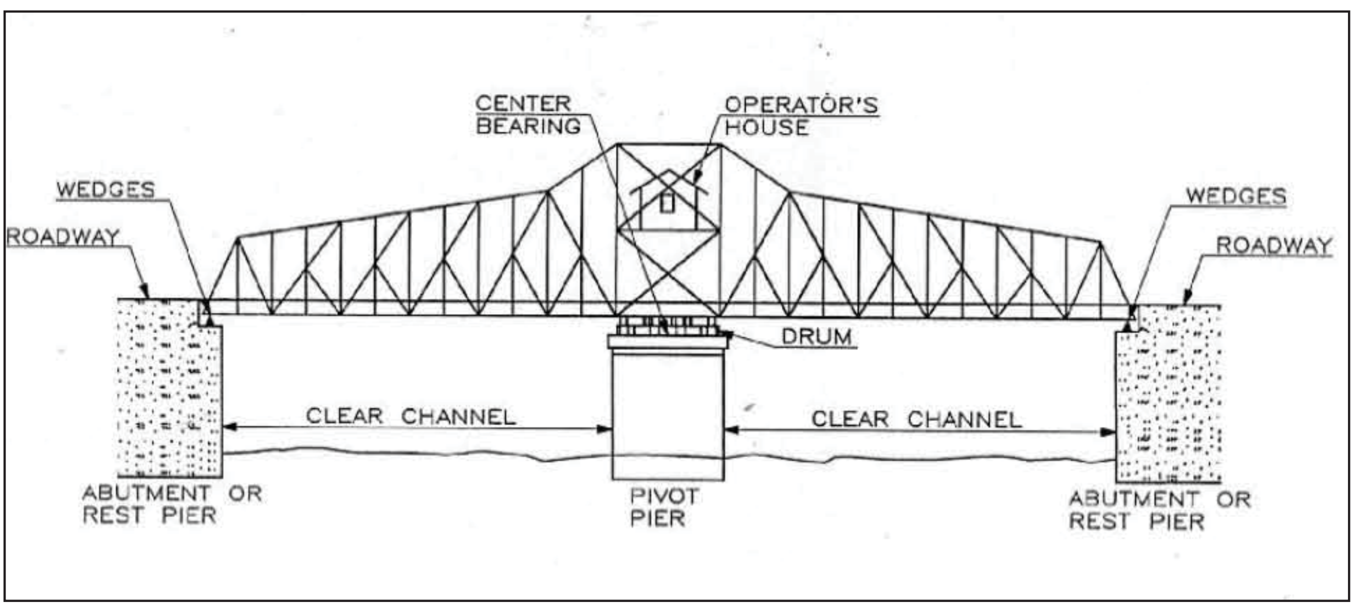
Moveable Bridges

Moveable bridges have moveable parts that allow boats and other marine traffic to pass through the area spanned by the bridge. Moveable bridges have been around since ancient times. The earliest examples were draw bridges that were hinged at one end and lifted at the other end by a rope—an early example in colonial America is the 1761 Sewall's Bridge. As the need for accommodating heavier loads and crossing longer spans created a rich period of experimentation in metal truss technology for railroad bridges, the same needs

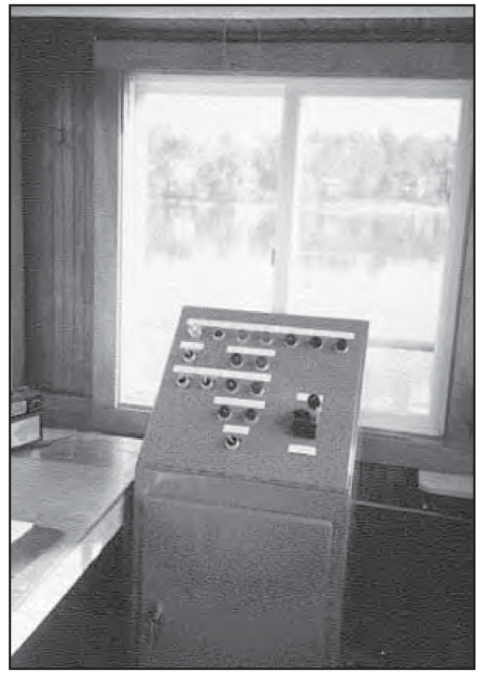
[43] Lichtenstein, 2004, II-7–8.
[44] Lichtenstein, 2004, II-8.
[45] Ibid.



Vertical lift nomenclature. Lichtenstein Consulting Engineers, 2004



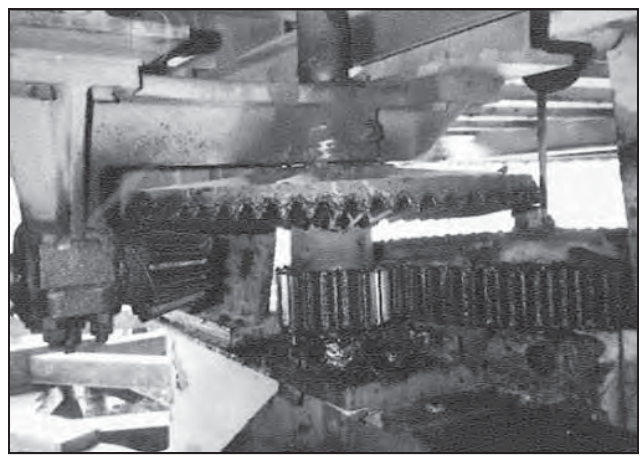
Swing span nomenclature. Lichtenstein Consulting Engineers, 2004 led to innovation in moveable bridge design in the mid to late nineteenth century. Moveable bridges were limited to simple draw bridges until advances in mechanical, electrical, and civil engineering made other types of moveable spans technologically feasible. Two types of historic moveable bridges exist in Maine: swing span bridges and vertical lift bridges. The 2001 Historic Bridge Survey counted eleven moveable highway bridges: eight swing span bridges and three vertical lift bridges.[46]



The Southport Bridge operator's room included this control panel in 1985.

Swing Span Bridges

Swing span bridges were in use in seventeenth-century Europe and possibly before. The rapid expansion of railways and the attendant evolution of bridge engineering and metallurgy led to a surge in the use and development of this type of bridge. A swing span bridge rotates horizontally around an axis so that it is parallel with the maritime channel. An asymmetrical swing span bridge has only one navigation channel with a short end with a counterweight that balances the bridge. Maine's swing span bridges are symmetrical swing spans that use a center-bearing design. With this design the span rotates on a vertical pin or pivot that is set on a pier (called the pivot pier). The center-bearing design is lighter and easier to design, operate, and maintain than another type of swing span bridge, the rim-bearing design, which was used for wider and heavier bridges. The center-bearing design rotates on a circular girder called a drum, which moves on rollers. These bridges have balanced wheels that take no load and ride on a steel circular track. A series of reducing gear sets and a rack and pinion rotate swing span bridges. The controls and machinery are located in operator's or equipment houses either on or adjacent to the bridge. If they were light enough, the swing span bridges could be operated manually; if they were larger, they were activated first by steam engines and later by direct current electric motors. The superstructures of swing spans reflected the current types used in fixed bridges, as the most appropriate type was used for the length and capacity required for the site. The Songo Lock Draw Bridge in Naples, built in 1901, is Maine's oldest remaining moveable highway bridge. Originally located over the Chutes River in Naples Bay, the State Highway Commission relocated the drawbridge to Naples in 1926. There is one other complete example of a period swing span bridge in Maine: Southport Bridge in Southport (1939).



The 1939 Southport Bridge's swing span over Townsend Gut is moved by this gear and mechanism.

[46] KCI, 1997, II-31–32; Lichtenstein, 2004, II-9.

Vertical Lift Bridges

Prominent bridge engineer J. A. L. Waddell designed Memorial Bridge, a vertical lift span built from 1920 to 1921 in Kittery. The bridge was removed in 2012.

Unlike swing span bridges, which pivot in a horizontal plane, vertical lift bridges do exactly as their name implies: they lift in a vertical plane, maintaining their horizontal position as they rise and descend. The earliest vertical lift bridges were built in the United States in the 1850s, but they were generally of modest span lengths and associated with canals. J. A. L. Waddell designed the first modern vertical lift bridge in 1894, the South Halsted Street Bridge over the Chicago River in Chicago, Illinois. The majority of large vertical lift bridges since 1894 have been variations of Waddell's design. A mechanical room on the lift span contains a power source that travels up and down with it. Gear trains transfer power to winding drums and wire ropes that pass over sheaves on steel towers and connect to concrete counterweights about equal to the span weight.[47]

The 1940 Sarah Mildred Long Bridge in Kittery was a vertical lift bridge with electric drive motors and Art Moderne-style towers.

Waddell's South Halsted Bridge presented a variety of engineering problems. How, for example, to cast the huge steel sheaves? Or how to deal with wire ropes that did not necessarily stretch uniformly? By 1907, Waddell teamed up with a mechanical engineer named John Lyle Harrington, who was able to address some of these complex mechanical problems and come up with a design that competed with other moveable bridge types. Waddell and Harrington enjoyed a great deal of success, designing over two dozen vertical lift bridges between 1909 and 1914. They decided to end their partnership that year due to personality conflicts and each enjoyed continued success with other business partners. Waddell designed the Memorial Bridge, carrying U.S. Route 1, over the Piscataqua River between Kittery and Portsmouth, New Hampshire in 1920-21. Waddell's design became so popular that period textbooks, including Hovey's *Moveable Bridges*, chose it to illustrate this bridge type. The bridge was removed in 2012. The other Waddell design is the Carlton Bridge adjacent to the shipyard in Bath, built in 1926, which is a double-deck bridge designed to accommodate vehicle and rail traffic. In 2000, the Maine Department of Transportation installed a new bridge to carry traffic on U.S. Route 1, flanking the original bridge, which still carries rail traffic. Harrington and his partner, Frank M. Cortelyou, designed the Sarah Mildred Long Bridge in Kittery in 1940 to relieve traffic congestion on Route 1 and to replace an one hundred year-old timber pile bridge over the Piscataqua River. The Maine-New Hampshire Interstate Bridge Authority oversaw construction of the double-deck bridge to serve both rail and highway traffic. The bridge received federal aid from the Public Works Administration, a New Deal work relief program. It spans the Piscataqua River upstream from Memorial Bridge and carries the U.S. Route 1 Bypass. In 1988 the bridge was renamed in honor of the Authority's longtime secretary.[48] Construction on a new span to replace the Sarah Mildred Long Bridge began in 2015.

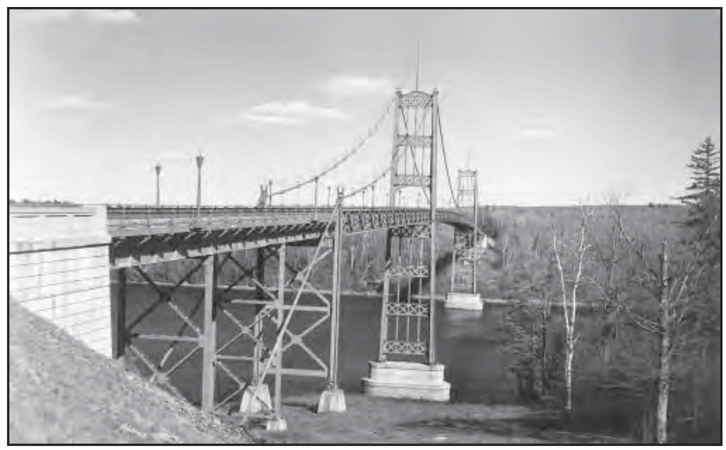
[47] Lichtenstein, 2004, II-10–11.
[48] Lichtenstein, 2004, II-11–12.

Suspension Bridges

Maine has two suspension bridges: the Wire Bridge in New Portland and the Deer Isle-Sedgwick Bridge in Deer Isle. Both bridges are significant examples of the evolution of suspension bridge technology on a national level. Additionally, the Waldo-Hancock Bridge, formerly in Prospect and replaced in 2006, was also nationally significant.[49]

Located in New Portland, the Wire Bridge was built over the Carrabassett River from 1864 to 1866. The bridge is listed in the National Register and is a Maine Historic Civil Engineering Landmark.

Suspension bridges are composed of two or more cables with the deck hung by vertical suspenders. The cables, which are in tension, pass over towers and are tied into anchorages that transmit the stresses into the foundation. Usually, the deck must be sufficiently stiffened by girders or trusses to prevent excessive vibrations from traffic and wind.



Built in 1931, the Waldo-Hancock Bridge in Prospect, was a significant example of the suspension bridge type until it was replaced in 2006.

Suspension bridge technology is ancient, with the earliest known examples made from bamboo cables in China during the first century B. C. Europeans were aware of the technology by the sixteenth century, but it fell to Americans to develop its full potential beginning in the nineteenth century. James Finley is usually recognized as building the first American suspension bridge from cables made of wrought iron chains over Jacobs Creek in Uniontown, Pennsylvania, in 1801. He was followed by other pioneer suspension bridge builders, most notably Charles Ellet and John Roebling, who in the 1840s made pioneering use of wire rope cables for exceptionally long-span bridges. Early extant examples of their work are Roebling's 1849 Delaware River Aqueduct between Pennsylvania and New York and Charles Ellett's 1849 Wheeling Suspension Bridge in West Virginia.

Maine holds an important place in early American wire suspension bridge technology by virtue of the Wire Bridge, built 1864–1866. The single-span, 163 foot-long suspension bridge has main cables composed of wrapped metal wires, timber frame towers, and anchorages of metal chains embedded in stone and concrete. The bridge is among the oldest and most distinctive early suspension bridges surviving in the United States. It reflects local thinking about technology. As several bridge historians have pointed out, the history of the bridge is surrounded by unsubstantiated local legend, including attribution to Colonel F. B. Morse in 1841–1842. Town records indicate, however, several payments to David Elder, cited in a March 1, 1866 entry as agent for the bridge, and to Captain John B. Clark between 1864 and 1866. Elder and Clark are believed to have patterned the New Portland bridge after an earlier wire suspension bridge in the region, the 1856 wire suspension bridge over the Sandy River at Strong, which no longer exists.

[49] The Suspension Bridge section of this chapter was taken from "Historic Bridge Survey: Phase II" completed by Lichtenstein Consulting Engineers for the MaineDOT in 2004 and reprinted here with slight modifications, II-13–15.

The United States eventually produced many of the world's longest monumental suspension bridges, from the Brooklyn Bridge in 1883 to the Golden Gate Bridge in 1939. Among America's leading twentieth-century suspension bridge engineers was David B. Steinman, who completed two significant works in Maine: the 1931 Waldo-Hancock Bridge and the 1939 Deer Isle-Sedgwick Bridge. Steinman earned an engineering degree from Columbia University in 1909 and after a period of apprenticeship with Gustav Lindenthal, then at work on New York's Hell Gate Bridge, emerged in the late 1920s as an outstanding and innovative suspension bridge designer. The St. Johns Bridge in Portland, Oregon, and the Waldo-Hancock Bridge, both built in 1931, were Steinman's first major suspension bridge commissions in the United States, although he had designed suspension bridges in Brazil and Canada. Later American commissions included New York's Thousand Islands Bridge (1938) and Michigan's Mackinac Bridge (1957).

The 1939 Deer Isle-Sedgwick Bridge in Deer Isle was famed bridge engineer David B. Steinman's second commission in Maine.

The 1,500 foot-long Waldo-Hancock Bridge was ranked as one of the great American suspension bridges of the twentieth century due to its innovative use of stretched wire rope strand cables that eliminated the time-consuming process of spinning the cables in place. It was the first American suspension bridge to use Vierendeel truss towers. Named after Belgian engineer, Arthur Vierendeel, their chief characteristic is the absence of diagonals. Rigid frame construction connects the posts to the chords. The advantage of this configuration is economy of material and construction, as well as aesthetics. The truss design was later used in other important bridges, most notably the Golden Gate Bridge in San Francisco. Steinman sought to emphasize straight lines with simple elements in repetition and alternation. The Waldo-Hancock Bridge was listed in the National Register in 1985. It was later named a Maine Historic Civil Engineering Landmark. After over seventy years of use, the cables were no longer functional and the bridge was replaced with the Penobscot Narrows Bridge in 2006.

Like the Waldo-Hancock Bridge, the 1939 Deer Isle-Sedgwick Bridge used both stretched wire rope strand cables and Vierendeel truss towers, but it is perhaps best known for its shallow stiffening girders, which are only six and a half feet deep. In the 1930s, the trend was to use shallow stiffening trusses or girders for economic and aesthetic reasons. At the time, Steinman and other engineers subscribed to a newly-popular theory that the mere weight of such long bridges would prevent them from requiring excessive stiffening. Unfortunately, this type of design led to the unforeseen problem of aerodynamic instability when high sustained winds caused vertical oscillation. This led to tragic consequences in 1940, when the Tacoma Narrows Bridge in Washington—a bridge strikingly similar to the Deer Isle-Sedgwick Bridge—was destroyed in a spectacular fashion by wind-induced vibrations. In response to the disaster, Steinman installed a system of diagonal stays on the Deer Isle-Sedgwick Bridge in 1943. In 1994, the Maine Department of Transportation placed U-shaped, steel plate wind fairings on the exterior faces of the stiffening girders in an effort to further dampen the effects of the wind.

Rigid Frame Bridges

Located in Union, Young's Bridge, built in 1917, is the earliest identified example of the standard low-rise rigid frame bridge used by the Maine State Highway Commission.

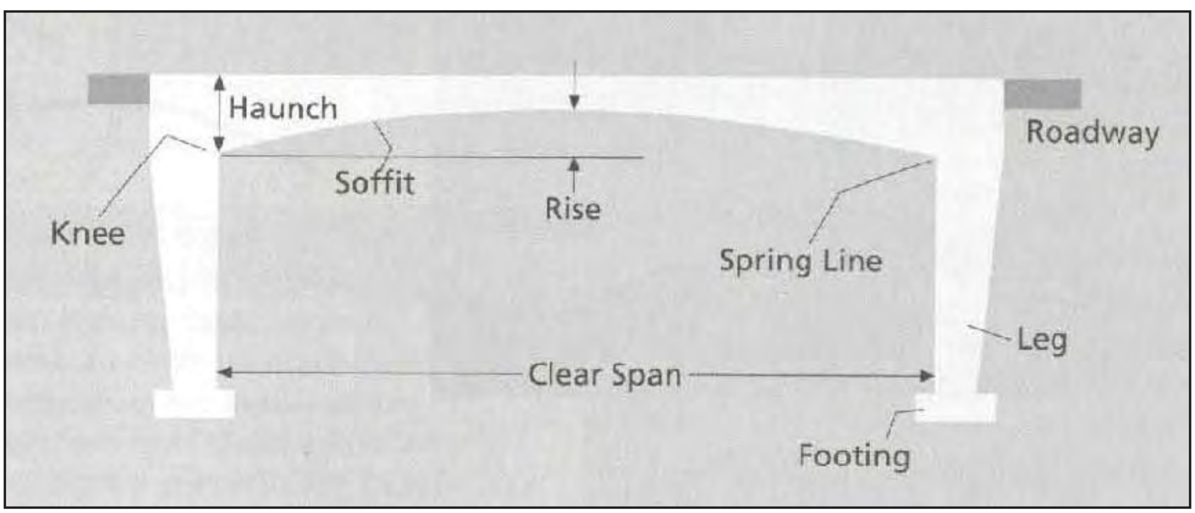
The reinforced concrete rigid frame bridge type, where the top member and vertical elements are integral to the structure, is one of the most efficient uses of both steel and concrete. It was developed in Europe during the late nineteenth century and transferred to the United States in the early part of the twentieth century. The Historic Bridge Survey identified two variants of the design in Maine: the "low-rise" and the "high-rise."[50]

Low-Rise Rigid Frame Bridges

Federal, state, and municipal engineers promoted low-rise rigid frame bridges as an economical and permanent solution to providing roads with short drainage structures and as such, share a similar history with other standard reinforced concrete bridge types, such as the slab and T-beam. Low-rise rigid frame bridges range in length from approximately fifteen to twenty-five feet long. The legs and slab are integral to the structure while haunches at the inside corners are reinforced to take stresses.

This bridge type was introduced in Maine and the United States during the first decade of the twentieth century and was usually identified in period literature as an open (no floor) or closed (with floor) box culvert. Today, they are considered rigid frame bridges because their structure contains the basic principle of a rigid frame bridge; the top member and the verticals are integral and the legs support the loads.

The Maine State Highway Commission quickly developed a standard design for their low-rise rigid frame bridges—the earliest identified extant one is the 1917 Young's Bridge in Union. Other examples in-



Rigid frame bridge nomenclature. Lichtenstein Consulting Engineers, 2004

[50] The Rigid Frame section was taken from the "Historic Bridge Survey: Phase II" completed by Lichtenstein Consulting Engineers for the MaineDOT in 2004 and reprinted here with slight modifications, II-23–24.

clude seven bridges in Acadia National Park, all built from 1928 to 1940. While low-rise rigid frame bridges perform a useful function, they do not have the engineering sophistication, proportions, or economical use of materials like the high-rise examples of the rigid frame.

The 1935 Partridge Bridge in Whitefield illustrates the intrinsic arch profile and handsome lines that characterize the high-rise rigid frame bridge type.

High-Rise Rigid Frame Bridges

In the 1920s, Arthur G. Hayden, designing engineer of the Parks Commission in Westchester County, New York, introduced the high-rise rigid frame bridge type from Europe for crossings that needed a greater vertical clearance and longer spans. This bridge design requires expensive and restrictive formwork to erect, but it is still a worthwhile design because it efficiently uses materials and reduces preparation work with decreased abutment masses. The rigid frame's slightly arched profile to the soffit provides maximum depth at the knees where the bending moment is greatest and the stress pattern most complex, resulting in well-proportioned spans with clean lines.

The Mechanic Falls Bridge, built in 1949 in Mechanic Falls, is one of Maine's earliest multiple-span, high-rise rigid frame bridges.

The State Highway Commission's Bridge Division, under the leadership of Max Wilder, was in step with national trends when it introduced this type of bridge design for longer-span crossings in the early 1930s. The first documented use in Maine is the 1931 Canal Bridge in Madison, a modest forty-one foot-long bridge. A longer and later example is the seventy-four foot-long Partridge Bridge in Whitefield, built in 1935.

A later mid-twentieth century refinement to the rigid frame bridge design was the application of continuous reinforcing across multiple spans. By the late 1930s, rigid frame bridges were common, but in general they were only used for single spans from thirty-five to eighty-five feet long. Multiple-span applications required difficult and sophisticated stress analysis that required more than the basic equilibrium equations with which engineers had become comfortable. In the 1940s, engineers demonstrated growing confidence in the design calculations necessary to build continuous, indeterminate structures of both steel and reinforced concrete. Most state highway departments attempted their first multiple span, rigid frame bridges in the years following World War II. One of the earliest and most complete in Maine was the 1949 Mechanic Falls Bridge.

Chapter 3

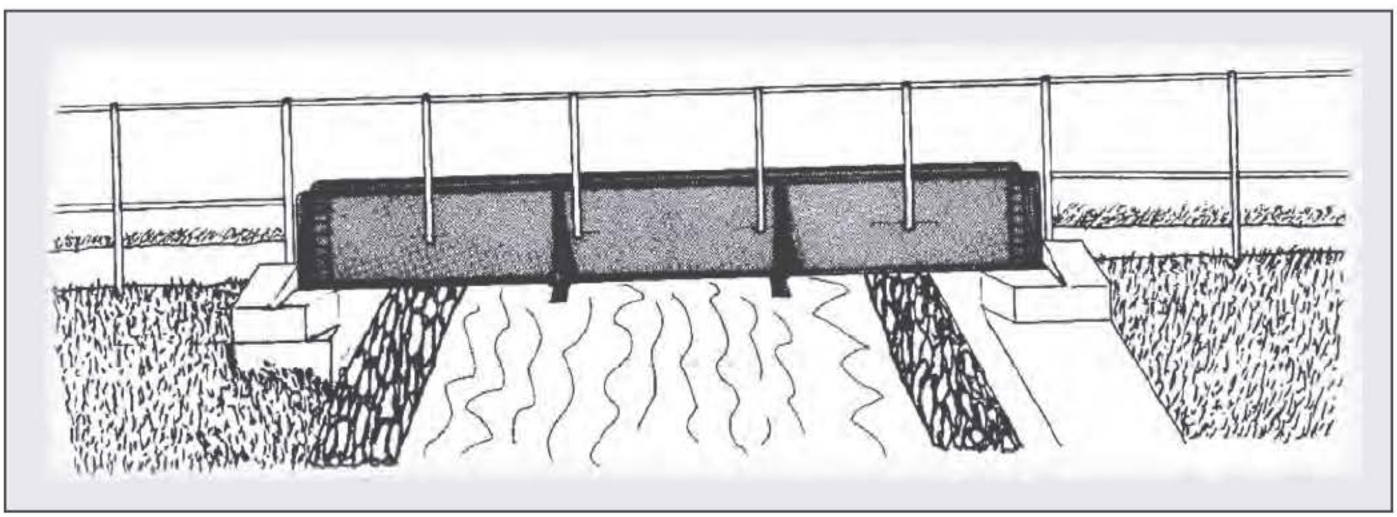
Girder-Floorbeam Bridges

Girder-floorbeam bridges are comprised of two girders connected by floorbeams, which support the deck and are placed perpendicular to traffic. The two most common designs of girder with floorbeam bridges are the thru girder and the deck girder. The thru girder is where the floorbeams are placed in line with the bottom flanges of the girders with the travelway passing between the paired girders. The deck girder is where the floorbeams are placed near the top flanges of the girders and the travelway located at the top of the girders. Other than the placement of the floorbeams and travelway, no significant technological difference exists between the thru and deck designs. Deck girders are often associated with locations where vertical underneath clearances were not critical.[51]

An important advance in girder technology occurred with the transition from wood to metal girders in the mid-nineteenth century. America's antebellum bridge engineers understood the superior bending strength of metal but the development of the technology and its widespread application relied upon later improvements in the manufacture of rolled-iron structural shapes such as angles, channels, plates, and I-beams.

As early as 1847, wrought-iron girder bridges were introduced by the railroads. In most instances, the railroad used built-up beams, composed of rivet-connected plates for the web and angles of the flanges, to make a beam of sufficient depth to span greater distances than possible with the rolled beams that were commonly used at that time. (The depth of a beam is related to span length: the greater the desired length, the greater the depth of the beam.) Built-up girder bridges proved to be efficient and economical for railroad-carrying spans; in fact, they were the only serious competitors to metal trusses for railroad use in the late nineteenth century.

Railroad companies especially appreciated the ease of installing girder bridges. Since the built-up beams were almost completely assembled in fabricating shops, conveniently located on rail lines, the bridges could be loaded easily onto flatbed cars. Once at the construction site, cranes quickly hoisted them into position with minimal traffic interruption. The ability to transport beams was often a factor limiting their



Girder-floorbeam. Illustration by Kevin Riley, MaineDOT

[51] KCI, 1997, II-30. The Girder-Floorbeam Bridges section was taken from the "Historic Bridge Survey: Phase II" completed by Lichtenstein Consulting Engineers for the MaineDOT in 2004 and reprinted here with slight modifications, II-24–30.

The 1890 Park Avenue Underpass in Portland is an early surviving example of a girder-floorbeam bridge with concrete encasement to protect the beams.

length, and in general, built-up girder highway bridges were not built in great numbers because of the difficulty of transporting the beams overland by wagons or sleds. Thus, most extant nineteenth-century girder bridges and many twentieth-century ones are associated with railroads. A number of railroad-built girder-floorbeam bridges in Maine are significant for their historic association with rail lines that made important contributions to the economic and physical development of the state, region, or locality. It is their historic connection with an important rail line with integrity that sets them apart from other bridges with a common technological heritage.

Bingham's Tom Collins Bridge, seen here in 1921, is a standard reinforced concrete thru girder type that the Maine Bridge Division used for a brief period in the early 1900s.

By the 1890s, improvements in the open-hearth steel-making process resulted in the manufacture of larger quantities of structural steel at lower prices. Consequently, bridge builders increasingly chose steel rather than wrought-iron sections to make use of steel's superior **tensile** strength. As steel plants developed larger rolling mills, it was also possible to substitute deeper rolled beams of I-section for built-up beams. Although wrought-iron rolled I-beams had been available since the 1850s, they had been used sparingly in bridge construction, usually as floor-beams or stringers of truss bridges, because of their high cost and the difficulties of rolling long and deep beams.

The girder-floorbeam bridge technology was mature by the last decades of the nineteenth century, and there have been few significant changes since. This bridge type continues to be built today with minor refinements, mostly in metallurgy and the use of welded and bolted connections rather than riveted connections. In addition, the increased application of continuous design principles advanced in the mid-twentieth century was applied to girder-floorbeam bridges.

The Historic Bridge Survey found eighty-six girder-floorbeam bridges constructed before 1956, not counting the previously-evaluated six moveable bridges that have girder-floorbeam superstructures. Maine's girder bridges fall within national trends and thinking about the technology. They are mostly textbook designs built using standard details for girders, flooring systems, railings, and substructure elements. However, twenty-two girder-floorbeam bridges are eligible for listing in the National Register of Historic Places.

All of the oldest extant examples in the state are associated with railroads. The railroads developed the technology in the mid-nineteenth century and used it unsparingly through the middle of the twentieth century.[52]

[52] The bridge survey includes only those railroad-built bridges that cross highways as grade separation structures. Although it is unknown how many other girder-floorbeams bridges are on the railroads, it is expected that the number is large. Most of these unsurveyed bridges are presumed to have been built between 1890 and 1929 when the railroad companies upgraded bridges on their lines for heavier locomotive loadings.

Girder-Floorbeam Railroad Bridges

Two of the most important rail lines in Maine are the Bangor and Aroostook (B & A) Railroad's line from Northern Maine Junction to Searsport and the Boston and Maine (B & M) Railroad's Saco-Biddeford Main Line.

The B & A line retains seven steel girder-floorbeam bridges. The line was the most costly construction project undertaken by the railroad to promote the development of northern Maine's wood products and agricultural industries. The B & A had built or acquired a network of lines north of Bangor between 1891 and 1902, but the company did not have an all-weather seaport terminal, leaving it at the financial mercy of other railroads, particularly the Maine Central, which could set rates and terms for shipment. The extension of the line from South LaGrange to Searsport had a significant impact on the growth of industry along the B & A, particularly the expansion of the Great Northern paper mills in Millinocket.

The Pennsylvania Steel Company of Steelton, Pennsylvania, held the B & A's contract for bridge construction and fabricated all of the identified girder-floorbeam bridges. The bridges are among the earliest extant examples of this type, and several bridges have good period details, such as shiplap or steel bents with built-up battered columns of Z-shaped section and plate. The line retains the integrity of its original design, including alignment, grade, cuts, fills, bridges, and many early twentieth-century facilities, including stations and depots, shops, and a yard.

The Bangor and Aroostook Railroad built the Monroe Road Railroad Bridge #1603 in Frankfort, one of seven overpass bridges built in 1905 for its Lagrange-Searsport extension.

Built from 1927 to 1928 in Saco, the Common Street Bridge illustrates the ubiquitous girder-floorbeam technology used by railroads across Maine and the nation.

The B & M's Saco-Biddeford Main Line retains another significant group of girder-floorbeam bridges. The B & M line from South Berwick to Portland by way of Saco-Biddeford was initially constructed in 1873. It was built in response to competition for the Boston-Portland traffic with the Eastern Railroad, in which the B & M had lost track rights over an earlier line. The B & M emerged from the financial turmoil of the 1870s as the strongest of the competing lines and became the dominant carrier of all freight and passenger traffic from Portland to Boston and other points in New England. The B & M played a significant role in the transportation and economic development of Maine by tying its agricultural and industrial products to the national economy. The line was the backbone of the B & M system and a dominant transportation force in the state through the 1920s until it began consolidating operations. The B & M slowly abandoned its lines after the 1930s in response to competition from motorized vehicles.

The B & M Main Line was continually improved from its initial development in 1873 through the end of its heyday in the late 1920s. The line was improved in 1927–1928 with the replacement of at least seven overpass bridges. All but two bridges are girder-floorbeams bridges fabricated by the Phoenix Bridge Company of Phoenixville, Pennsylvania. The bridges are intact examples of their type, engineered for heavy locomotive loadings.

Note: This section was adapted from the "Historic Bridge Survey: Phase II" completed by Lichtenstein Consulting Engineers for MaineDOT in 2004, II-24–30.

The oldest example in the survey is the 1890 Park Avenue Underpass in Portland. It is an early application of concrete encasement, a technique that was successfully developed to protect steel beams in the late nineteenth century and was very popular through the first half of the twentieth century. In this case, the concrete encasement is also used as an architectural treatment in deference to the bridge's prominent urban situation. The bridge is among the earliest extant structures built by the Portland Union Railway Station Company, organized in 1887 to rationalize and improve the terminal operations of formerly competing rail lines in a congested urban setting.

The most impressive of the state bridge division girder bridges are two multiple-span continuous-deck girder bridges built in the 1940s. The 1940 Seven Mile Brook Bridge in Vassalboro and the 1946 Highland Avenue Bridge in Houlton have haunched built-up girders with center spans of over a hundred feet. They are historically and technologically significant applications of continuous design principles illustrating the economy of design and material achieved during the mid-twentieth century. Although not early in a national context—the continuous designs began appearing in the 1920s and 1930s—they are the earliest continuous deck girder floorbeam bridges designed by the bridge division under the leadership of state bridge engineer Max Wilder.

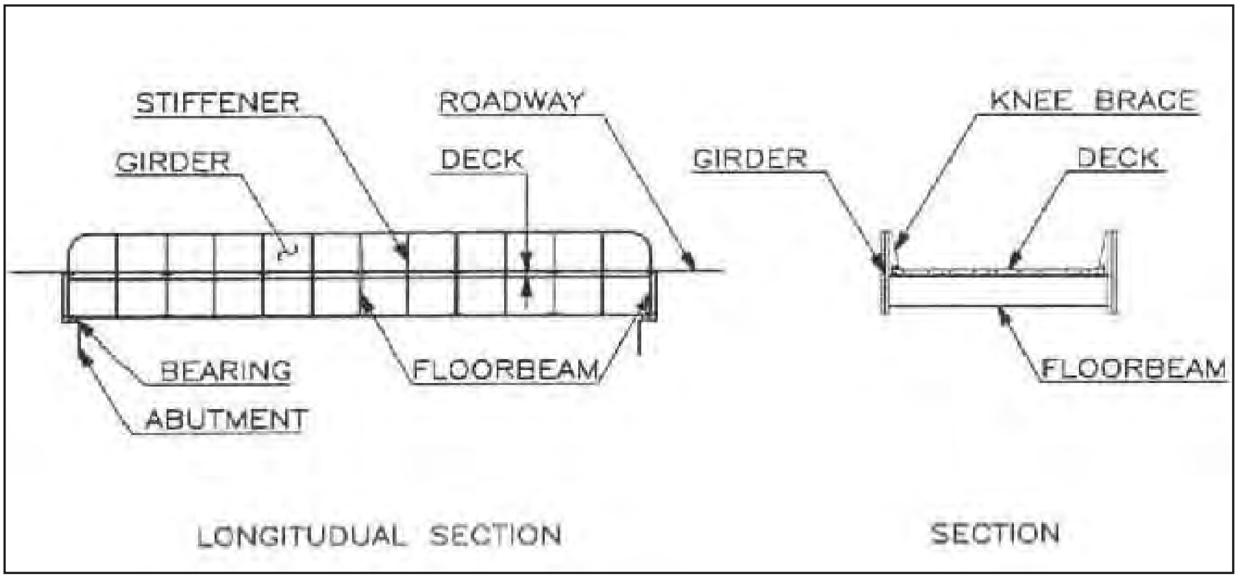
Most of Maine's girder-floorbeam bridges are steel but it is possible to build this bridge type out of other materials, including reinforced concrete. Reinforced concrete thru girder bridges are composed of a pair of cast-in-place longitudinal girders and transverse floorbeams that are connected by the arrangement of the steel reinforcing bars. The roadway passes between the paired girders. The girders are commonly very large in appearance and have panels to save on weight. The girders serve as the bridge parapets as well as the main supporting members. Two reinforced concrete thru girder bridges were identified in the bridge survey. The 1916 Tom Collins Bridge in Bingham is the earliest and most intact, and the other is the Abbot Bridge in Abbot, built in 1918, which is closed to traffic and has lost integrity of original design and materials.

Stringer Bridges

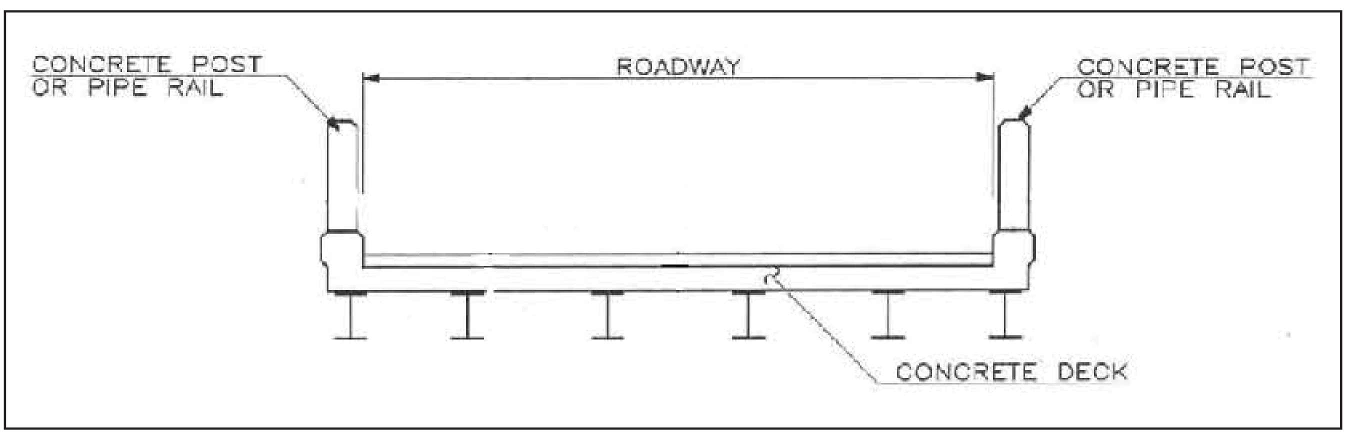
The stringer bridge type consists of a series of parallel, longitudinal beams supporting a deck, usually of wood planks or concrete. The stringer bridge, like girder bridges of all materials, relies on the bending strength of the material to resist the loads. An important advance in stringer technology occurred with the transition from wood to metal beams in the mid-nineteenth century. America's antebellum bridge engineers understood the superior bending strength of metal, but the initial development of the technology and its widespread application relied upon later improvements in the manufacture of rolled-iron structural shapes.[53]

Pennsylvania's Bethlehem Steel Company introduced a major technological breakthrough when it began producing wide-flange rolled steel beams at its Grey Mill plant in 1908. The mill, named after its inventor Henry Grey, rolled beams at greater speeds and depths with no reduction in strength and at an approximately ten percent savings in material. Although the company initially first met difficulties marketing the new 26 inch, 28 inch, and 30 inch deep beams, Bethlehem had overcome these problems by the early 1910s. J. A. L. Waddell, the great vertical lift bridge designer, touted the superiority of the improved steel I-beams in his 1916 edition of *Bridge Engineering*, calling them a great boon to bridge designers and builders because of their simplicity, compactness, and lower price.

[53] In Maine stringer bridges and T-beam bridges are coded as girder bridges in TINIS, MaineDOT's database. The Stringer Bridge section was adapted from the "Historic Bridge Survey: Phase II" completed by Lichtenstein Consulting Engineers for MaineDOT in 2004, II-33–35.



Girder bridge nomenclature. Lichtenstein Consulting Engineers, 2004



Stringer bridge nomenclature. Lichtenstein Consulting Engineers, 2004

As a class, rolled steel stringer bridges proved ideally suited for the highway building campaigns of the twentieth century. They came to the forefront before World War I, and by the mid-1920s, rolled section stringer bridges were ubiquitous. The advantages of the technology were particularly attractive to state and county bridge engineers for spans up to sixty feet in length. They could be easily erected with readily-available beam sections and were cheaper than pony truss bridges. Rubber-tired trucks and improved heavy construction equipment eased the problems of transporting girders and erecting them on site. With accessible flat surfaces, stringer bridges were easier to clean and paint than trusses and a concrete deck over the beams added protection from exposure to the elements. Steel stringer bridges were common in Maine, as the Historic Bridge Survey identified more than 570 examples that were built prior to 1956.

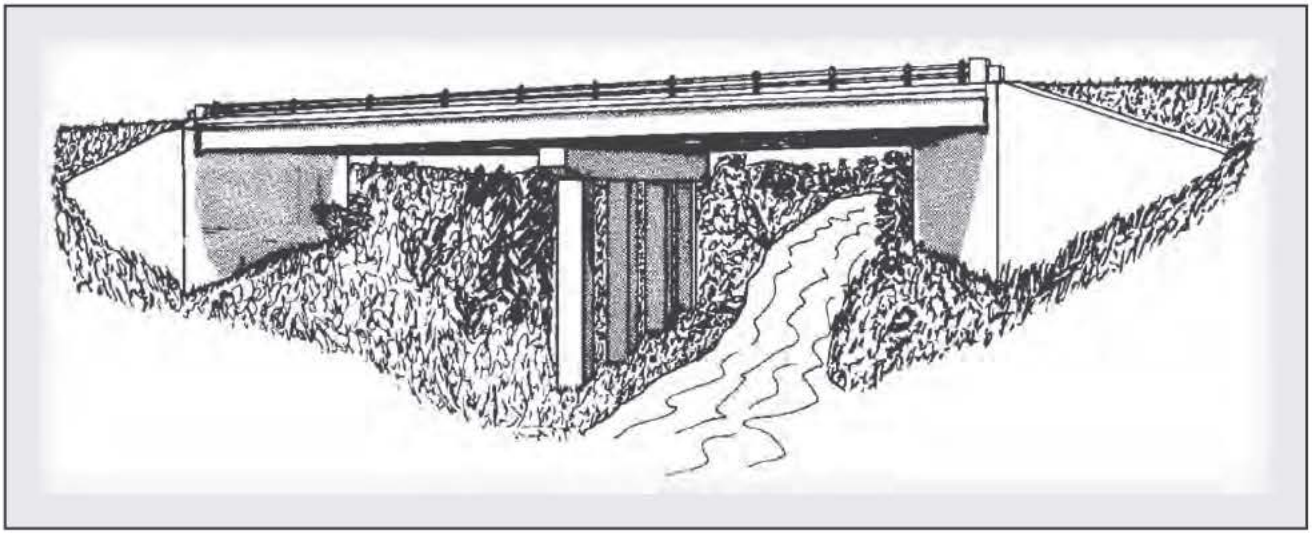
The 1920 Jellison Bridge in Sanford is a good complete example of the jack arch deck design.

The five-span, 344 feet-long steel stringer Somesville Bridge, built in 1937 in Saco, was an early application of continuous deck design by the state bridge division.

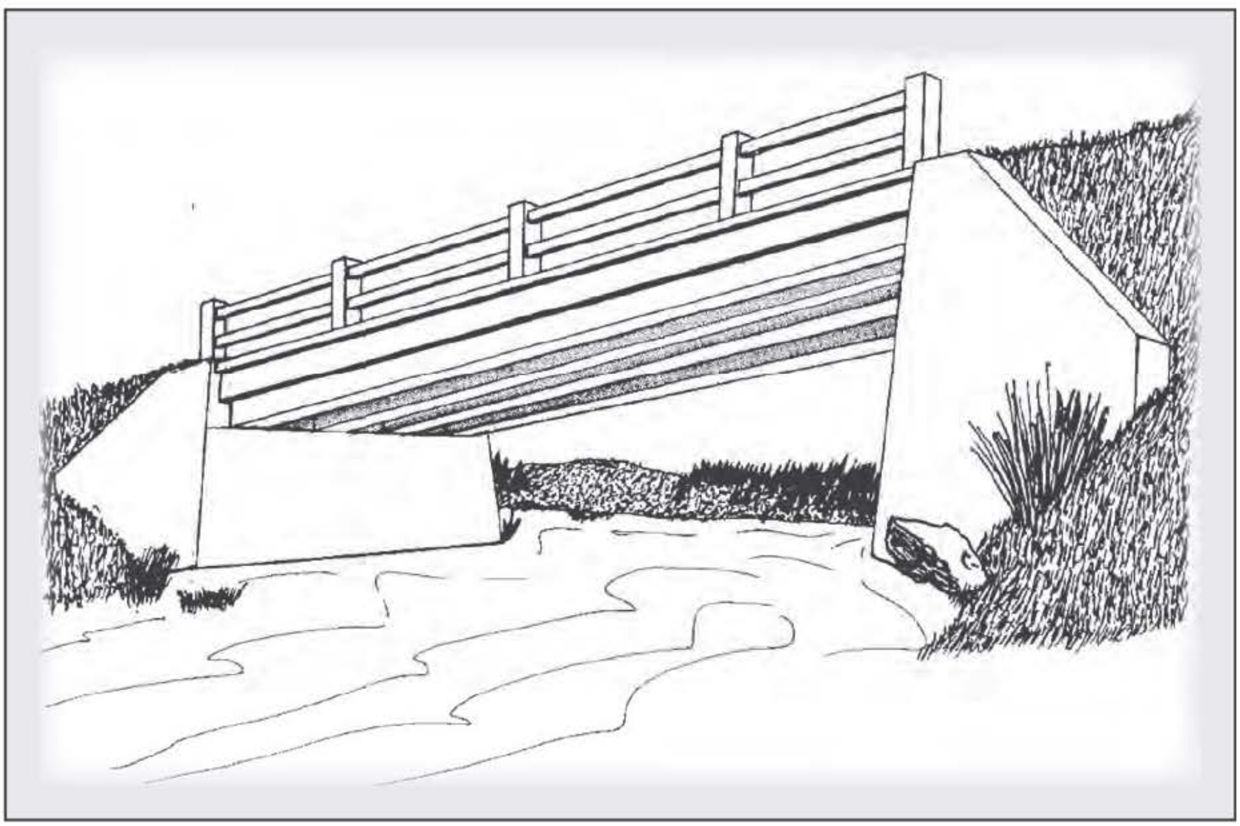
Several common design variations of the steel stringer bridge type were in use in Maine and throughout the United States during the first half of the twentieth century. The stringers could be used plain, completely encased in concrete, with a jack arch deck slab, or with a continuous reinforced concrete deck. A common detail of steel stringer bridges is the concrete encasement of the beams. This technique was introduced in the 1890s to protect beams from corrosion and to eliminate the need for periodic painting. Although it added dead load to the bridge, encasement had long-term maintenance cost benefits and was used frequently as a technique by highway departments and railroad companies through the mid-twentieth century.

The concrete jack arch deck design was used for both local and state bridges from the 1910s to 1930s. By using a form liner like corrugated metal sheets placed in an arched shape between the stringer, the concrete deck was poured so that it integrated the stringers with the deck and was thus better at distributing the live loads. The jack arch deck design became obsolete in the late 1930s as continuous reinforced concrete deck technology improved.

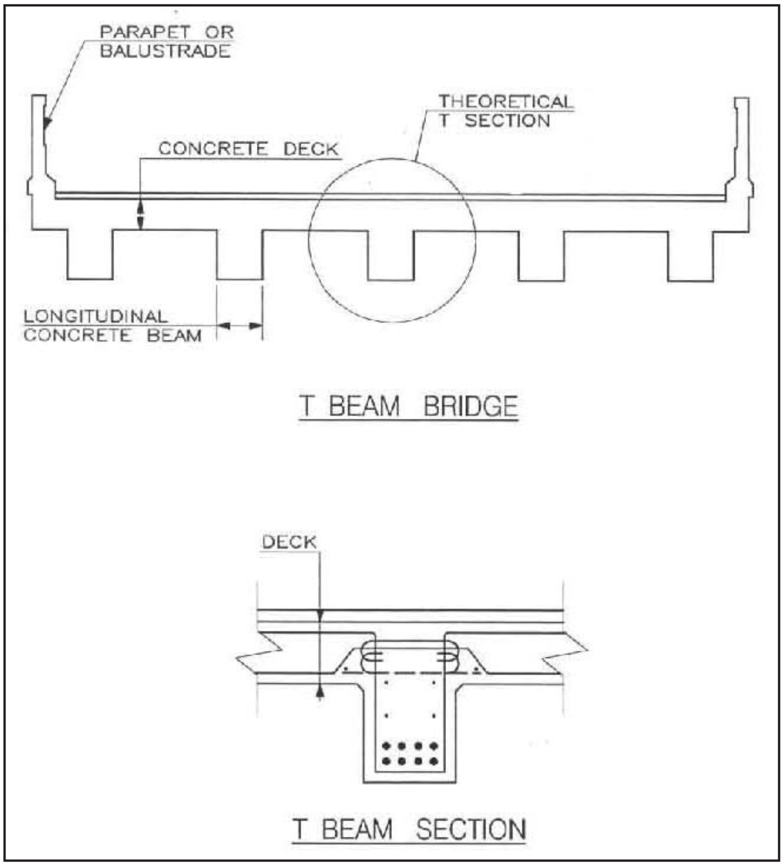
Continuous design steel stringer bridges—where the beam continues uninterrupted over one or more piers—were both more technologically advanced and economical to build and maintain than earlier steel stringer bridges. After 1935, they became very common in Maine, with over 120 pre-1956 examples identified by the bridge survey. They have significant economic advantages because they use less material for a given span length than simple spans. By spanning greater lengths with smaller section beams than comparable simply supported spans, which must accommodate the entire load within the span, the continuous span distributes loads from bearing to bearing over two or more spans. The reinforced concrete deck is continuous over the interior substructure units, thus reducing the number of expansion joints, whose failure is a primary source of bridge deterioration.



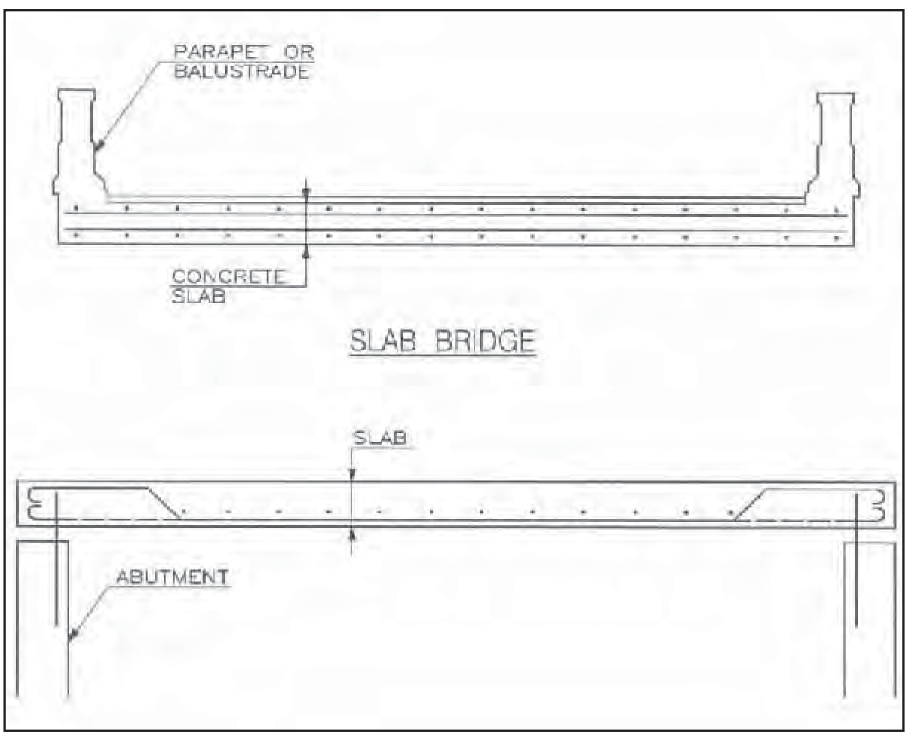
Multi-span steel stringer bridge. Illustration by Kevin Riley, MaineDOT



T-beam bridge. Illustration by Kevin Riley, MaineDOT



Typical T-beam section. Lichtenstein Consulting Engineers, 2004



Typical slab bridge. Lichtenstein Consulting Engineers, 2004

Advances in engineering theory and knowledge led to the increased use of continuous design bridges. Perhaps the most important advance was the development of standard methods for determining the forces—the **moments** and **shears**—in continuous beam bridges. Prior to this time, the design of continuous beam bridges was tedious, intricate, and time consuming. In fact, few state bridge engineers used continuous designs because of the problems involved in analyzing the indeterminate structures. Beginning in 1932, the American Society of Civil Engineers published standard methods and tables for calculating moment distribution and in 1941 AASHO added these to their standard specifications, making continuous steel stringer bridges even more common after World War II. The state bridge division was apace with national trends in taking advantage of the economy of continuous designs. One of the division's early complete examples of continuous steel stringer bridges is the 1938 Badger Island Bridge in Kittery.

The 1909 Old Buffam Bridge in Wells is a slab bridge located on the old alignment of the Boston Post Road.

The 1919 Kingman Road Bridge in Mawahoc Plantation is among the earliest, state-built T-beam bridges in Maine.

Reinforced Concrete Slab & T-Beam Bridges

In the late 1890s advancement in the understanding of reinforcing placement to accommodate tension and shear forces resulted in the more frequent use of reinforced concrete for slab and T-beam bridges early in the twentieth century. The appropriateness of one bridge type over another was predicated on several factors, such as length of span, roadway profile, and economical use of steel. Beginning in the 1910s, reinforced concrete slab and T-beam bridges proved ideally suited for the preparation of standard plans that could be used in a variety of conditions. As a result, state highway departments built hundreds of nearly identical slab and T-beam bridges as part of the development of state highway systems. Slab and T-beam bridges in Maine are technologically undifferentiated from those in other states.[54]

The slab bridge concentrates reinforcing steel in the form of twisted or deformed rods in the lower portion and ends where tensile forces and shear are the greatest. As with all other bridge types, the amount of steel and depth of the slab is predicated on its length and live load capacity. Slab bridges span up to about thirty-five feet; beyond that width, other bridge types are more economical. Slab bridges are the most common bridge type in the historic bridge inventory with over six hundred pre-1956 examples. The earliest complete example is the 1909 Old Buffam Bridge in Wells, which was built as part of an early improvement to the Boston Post Road, later designated U.S. Route 1.

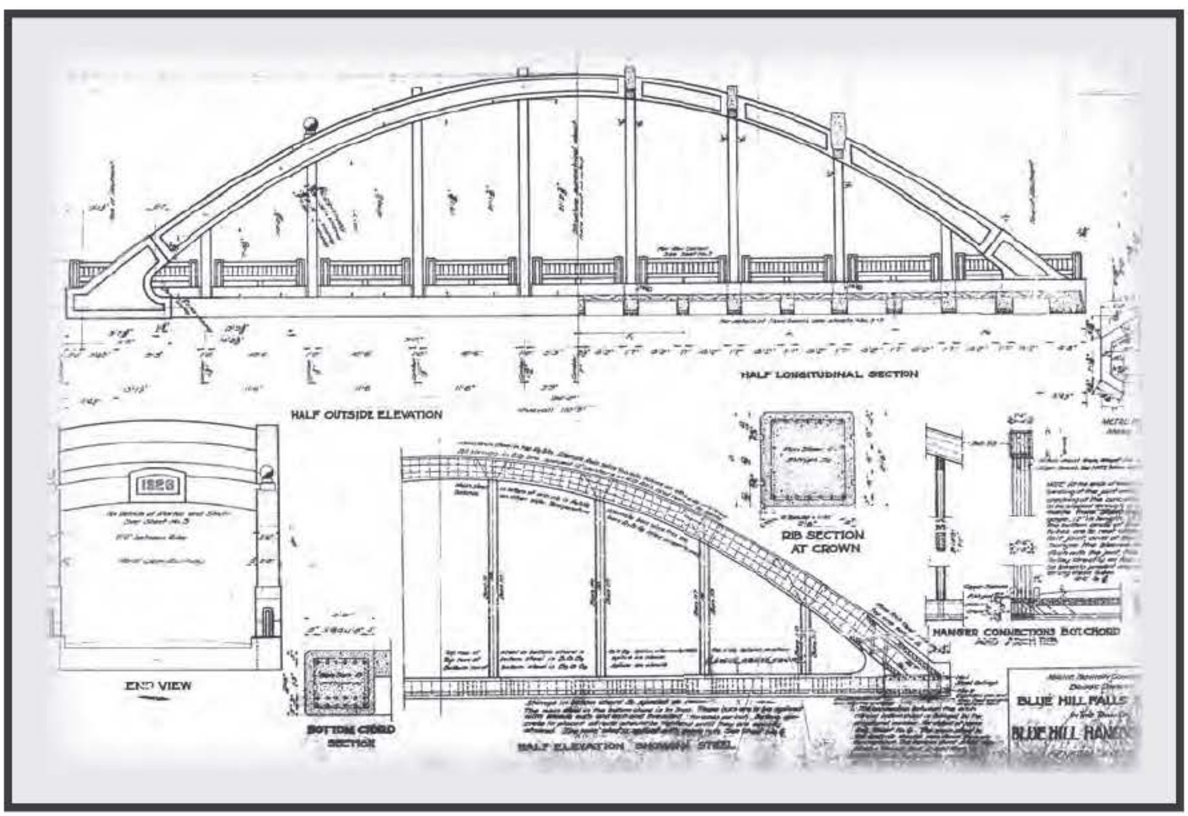
[54] The Reinforced Concrete Slab and T-beam Bridges section was adapted from "Historic Bridge Survey: Phase II" completed by Lichtenstein Consulting Engineers for the MaineDOT in 2004, II-36–37.

T-beams bridges are cast-in-place reinforced concrete beams with integral monolithic flanking deck sections used for spans of up to fifty feet in length. The primary reinforcing steel is placed longitudinally in the bottom of the beam stem and the deck or flange reinforcing is placed perpendicularly to the stem. T-beams are almost always supported on reinforced concrete substructures and they were favored in Maine for span lengths of over twenty feet because of their low long-term maintenance and thus overall economy of material. The technology of the T-beam bridge did not change from the 1910s through the 1950s. With its integral connection of the longitudinal beam and deck section, it is a more efficient use of material than the slab design. The T-beam design proportions the deck thickness and longitudinal beam size and spacing to achieve a lighter, stronger, and more economical section.

Beginning in the late 1910s, T-beam bridges emerged as one of the most popular state bridge department designs, partly due to a state-sponsored funding mechanism. The General Bridge Act of 1915 established regular funding and a set of procedures for the improvement of the state's highway bridges. The T-beam became a standard state highway bridge type for use in the development of the state highway system. In fact, the Historic Bridge Survey identified more than 260 T-beam bridges in Maine. The T-beam bridge design was used widely through the 1920s and early 1930s and continued to be popular through the 1950s, although it increasingly faced competition from steel stringer technology in the same range of span lengths. The cast-in-place bridges are labor intensive owing to the requisite form work and they are not built frequently today because of high labor costs. Early complete examples of this workhorse bridge type are the 1918 Leigh Bridge in Vassalboro and the 1919 Kingman Road Bridge in Macwahoc Plantation.

CHAPTER 4

Photo Gallery of Historic Bridge Types



Previous: Design plans for the Blue Hill Falls Bridge built in 1926.

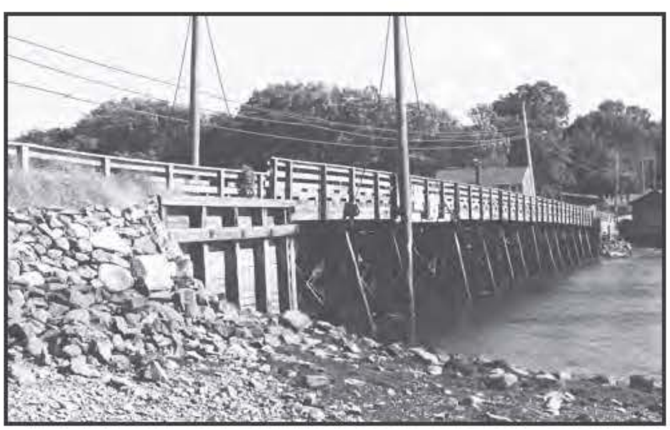
Photo Gallery of Historic Bridge Types

The construction of bridges and roadways in Maine has evolved significantly since the first Native American and Colonial European footpaths that accommodated only an individual and a horse. Well maintained and wide paved roads were not common in Maine until the late nineteenth and early to mid twentieth centuries. Similarly, bridges during the early settlement period were practical timber structures spanning relatively small waterways, but in the eighteenth century, bridge builders completed more complex timber pile structures. Later technological advances gave Maine bridge designers the ability to create longer and more efficient spans. The nineteenth century first saw the refinement of iron and steel production and then the advent of reinforced concrete; these materials dramatically shaped the evolution of bridge design. As bridge engineers formalized their profession, they created more standardized bridges, but the state's challenging terrain necessitated personal ingenuity to ensure a successful structure. Today's bridge building and roadway design is rooted in this rich legacy.

The gallery visually highlights the legacy of bridge building in Maine and displays the state's historic bridge types. These historic bridge types have been previously outlined in Chapter 3. The bridges included in this gallery are all MaineDOT owned or managed and were included in the department's Historic Bridge Survey. In addition, the bridges are either listed in or eligible for listing in the National Register of Historic Places. Each entry notes the bridge's number, name, location, and date of construction. Unless otherwise stated, all photographs in this section are from MaineDOT's Historic Bridge Survey, conducted from 1999 to 2001. In some instances, a bridge has unfortunately been lost since the Historic Bridge Survey and its date of replacement has been included.

Timber

3096 Sewall's Bridge, York, 1934



Cribwork

2033 Bailey Island Bridge, Harpswell, 1926

Photo taken 2010

Stone Slab

0356 UL #1 Bridge, Mt. Desert, c.1960, Replaced 2002

0747 Watson's Bridge, Waterford, 1890

Photo taken 1924

1097 Water Street Bridge, Hartland, c.1925

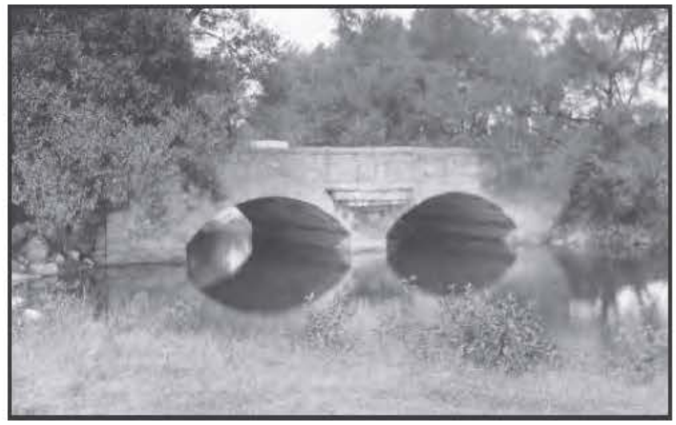
5042 Richardson Brook Bridge, Mt. Desert, 1925

Chapter 4

Arch: Stone

0328 Clark Street Overpass Bridge, Portland, c.1873

0490 Vaughan Memorial Bridge, Hallowell, 1905



0563 Water Street Bridge, Augusta, 1854

0619 Arch Bridge, Bristol, c.1905

Photo taken 1924

0965 Meadow Bridge, Milo, c.1895

1358 Bridge Street Bridge, Sanford, 1903

2021 Arch Bridge, Pembroke, 1894

2560 Mill Creek Bridge, Falmouth, 1894

2719 Riggs Bridge, Augusta, c.1900, Replaced 2010

Arch: Steel

2585 Morse Bridge, Rumford, 1935

Arch: Reinforced Concrete

0458 Eagle Lake Road Bridge, Bar Harbor, 1928

0459 Overpass Bridge, Mt. Desert, 1932

0469 Kebo Brook Bridge, Bar Harbor, 1938

0471 Mountain Road Underpass Bridge (NPS#020P), Bar Harbor, 1951

0470 Overpass Bridge (NPS#1700-002P), Bar Harbor, 1938

0472 Overpass Bridge (West Street-NPS#010P), Bar Harbor, 1953

0475 Otter Creek Bridge (NPS#019P), Mt. Desert, 1938

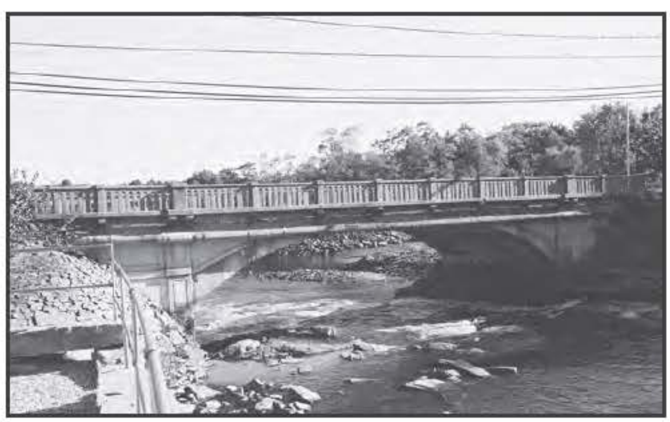
0559 Overpass Bridge (NPS#0265), Mt. Desert, 1933

1359 Washington Street Bridge, Sanford, 1911

2187 Covered Bridge, Norridgewock, 1928, Replaced 2011

2257 East Rochester Bridge, Lebanon, 1946

2272 Falls Bridge, Yarmouth, 1930



2432 Kezar Falls Bridge, Parsonsfield, 1924, Replaced 2000

2573 Milo West Opening Bridge, Milo, 1915

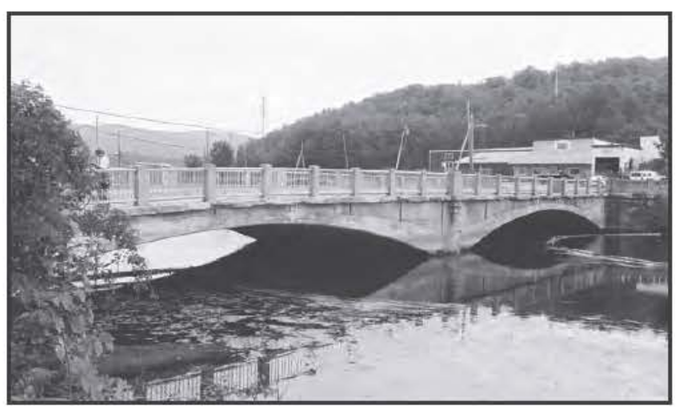
2682 Pope Memorial Bridge, East Machias, 1902

2990 Chisholm Park Bridge, Rumford, 1929

*3876 Johnsons Mill Bridge, Waterboro, 1920**

Photo taken 1924

3638 Hartford Street Bridge, Rumford, c.1915

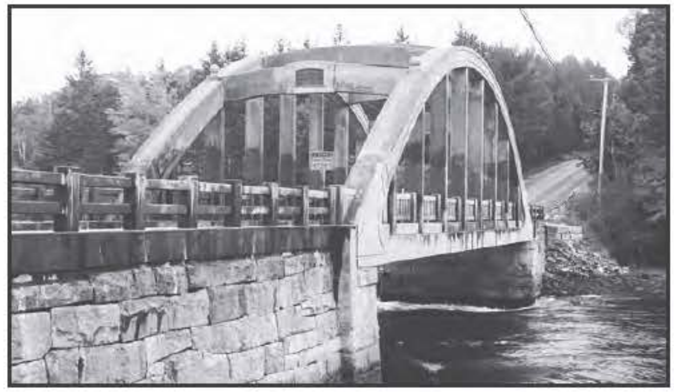


**Built in 1920 as a reinforced concrete arch; widened in 1953 with a concrete slab addition.*

5003 Chestnut Street Bridge, Lewiston, 1928

Photo taken 1928

5038 Blue Hill Falls Bridge, Blue Hill, 1926



5063 Lower Village Bridge, Phillips, 1927

5131 Carrabassett Bridge, New Portland, 1923

5852 Centennial Bridge, Kingfield, 1916

Truss: Paddleford

1001 Lovejoy Bridge, Andover, 1868

1004 Hemlock Bridge, Fryeburg, 1857

1005 Bennett Bridge, Lincoln Plantation, 1898

1007 Artist's Covered Bridge, Newry, 1872

1010 Porter-Parsonsfield Bridge, Parsonsfield, 1876

Photo taken 1941

Truss: Long

1003 Robyville Bridge, Corinth, 1876

Truss: Howe

1006 Watson Bridge, Littleton, c.1903

Photo taken 1924

5352 Hobb's Railroad Overpass Bridge, Berwick, 1942, Removed 2000

Truss: Pratt

0159 Bangor & Aroostook Railroad Bridge #A44.74, Ashland, 1902

0323 Free/Black Bridge, Brunswick, 1909, Lower Deck Removed 2014

0327 St. John Street Underpass, Portland, 1890

1351 Elm Street Bridge, Biddeford, 1928

2565 Mill Pond Bridge, Salem Township, 1929, Replaced 2004

2904 Wadsworth Street Bridge, Thomaston, 1925, Replaced 2015

3016 Back River Bridge, Arrowsic, 1933, Replaced 2007

5429 Grants Railroad Overpass Bridge, Berwick, 1890, Replaced 1999

Truss: Pennsylvania

2398 International Bridge, Fort Kent, 1929, Replaced 2012

2399 International Bridge, Madawaska, 1921

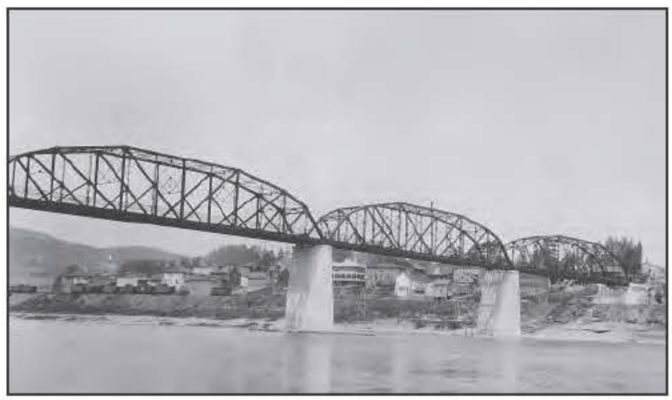


Photo taken 1922

2608 New Sharon Bridge, New Sharon, 1916, Removed 2014

3040 Piscataquis Bridge, Howland, 1929, Replaced 2010

Chapter 4

Truss: Parker

1474 North Turner West Bridge, Turner, 1936, Replaced 2008

1522 Kennebec River Center Bridge, Fairfield, 1934, Replaced 2001

3106 Kennebec River East Bridge, Fairfield, 1934, Replaced 2001

Photo taken 1934

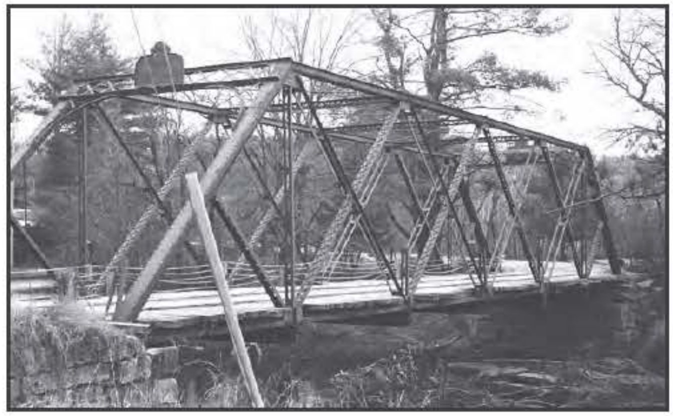
3214 North Turner East Bridge, Leeds, 1936, Replaced 2008

5084 Androscoggin River Bridge, Gilead, 1921

Truss: Warren

0210 Overpass Bridge, Yarmouth, 1888, Replaced 1999

0238 Ryefield Bridge, Harrison, 1912



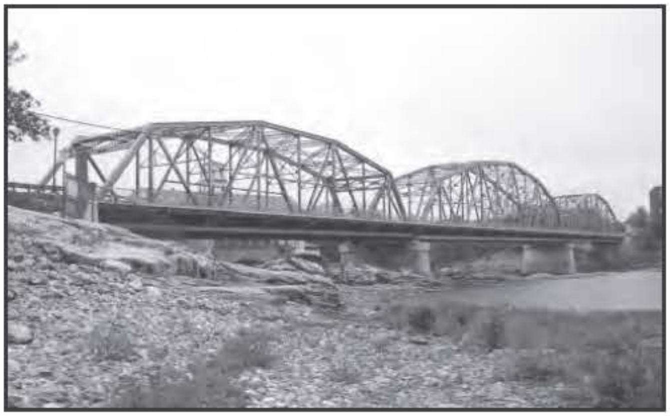
0266 Gambo Falls Bridge, Windham, 1912

1022 Bailey Bridge, Harmony, 1915, Removed 2000

1523 Kennebec River West Bridge, Fairfield, 1934, Replaced 2001

1525 Canal Bridge, Hollis, 1937, Replaced 2015

2016 Frank J. Wood Bridge, Brunswick, 1932



2605 New Mills Bridge, Gardiner, 1947, Replaced 2009

3284 Dock Bridge, Alna, 1936

3330 South Bridge, Auburn, 1937

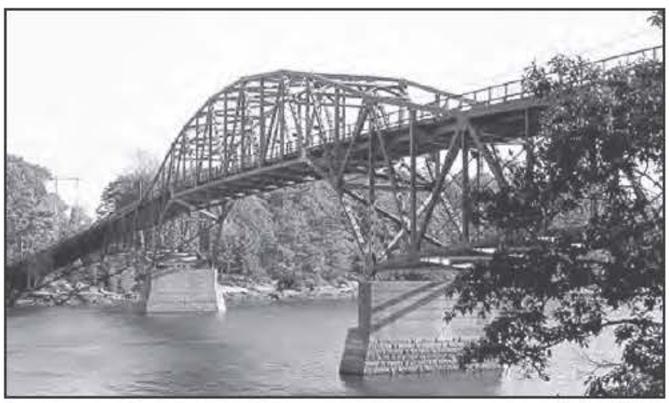
3333 Bar Mills Bridge, Hollis, 1937, Replaced 2015

3334 Durham Bridge, Durham, 1937, Replaced 2015

3340 West Buxton Bridge, Buxton, 1937

Truss: Cantilever

2026 Max L. Wilder Memorial Bridge, Arrowsic, 1950



5196 Memorial Bridge, Augusta, 1949

5572 Aroostook River Bridge, Caribou, 1952

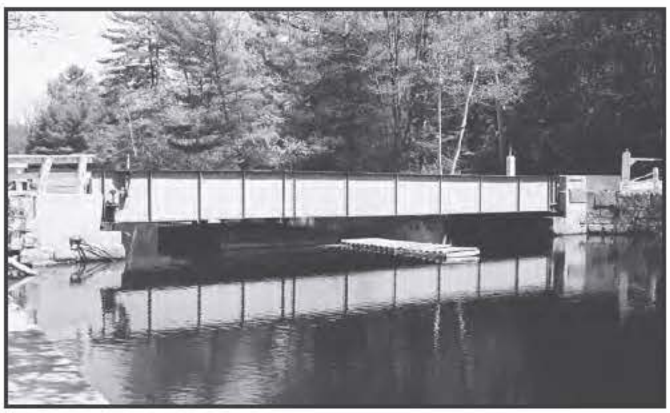
Photo taken 1952

Moveable: Swing Span

1475 Great South Bridge, Milbridge, 1936, Replaced 2010

2506 Maine Kennebec Bridge, Richmond, 1931, Replaced 2013

2780 Songo Lock Drawbridge, Naples, 1901



2789 Southport Bridge, Southport, 1939

Moveable: Vertical Lift

2546 Memorial Bridge, Kittery, 1921, Replaced 2013

3641 Sarah Mildred Long Bridge, Kittery, 1940, Replaced 2015

Suspension

3008 Waldo-Hancock Bridge, Prospect, 1931, Replaced 2006

Photo taken 1931

3257 Deer Isle-Sedgwick Bridge, Deer Isle, 1939

Photo taken 2009

3383 Wire Bridge, New Portland, c.1866

Rigid Frame: Low

0466 Bridge 1, Mt. Desert, 1928

Photo taken 2011

0467 Bridge (NPS#031P), Mt. Desert, 1928

Photo taken 2011

0468 Bridge (NPS#032P), Mt. Desert, 1928

Photo taken 2011

0477 Overpass Bridge (NPS#0055), Mt. Desert, 1939

0478 Carriage Road Bridge (NPS#004P), Mt. Desert, 1952

0479 Bridge (NPS#030P), Mt. Desert, 1928

Photo taken 2011

2276 Parkman Road/Ferguson Stream Bridge, Cambridge, 1929

2971 Young's Bridge, Union, 1917

3172 Railroad Crossing Bridge, Freeport, 1936

3525 Danforth Street Crossing Bridge, Portland, 1939

3581 Little Cold River Bridge, Stow, 1938

3966 Sandy Creek Bridge, Bridgton, 1949

5380 Route 3 Overpass Bridge (NPS#0060), Bar Harbor, 1940

Rigid Frame: High

2540 Mechanic Falls Bridge, Mechanic Falls, 1949

2629 Old Iron Bridge, Houlton, 1944

2650 Partridge Bridge, Whitefield, 1935

Girder-Floorbeam

0326 Park Avenue Underpass Bridge, Portland, 1890

0564 Water Street Bridge Underpass Bridge, Augusta, 1914

0565 Second Street Bridge, Hallowell, 1930, Replaced 2009

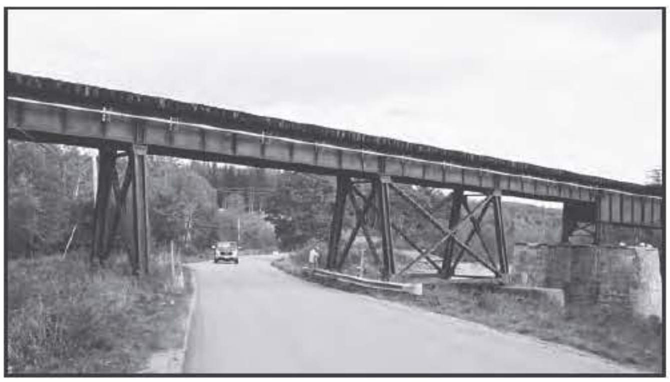
1130 Bangor & Aroostook/Monroe Road Railroad Bridge #1603, Frankfort, 1905

1132 Bangor & Aroostook Railroad Bridge #14.58, Frankfort, 1905

1136 Bangor & Aroostook Railroad Bridge #15.61, Frankfort, 1905

Photo taken 2004

1143 Bangor & Aroostook Railroad/River Road & Marsh Road Bridge, Winterport, 1905



1352 Front Street Bridge, Saco, 1928

1354 Common Street Bridge, Saco, 1928

1355 James Street Bridge, Saco, 1928

1357 Navy Yard Entrance Bridge, Kittery, 1919

1364 Beach Street Bridge, Saco, 1928

1365 Old Orchard Road Bridge, Saco, 1927

2151 Charles River Bridge, Fryeburg, 1930, Replaced 2011

2845 Tom Collins Bridge, Bingham, 1921

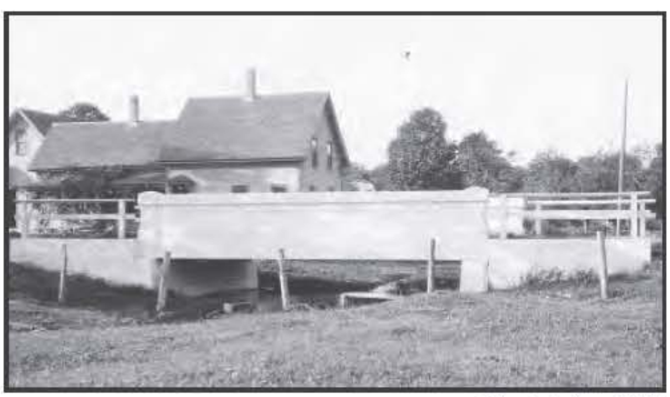


Photo taken 1921

3526 Bangor & Aroostook Railroad Bridge #27.731, Hampden, 1905

3657 Seven Mile Brook Bridge, Vassalboro, 1940

3874 Highland Avenue Bridge, Houlton, 1946, Replaced 2001

3945 Veterans Memorial Bridge, South Portland, 1954, Replaced 2012

5258 Grist Mill Bridge, Lebanon, c.1790

5276 Viaduct Bridge, Kittery, 1921, Replaced 2012

5337 Boston & Maine Railroad Underpass Bridge, Wells, 1920

5388 Bangor & Aroostook Railroad Bridge #07.51, Stockton Springs, 1905

5391 Water Street Bridge, Hallowell, 1914

5420 Bangor & Aroostook Railroad Bridge #29.64, Hermon, 1905

Stringer

0633 Herbert Bridge, Bristol, c. 1950

0999 Mill Road Overpass Bridge, Topsham, 1909

1302 Jellison Bridge, Sanford, 1920

1353 Wharf Street Bridge, Saco, 1928

2031 Badger Island Bridge, Kittery, 1938

3412 Somesville Bridge, Saco, 1937, Replaced 2015

3597 Overpass-Summer Street Bridge, Kennebunk, 1932, Replaced 2004

Photo taken 1982

6015 B Road Overpass Bridge, Portland, 1954, Removed 2004

6016 Danforth Street Viaduct Bridge, Portland, 1954, Removed 2004

Reinforced Concrete Slab

0821 Old Buffam Bridge, Wells, 1909

2096 Branch Mills Bridge, China, 1931

Photo taken 1931

2893 Village Bridge, Blue Hill, 1930

T-Beam

0463 Graham Lake Dam Bridge, Ellsworth, 1922

5230 Main Street Bridge, Yarmouth, 1948

Photo taken 1948

2454 Leigh Bridge, Vassalboro, 1918

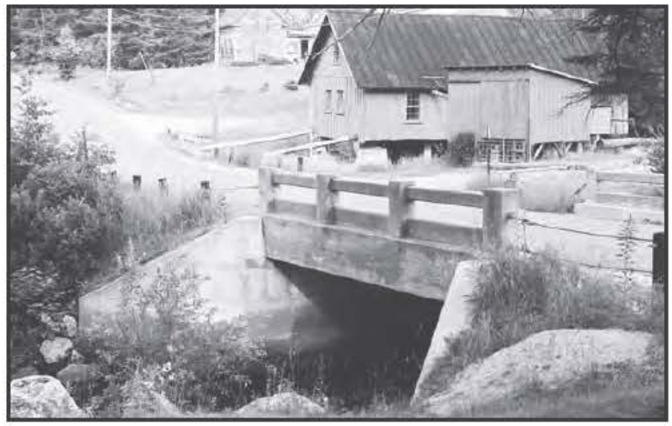
2674 Pleasant River Bridge, Columbia Falls, 1920

5021 Kingman Road Bridge, Macwahoc Plantation, 1919

Culvert*

0403 McLeary Brook Bridge, Strong, c.1879

3590 Andrews Bridge, Woodstock, 1938



**MaineDOT defines a culvert as a span less than 10 feet.*

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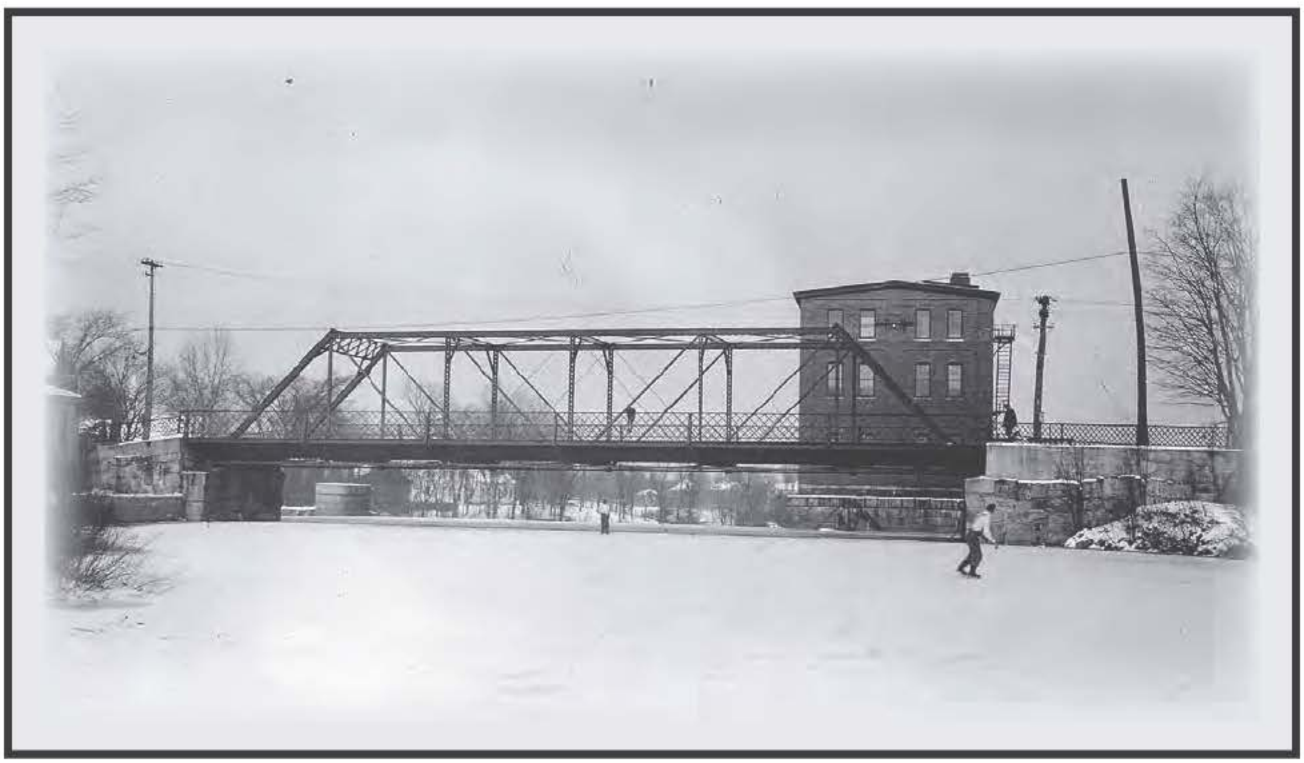

Previous: An ice skater glides below a former metal truss bridge in Mechanic Falls in 1932.

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INDEX

Previous: A car stops to pay a toll on the Maine Kennebec Bridge spanning between Richmond and Dresden in 1945.

Index

Index

Historic Bridges of Maine

Historic Bridges of Maine **documents the evolution of transportation and bridge building in the Pine Tree State. This richly-illustrated book spans from prehistory to the present day. It carefully describes bridge types from the earliest timber and stone spans to modern steel and concrete designs. These bridges were often creative solutions to the challenges posed by crossing the state's waterways and topography. Historic bridges serve as lasting testaments to the ingenuity of Mainers.**

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