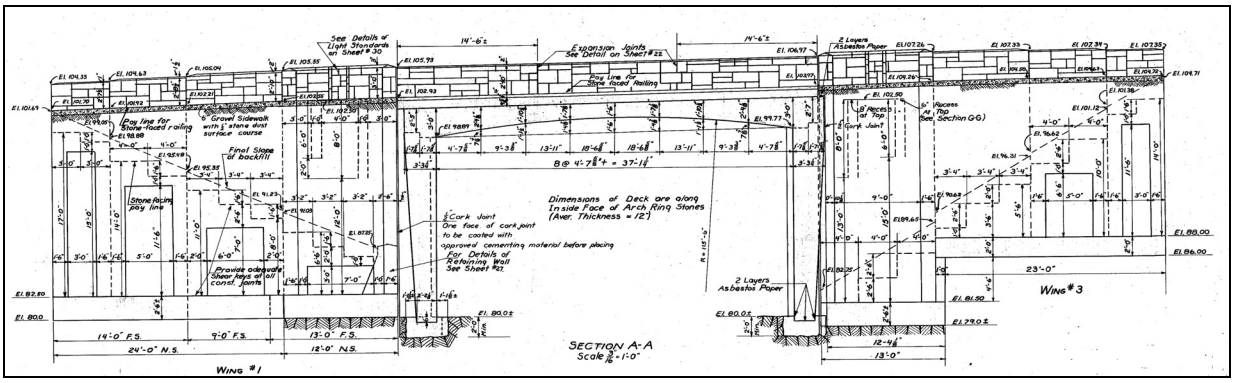
CLIFFORD BROKER, SR.

A Monograph of his Career as a Bridge Designer
with the New Hampshire State Highway Department
ca. 1933-ca. 1945



Detail, Section A-A, sheet 23, designed and drawn by Clifford Broker, October 1935
Bridge No. 095/121, Durham, Old US Route 4 over Boston & Maine Railroad
Collection of Bridge Design, New Hampshire Department of Transportation, Concord, NH

PRESERVATION COMPANY
Laura B. Driemeyer

2010

Clifford Broker, Sr. (1903-1992), structural engineer, was active from the early 1930s to the 1980s, predominantly in New Hampshire but also in other parts of New England (*Figure 1*).[1] He brought to his work his extensive engineering training grounded by his "high moral values…exemplified by [his] utmost integrity" and his strong Christian faith.[2] For the first fifteen-plus years of his professional career in New Hampshire, Broker designed bridges, predominantly for the New Hampshire State Highway Department but also after he established his own firm. Over the course of his career with the State Highway Department, from ca. 1933 to 1941 and ca. 1944-1945, he designed at least twenty-five bridges for the department (sometimes with other engineers) and was involved with at least an additional eight designs, tracing and/or checking the plans.[3] After leaving the State Highway Department Broker established his own structural and consulting firm, Clifford Broker Associates. Over roughly the next forty years the firm designed predominantly new multi-story commercial and residential structures but also smaller projects including additions to historic structures.[4]

Figure 1

Clifford Broker, 1929. From Peddler (Worcester Polytechnic Institute Yearbook, 1929).

Through his civil engineer training at Worcester Polytechnic Institute and his subsequent graduate education at Polytechnic Institute of Brooklyn and Tufts University, Broker likely learned the latest in reinforced concrete bridge designs and the skills

[1] This monograph was written as mitigation for the removal of a reinforced concrete rigid-frame bridge designed by Clifford Broker in 1941 (Bridge No. 073/065). The bridge originally carried NH Route 125 (Crawley Falls Road) over the Exeter River in Brentwood. See Preservation Company (Laura B. Driemeyer), "Crawley Falls Road over Exeter River," New Hampshire Historic Property Documentation, State No. 643 (2010). Copy on file at New Hampshire Division of Historical Resources (NHDHR), Concord, New Hampshire.

[2] Mrs. Clifford G. Broker, letter to author, 9 August 2010.

[3] These numbers are based on an examination of the bridge design cards for bridges designed by the highway department which are located in the Department of Bridge Design, New Hampshire Department of Transportation (NHDOT). These cards were created at the time of a new bridge design. They identify the structure to be replaced (usually), the proposed structure with its general dimensions and materials, itemized costs of materials, the names or initials of the men in Bridge Design responsible for the design, drawing, and checking of the design, and on occasion the name of the contractor. A second set of valuable records maintained by Bridge Design are the bridge cards. These cards, first created beginning in 1940 for all extant bridges, include photographs of the bridge, plan and section and/or elevation, and measurements. The majority of these cards appear to have been prepared by Wendell H. Piper (1884-1972), as they feature his initials. Piper was an architect who was employed by the highway department by 1937 for the planning survey. Ancestry.com, *New Hampshire City Directories* [database on-line] (Provo, UT: The Generations Network, Inc., 2005) [Concord, NH 1937] (hereafter Ancestry.com, Concord Directory, 1937). A few of the cards from 1940 feature Broker's initials, providing a second record of his clear and distinctive penmanship and clear drafting skill. See, for instance, Milton 101/110 and Wakefield 245/066, both concrete rigid-frame bridges with stone facing.

[4] Aside from the plans for the Highway Department, no other project design materials have been located related to Broker's work. Broker's son and daughter-in-law were contacted with the hope the family might still have materials connected his career. Mrs. Broker indicated, however, that after Broker's death "everything was dispersed appropriately to former clients or discarded." Furthermore, Broker's son was too young during the 1930s and 1940s to have any knowledge of his father's work with the Highway Department. Mrs. Clifford G. Broker, 9 August 2010.

necessary to make complex calculations. His college training in the 1920s coincided with a period of extensive use of reinforced concrete for a variety of bridge forms. Engineering journals featured numerous articles on reinforced-concrete bridge design forms, such as Arthur G. Hayden's seminal 1926 article "Rigid Frames in Concrete Bridge Construction," in *Engineering News-Record*. Hayden subsequently published *The Rigid-Frame Bridge* in 1931 which further elaborated upon his experience and understanding of this bridge type. Broker's work at the Highway Department to a large extent demonstrates his thorough understanding of these materials and the different forces at work in these designs but also the ability to make the complex calculations entailed in such designs. The majority of his bridge designs for the State Highway Department employed reinforced concrete types, including reinforced concrete rigid-frame bridges, concrete T-beams, concrete slabs, and concrete boxes. In New Hampshire in the 1920s and 1930s, the use of reinforced concrete was especially popular for small- and mid-sized bridges. While the majority of Broker's designs were for reinforced concrete types he did design two notable steel truss bridges spanning the Connecticut River north of Lebanon, New Hampshire. It appears that Broker's particular understanding of reinforced concrete and steel for building purposes easily carried over into his design work produced by the architectural and engineering firm after he left the highway department. His firm's institutional designs commonly feature steel and concrete with brick facing.

Biographical

Clifford Broker, one of seven children and the third son of George and Annie (Blake) Broker, was born 1 July 1903 in Brooklyn, New York. Broker attended Tilton School in New Hampshire, graduating in 1925 at the head of his class. Four years later he graduated from Worcester Polytechnic Institute with a bachelor's degree in civil engineering.[5] His 1929 yearbook entry noted "[a]s a hard worker 'Cliff' has always finished everything that he has undertaken, a valuable characteristic indeed for an engineer to have."[6]

After graduation, he returned to Brooklyn and worked as a civil engineer for the New York Bureau of Water Supply. In 1930 he was living with his cousin Albert Aeryus, also employed as a civil engineer by the Bureau of Water Supply.[7] During this time Broker also attended Polytechnic Institute of Brooklyn where he earned a Master's in Civil Engineering. Subsequently he did work towards a Ph.D. at Tufts University.[8] In 1930 he married Isabelle Gerrish of Webster, New Hampshire, and soon thereafter moved to New Hampshire; they had met as students at Tilton School.[9] Initially the couple may have lived in Webster but by 1937 they had settled in Concord, at 140 Warren Street, where they remained until the early or mid-1940s. By 1947 the couple and their three young sons (Clifford Gerrish, b. 1933; Paul C., b. 1938; and Nathanael, b. 1943) were living in Webster, perhaps to be near Mrs. Broker's family while Broker tried to establish his practice as a structural and architectural engineer. The family

[5] Worcester Polytechnic Institute, *The Peddler…of Worcester Polytechnic Institute* (Worcester, MA: The Class, 1929), 75. Copy courtesy of Margaret Anderson, Archivist, Worcester Polytechnic Institute, Archives and Special Collections. "Clifford Broker, 89, noted architect, engineer," *Concord Monitor*, 25 November 1992.
[6] Ibid.
[7] Ancestry.com, *1930 United States Federal Census* [database on-line] (Provo, UT: Ancestry.com Operations Inc, 2002) [Brooklyn, NY] (accessed July 2010).
[8] "Clifford Broker '29," *WPI Wire* 7, no. 2 (1992): 19. Copy courtesy of Margaret Anderson, Archivist, Worcester Polytechnic Institute, Archives and Special Collections. "Clifford Broker, 89, noted architect, engineer."
[9] Ibid.

moved back to Concord by 1951, living at 18 Rockland Road, where they continued to reside for much of the remainder of their lives.[10]

Clifford Broker's employment with the State Highway Department coincides with a period of considerable bridge design activity in New Hampshire and standardization of bridge types for the states' roads and highways. The State Highway Department first developed in the early twentieth century. In 1905 the state established the position of State Highway Engineer. Ten years later the office was reorganized as the New Hampshire State Department of Highways and remained under that title until 1950.[11] Broker's name first appears in State Highway Department Bridge Design records in October 1933, on a set of plans for a bridge he designed in Grantham, New Hampshire.[12] Bridge Design records suggest he worked at the State Highway Department from the fall of 1933 through the summer of 1941. His name is absent from design records between Fall 1941 and late 1944; the Concord City Directory suggests he worked in Massachusetts during the war. During this period, due to materials shortages and the war effort, bridge design and construction in New Hampshire was quite limited. In 1942 Federal Aid highway monies to the states were restricted, with funding available only for new construction requested or approved by the War Department. As a result, bridge construction was reduced and in New Hampshire only eleven State Aid bridges were built. The next year the state built just four bridges and then for the remainder of the war the state's bridge building program was halted.[13] Broker's name reappears in Bridge Design records by late 1944 and he seems to have remained with the Highway Department until at least the fall of 1945 before leaving permanently to establish his own practice.[14]

Broker's professional memberships included the New Hampshire Society of Engineers and the National Society of Professional Engineers.[15]

State Highway Department, Bridge Design Division, ca. 1933-ca. 1941, ca. 1944-1945
By the fall of 1933 Broker was employed by the State Highway Department as an engineer in the Bridge Design Division.[16] By that time the Highway Department had grown since its initial establishment in 1905 to employ 2,000 or more persons, of which the Bridge Design division

[10] Ancestry.com, *New Hampshire City Directories* [database on-line] (Provo, UT: The Generations Network, Inc., 2005) [Concord, NH 1933-1962] (hereafter Ancestry.com, Concord Directory 1933-1962). "Clifford Broker, 89, noted architect, engineer." Ancestry.com. *U.S. Public Records Index, Volume 1* [database on-line] (Provo, UT, USA: Ancestry.com Operations, Inc., 2010). Ancestry.com, *U.S. Public Records Index, Volume 2* [database on-line] (Provo, UT, USA: Ancestry.com Operations, Inc., 2010).

[11] Patrick Harshbarger and Ingrid Wuebber (TranSystems & URS Corporation), "Robert John Prowse: A Monograph," 3, fn 1, http://www.nh.gov/nhdhr/publications/prowse.htm (accessed June 2010). In 1950 the department was restructured again as the New Hampshire Department of Public Works and Highways. In 1986 it became the New Hampshire Department of Transportation (NHDOT). Ibid.

[12] New Hampshire Department of Transportation, Bridge Design, Design Card for Bridge No. 140/069 in Grantham (NH 114 over Stocker Pond Outlet) (hereafter Design Card, No. 140/069). See below for discussion of his bridge designs by type.

[13] Louis Berger Group, "Pittsburg-Clarksville Route 145 Bridge (Bridge No. 090/120)," New Hampshire Historic Bridge Documentation, State No. 551 (2004), 5. Copy on file at NHDHR.

[14] Bridge Design Cards. Ancestry.com, Concord Directories 1942, 1947. There is a gap between October 1936 and December 1939, when his name does not appear on any new designs. The absence for that period cannot be explained at this time. His initials appear on at least two Bridge Cards in July 1940. See Milton, Bridge No. 101/110 and Wakefield, Bridge No. 245/066, both stone-faced, reinforced concrete, rigid-frame bridges.

[15] Worcester Polytechnic Institute, "Clifford Broker '29," 19.

[16] This date is based on the first identified bridge design plans with Broker's name on them.

was a significant group. Bridge Design was under the able guidance and direction of John W. Childs, the State Bridge Engineer since the mid-1920s, and Harold E. Langley, the Assistant State Bridge Engineer who would succeed Childs in 1942. Under their forward-thinking leadership bridge design adopted "then-current trends in modern highway bridge design," notably reinforced concrete and steel girder bridges.[17] *Specifications for Construction and Reconstruction of Roads and Bridges* by New Hampshire was first published in 1927 and then revised in 1931. Childs and Langley had contributed to that publication and those employed in the division had to have a working knowledge of its contents. So, by the time Broker joined the division, standardized designs would have been a key part of the division's design process.[18]

As previously noted Broker is known to have designed over twenty-five bridges (or additions to bridges) for the State Highway Department, either by himself or with other engineers in the department. In addition, he was involved with eight other designs, drawing and/or tracing the plans or checking those designed by others. Of the twenty-five-plus designs by Broker, seven have been altered through widening or redecking or other such modifications and at least six have been replaced, but the others remain largely intact as designed.

During the years Broker worked at the highway department, State and Federal funding programs allowed the continuation of major road and bridge construction and reconstruction in spite of the Great Depression, as part of the trunk line system improvements first begun in the 1910s. The building accelerated in the 1920s and continued into the 1930s at which time the number of engineers employed in Bridge Design had increased significantly. The late 1920s and early 1930s in particular represented a period of acceleration and codification of bridge building activities in the state. Broker's hiring coincides with that point in time when the division sought out a number of qualified civil engineer graduates from the several New England colleges or universities with engineering programs, including Massachusetts Institute of Technology, Worcester Polytechnic Institute, and University of New Hampshire.

Concrete Flat-slab Bridges

Broker's first known bridge design while employed by the State Highway Department was for a reinforced-concrete flat-slab bridge. The use of this bridge type coincided with the rise of bridge construction in concrete, especially on government-funded building projects in the 1920s and 1930s. During the Depression era the use of concrete for bridge construction was popularized for several reasons. The form and material lent itself to economical and durable bridge construction by local labor at a time when money was scarce but labor was not. "Economical, long-lasting, and capable of being built with local labor, the concrete bridge put federal highway dollars targeted for economic relief directly into the hands of laborers, who needed it most."[19]

Cast-in-place flat-slab bridges, the simplest type of a reinforced-concrete bridge, appeared initially in the first decade of the twentieth century and by the end of the first quarter of the twentieth century many states had adopted this type as the preferred one for spans of modest

[17] Harshbarger and Wuebber, 12.
[18] Ibid. For a good overview of the bridge design division and the process of bridge design in the 1930s see ibid, 12-13. The first instance of Broker's initials on bridge design plans is as the designer and not as a drawer, suggesting he had some experience and therefore may not have been considered a junior engineer.
[19] Louis Berger & Associates (Richard M. Casella), "Barnstead Bridge (Bridge No. 097/108)," HAER No. NH-30 (1997) [HAER, NH, 7-PITTS, 1-] < http://memory.loc.gov/ammem/collections/habs_haer/ > (accessed September 2008), 6

length. This type consists of a reinforced-concrete slab superstructure in turn supported by the substructure, most commonly abutments. By the 1910s this bridge type consisted most commonly of a "one-way" flexure system. The reinforcing steel, comprised of twisted or deformed rods, is concentrated in the lower portion and ends. By the 1920s a number of states had adopted a standard slab design for bridges less than 25' long and in the 1930s and into the early 1940s the flat-slab bridge was commonly used by for small highway bridges.[20] In New Hampshire the highway department designed many of these bridges, most generally for clear spans of less than 20' in the 1920s and 1930s, during a period of significant road and highway improvement throughout the state.[21]

The concrete flat-slab bridge designed by Broker carries NH 114 over the Stocker Pond Outlet in Grantham (Bridge No. 140/069). The plans indicate Broker designed the bridge 25 October 1933, drew the plans two days later, and traced them on 28 October 1933 (see A1-A2). The 25'-7½"-wide bridge has a clear span of 24' and replaced an earlier structure located slightly

Figure 2

Grantham, downstream elevation, Bridge No. 140/069 (NH Route 114 over Stocker Pond Outlet), designed 1933, built 1934, photo ca. 1975. Source: NHDOT Bridge Design

downstream from the new structure. The bridge featured mass concrete abutments and wing walls and cable railings. The design required differently configured concrete wing walls owing to the setting; the two downstream ones abutted the earlier bridge's masonry abutments. The bridge's placement was likely adjusted to improve the approaches. The cost of the materials was estimated to be nearly $4,500.[22]

[20] Parsons Brinckerhoff and Engineering and Industrial Heritage, "A Context for Common Historic Bridge Types," NCHRP Project 25-25, Task 15. Prepared for the National Cooperative Highway Research Program, Transportation Research Council, National Research Council (October 2005), 3-83-3-84. Patrick Harshbarger, Lichtenstein Consulting Engineers, *North Carolina Department of Transportation Historic Bridge Inventory* (January 2005), 41.
[21] *Annual Reports of the State Highway Department of New Hampshire*, 1925-1932.
[22] Bridge Design card, Grantham, No. 140/069.

Broker would be involved with the design two more concrete flat-slab bridges while with the highway department. One month after the Grantham bridge design, Broker worked on a concrete flat-slab bridge designed by Leon C. Marshall (1884-1966), one of the more senior engineers in the department by that time, in Holderness (Bridge No. 109/109), to carry NH Route 175 over Owl Brook.

Like the Grantham bridge, the Holderness bridge also had mass concrete abutments and wing walls but had a clear span of only 19' and a molded panel on the outer faces of the deck, a detail that does not appear on the plans. A second modification of the plans, likely at the time of

Figure 3

Holderness, upstream elevation, Bridge No. 109/109 (NH Route 175 over Owl Brook), designed 1933 with Leon C. Marshall, photo ca. 1941. Source: NHDOT Bridge Design

construction was the replacement of a cable rail with wood railing (see A3-A4).[23] The design is dated 6 November, 1933. The two men drew the plans the next day, and then traced them the day after that. The State-Aid funded bridge replaced a wooden bridge and was completed the following year; the materials had been estimated to cost just over $4,000.[24]

[23] Bridge design card, Holderness, No. 109/109.
[24] Ibid. The bridge was widened in 1983.

Late in his career with the department, in July 1945, Broker designed another concrete flat-slab bridge, carrying Pinkham B Road over Bumpus Brook in Randolph (Bridge No. 155/057).

Figure 4

Randolph, upstream elevation, Bridge No. 155/057 (Pinkham B Road over Bumpus Brook), designed and built 1945, built 1934, photo 1951. Source: NHDOT Bridge Design.

The plans, confined to just one sheet, substantiate Broker's considerable experience with reinforced-concrete bridges and the extent of standardization of this bridge type by this period (see A5). This design, for a bridge with a 20' clear span and estimated quantities cost of just over $3,800, would have been fairly straight forward, aside from the bridge skew and need for differently sized and angled wing walls. The bridge replaced a narrower plank on log stringer bridge set on stone-filled log cribbing.[25]

Concrete Rigid-frame Bridges

Concrete rigid-frame bridges constitute the greatest number of bridges designed by Broker while at the State Highway Department, numbering at least seven over the course of his entire career with the department. New Hampshire was one of a comparably small number of states to wholeheartedly adopt the concrete rigid-frame bridge for use on its roadways, especially in the 1930s. By 1933 the Highway Department was one of fifteen state agencies to have adopted the concrete rigid-frame as a standard bridge design. New Hampshire built at least eighty concrete rigid-frame bridges between 1929 and 1940 with the majority spanning waterways.[26] After the Second World War this bridge type remained popular for grade separations on highways.[27] "The form was inexpensive, easily constructed, and aesthetically appealing for a standardized bridge structure."[28]

The concrete rigid-frame bridge is a deck bridge but it differs from simple span bridges supported by abutments in one significant way. The use of "continuous construction" improved upon the more traditional method of beams supported by abutments through the use of a built-up

[25] Bridge design card, Randolph, No. 155/057.
[26] Harshbarger and Wuebber, 14.
[27] Parsons Brinckerhoff and Engineering and Industrial Heritage, 3-96.
[28] Ibid.

joint between the horizontal and vertical members. In a rigid-frame bridge the deck and abutments are rigidly jointed with steel reinforcement bent at right angles and tied to the reinforcement in the deck and abutments. This allows the load to be transmitted through the joint to the abutments or legs allowing both the deck and the abutments to carry the load and in turn reducing the amount of material necessary in the horizontal members as they are no longer the sole bearers of all the load.[29] Because the forces are distributed evenly through the bridge, there is no need for substantial abutments to counter outward pressure or lateral force, such as with concrete arch bridges.[30] This homogenous unit represents a high point in American concrete bridge design.[31] The design of this bridge type required the technological expertise to calculate the forces, and Clifford Broker was one of a number of knowledgeable young engineers with such expertise employed by the Bridge Design Division of the New Hampshire State Highway Department in the 1930s.[32] These men (a number of them graduates of Worcester Polytechnic Institute, like Clifford Broker) brought with them the ability to perform the advanced engineering needed to analyze statistically indeterminate frames constructed in these decades.

This bridge technology proved popular especially in the 1930s for several additional reasons. The use of statically indeterminate designs provided significant cost savings in materials and construction costs.[33] Though the construction method required expensive framework, it used the construction materials efficiently. This, in turn, reduced the amount of excavation necessary for the abutments, in contrast with many other bridge types of the period, because of the efficient distribution of forces.[34]

Cost savings also was possible because "[c]ontinuous designs, which are a subset of statically indeterminate structures, also had the considerable advantage of reducing the number of expansion joints, an area of high maintenance in bridge decks due to moisture-related deterioration and the impact of moving vehicles."[35] In addition, this bridge type lent itself to "extreme adaptability to architectural expression as compared with ordinary types of construction."[36]

Concrete rigid-frame technology was first developed in Germany for building construction. The low construction costs associated with this technology soon prompted its use for bridge construction over smaller crossings and for railroad grade separations. In the United States, the technology was first used in the 1920s on bridges over the increasing number of parkways, such as the Bronx and Merritt Parkways. Arthur C. Hayden, design engineer for the Westchester County Park Commission of New York introduced the reinforced-concrete rigid-frame bridge to American engineers in the early 1920s. Between 1922 and 1925 Hayden designed eight concrete rigid-frame bridges built over the Bronx Parkway. Over the next five years, after the

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[29] Historic Resource Consultants (Matthew Roth), "Merritt Parkway Bridge No. 744 (Sport Hill Road Bridge)," HAER No. CT-55 (1986), HAER, CONN, 1-FAIRF, 18- <http://memory.loc.gov/ammem/collections/habs_haer/> (accessed September 2008). Louis Berger & Associates.

[30] Excerpt on concrete rigid-frame bridges from forthcoming volume, James L. Garvin, *New Hampshire's Historic Highway Bridges: Wood, Metal, and Masonry*. Copy kindly provided to author.

[31] Parsons Brinckerhoff and Engineering and Industrial Heritage, 3-96.

[32] Harshbarger and Wuebber, 14-15.

[33] Ibid., 17. For a concise discussion of statically indeterminate structures see ibid., 16-18.

[34] Harshbarger, 47.

[35] Harshbarger and Wuebber, 17.

[36] Arthur G. Hayden, *The Rigid Frame Bridge* (New York: John Wiley & Sons, 1931), vii, quoted in Harshbarger and Wuebber, 14.

reorganization of the commission as the Westchester County Park Commission, seventy-one additional concrete rigid-frame bridges designed by Hayden were erected along the new Hutchinson and Cross County Parkways. In 1926 Hayden's article "Rigid Frames in Concrete Bridge Construction," appeared in *Engineering News-Record*. The article highlighted the strength, economy, and architectural benefits of the concrete rigid-frame bridge. Hayden presented two types of structural analysis, accompanied by drawings of arrangements of steel reinforcement for several different forms of rigid-frame bridges. The national engineering community, and New Hampshire in particular, adopted Hayden's analytical methods and widely copied his designs. By 1932, over 200 rigid-frame bridges had been constructed throughout the United States and Hayden was recognized as the leading expert of this bridge type and its chief early promoter in the United States.[37]

The first concrete rigid-frame bridge design to bear Broker's initials is one spanning the Pemigewasset River in Woodstock (Bridge No. 170/159) that he designed in January 1934 with the more senior engineer Ralph R. Kenney (1896-1994).[38] The plans for this State-Aid bridge show two versions, one with stone facing, and one without. The reason for this is unknown, but

Figure 5

Woodstock, upstream side, Bridge No. 170/159 (NH Route 112 over Pemigewasset River), designed by Ralph K. Kenney and Clifford Broker, 1934, photo ca. 1941. Source: NHDOT Bridge Design.

in the end the stone-faced version was selected. This bridge design resembles a number of similarly styled and detailed ones of comparable lengths (it has a clear span of 80') and settings (near town centers) that were designed and constructed by the State Highway Department in the 1930s and early 1940s with State-Aid Bridge monies. The nicely detailed structure was built by Eastern States Bridge Company of Concord, New Hampshire, a well-known builder of New Hampshire bridges in this period.[39]

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[37] Louis Berger & Associates, 6.

[38] For some biographical information on Kenney see James L. Garvin, "Engineers Known To Have Worked in Bridge Design at the New Hampshire Highway Department from the 1920s to the 1940s, with Notes on Jobs with Which They were Associated," 3, Revised 7/2000, 10/2006 (copy on file at NHDHR) and Preservation Company (Laura B. Driemeyer) and Rich Casella, "NH Route 137 Moose Brook Bridge, Hancock," New Hampshire Historic Property Documentation, NH State No. 628 (2008), 16. Copy on file at NHDHR.

[39] Bridge design card, Woodstock, No. 170/159. Bridge card, Woodstock, No. 170/159. For some comparables see Preservation Company, "Peterborough Downtown Historic District," Area Form, New Hampshire Division of Historical Resources (forthcoming). For more information on Eastern States see James L. Garvin, "Builders of

Broker worked on an additional three concrete rigid-frame bridge designs between 1935 and 1939. In October 1934 Broker designed a stone-faced bridge spanning Cohas Brook in

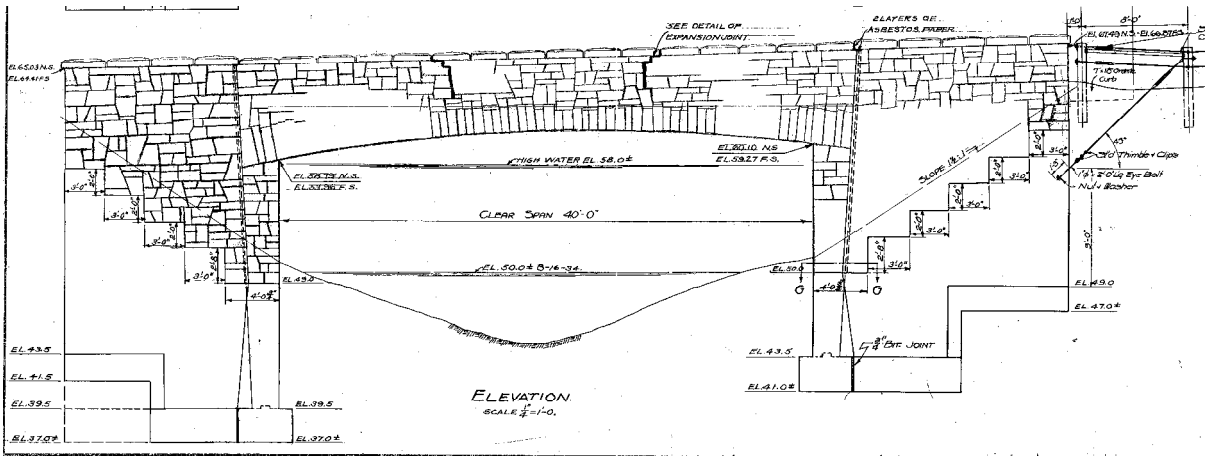

Figure 6

Manchester, elevation, Bridge No. 176/119 (NH Route 28A-South Mammouth Road over Cohas Brook), designed and drawn by Broker 1934, built 1935. Source: NHDOT Bridge Design.

Manchester (Bridge No. 176/119). The plans were drawn by several engineers, including Broker (see A6-A7). The new bridge had a clear span of 40' and replaced a narrower plate girder bridge. The new bridge had sidewalks along both sides of the roadway and was built by Lawes of Manchester at an estimated materials cost of just over $23,000.[40]

In 1935 Clifford Broker and Wesley E. Haynes (1911-1994) designed a stone-faced bridge carrying Old US Route 4 over the Boston & Maine Railroad (Bridge No. 095/121, built 1936) in Durham. The design is notable for its art deco pylons supporting the stone light posts set back from the roadway (see A11-A13).[41] Originally estimated to cost nearly $82,000, the final cost totaled over $84,000. The new structure replaced a narrow wooden truss structure and was built by Central Construction Company of Lawrence, Massachusetts.[42]

Bridges in New Hampshire," 9 August 1999; updated April 2008 (copy on file at NHDHR) and Preservation Company, "Old Town Road-Ammonoosuc River Bridge (No. 143/051)," New Hampshire Historic Property Documentation, NH State No. 629 (2008). Copy on file at NHDHR.

[40] Bridge design card, Manchester, 176/119.

[41] The light posts had been removed by 1971, per photos in Bridge Design.

[42] Bridge design card, Durham, 095/121. Bridge card, Durham, 095/121.

Figure 7

Durham, southeast elevation and northwest approach, Bridge No. 095/121 (Old US Route 4 over Boston & Maine Railroad), designed by Clifford Broker and Wesley E. Haynes, 1935, photo ca. 1941. Source: NHDOT Bridge Design.

Also in 1935 Broker worked with Ralph R. Kenney again on the design of another stone-faced example, though Broker may have been the lead designer. Longer than the previous two designs, this two-span structure crosses the Contoocook River in the center of the village of Contoocook in Hopkinton (Bridge No. 102/143). The design required placement in a developed area, in close proximity to railroad tracks and the intersection of several roadways at the north end (see A14-A16). The attractive structure replaced a covered wood bridge at this location.

Figure 8

Hopkinton (Contoocook Village), upstream elevation and south approach, Leroy R. Kimball Bridge, Bridge No. 102/143 (NH Route 103/NH Route 127 over Contoocook River), designed by Clifford Broker and Ralph R. Kenney, 1935, photos ca. 1941. Source: NHDOT Bridge Design.

The design card and plans for this bridge in particular may help elucidate the design process in the department and areas of expertise for the different engineers. Sheet No. 3 (A-16) may clearly demonstrate Broker's particular strength in bridge design. Nearly all the information on this sheet represents the placement of the steel reinforcement throughout the structure and it is the sheet where Broker is listed as the sole designer and drawer of the very complex steel reinforcement placement on this two-span bridge.

Broker designed three more concrete rigid-frame bridges in the 1940s. In the spring of 1940 Broker designed a small, ashlar stone-faced concrete rigid-frame bridge in Hill, carrying NH Route 3A over Needle Shop Brook (Bridge No. 157/108). The rather distinctive structure has a

Figure 9

Hill, upstream elevation, Bridge No. 157/108 (NH Route 3A over Needle Shop Brook), 1940, photo ca. 1941. Source: NHDOT Bridge Design.

clear span of just 22'-0-¾".[43] The structure, constructed by Littleton Construction Company of Littleton, New Hampshire, was for a newly aligned roadway or crossing. The plans reveal Broker designed and drew the general plan, elevations, and reinforcement for the superstructure but George W. Waymouth (1892-1979) designed the layout and steel for the wings (see A17-A18).[44]

In May 1941 Broker designed a concrete rigid-frame bridge but without stone facing to carry NH Route 125/Crawley Falls Road over the Exeter River in Brentwood (Bridge No. 073/065).[45] The Crawley Falls Bridge was erected in 1941 by the state, funded by the State-Aid account, at a cost of $1,800, at an early crossing in Brentwood and in the vicinity of early settlement and industrial activity.[46] It replaced a through wood pony truss bridge set on mass split, dry laid stone abutments.[47] Broker used the existing abutments, tying the legs of the new structure into them (see A19-A20).[48]

[43] In the 1989 thematic review of reinforced-concrete rigid-frame bridges, this design was assigned a score of 18 points. "Reinforced Concrete Rigid Frame Bridges, Thematic Review (1989)." Copy available in Bridge Design, NHDOT.

[44] Bridge design card, Hill, No. 157/108. Bridge card, Hill, No. 157/108. For biographical information on Waymouth see Preservation Company (Laura B. Driemeyer) and Rich Casella, 14-16.

[45] In the 1950s, as part of a straightening of NH Route 125, a new bridge was constructed upstream bypassing the Broker designed bridge over the Exeter River.

[46] New Hampshire State Highway Department, *Annual Report of the State Highway Department of New Hampshire* (Concord, NH: State Highway Department, 1940), 77. This figures differs significantly from a cost estimate of nearly $5,000. Bridge design card, Brentwood, No. 073/065. J. Rowe, "A Plan of Brentwood in the State of New Hampshire," 1805.

[47] Bridge design card, Brentwood, No. 073/065. Bridge card, Brentwood, No. 073/065.

[48] For a detailed description of this bridge see Preservation Company (Laura B. Driemeyer), "Crawley Falls Road over Exeter River."

The bridge is a mid-sized, standard-design concrete rigid-frame bridge with an arch effect and a concrete deck, cast in place, a type commonly built in the United States from 1922 through the mid-twentieth century. The single-span bridge has no skew. The Crawley Falls Road Bridge has an overall length of 36' with a clear span of 31'. The overall width of 27' includes two 12'-0"-wide travel lanes between the curbs and a width of 25'-4" between the rails. The slightly arched bridge deck measures 2'-6" at the abutments and tapers to 1'-3" at the center with a clear water height of 13' at midspan. Atypically, the straight abutments or legs are not tapered and so measure 2'-6" at the top and bottom. The wearing surface is covered with asphalt. Replacement galvanized "W-beam" railings set in the curbing line either side of the bridge. The metal railings replaced the original single 3" x 8" wood rails affixed to 5" x 5" posts in the late 1970s. No sidewalk is present on the bridge and the approaches lack curbing. Simple decorative treatment on the rigid frame consists of single incised panels. This detailing appears to be an on-site addition as it is not shown on the design plans.[49]

The wing walls are reinforced-concrete parallel type on top of old mass rubble stone wings, some mortared and some dry laid. The frame legs form facing for the old stone abutments. The earlier stone abutments are faced with concrete.[50]

As shown in the drawings, the size of the steel reinforcement extending between the deck and the legs is 1-1/8" square rebar, set 9" on center. Two lengths of rebar were used in alternation, each type set 1'-6" on center, one extending 5'-6" from the leg into the length of the deck and the other extending 10'-6" into the length of the deck, for a total of eighteen bars each or thirty-six bars total spanning the width of the deck. At each end of the deck is a ½" expansion joint.[51]

Figure 10

Brentwood, upstream elevation, Bridge No. 073/065 (Crawley Falls Road over Exeter River), 1941, photo ca. 1942. Source: NHDOT Bridge Design.

[49] Preservation Company (Laura B. Driemeyer), "Crawley Falls Road over Exeter River."
[50] Ibid.
[51] Ibid.

Broker's last known design of a concrete rigid-frame bridge while with the State Highway Department was done after the Second World War, when he returned to the Bridge Design Division after an apparent hiatus of several years. In January 1945, Broker designed another relatively short (clear span of 28'-6"), plainly detailed concrete rigid-frame bridge in Orford,

Figure 11

Orford, downstream elevation, Bridge No. 100/090 (Dame Hill Road over Jacobs Brook), photo ca. 1947. Source: NHDOT Bridge Design.

carrying Dame Hill Road over Jacobs Brook (Bridge No. 100/090). The bridge was to replace a narrower wood truss bridge, with an estimated materials cost of nearly $14,000. It was not completed until 1947, however, possibly due to continuing shortages of certain materials in the immediate post-war period.[52]

Concrete T-Beam Bridges

Broker also designed several other reinforced-concrete type bridges during his tenure with the State Highway Department. He designed at least three concrete T-beam bridges; several have subsequently been widened and/or rebuilt.

T-Beam construction became commonplace in the 1920s and 1930s. Contemporary with concrete slab bridges, this bridge type required less concrete than concrete slab and girder types and its construction was more economical on lengths greater than 25'.[53] This bridge type, however, was commonly confined to bridges less than 50' in length as the span length was more limited than for arches or trusses and required supporting piers or bents in contrast with other types at longer lengths. Nevertheless, concrete T-beams were one of the forms to be standardized by state highway departments.[54]

T-beam bridges are constructed of a single block of concrete consisting of the deck and beams, cast-in-place, appearing as rows of Ts in section. In the design, the proportion between the thickness of the deck and the size and placement of the beams creates a "light, strong, and

[52] Bridge design card, Orford, No. 100/090. Bridge card, Orford, No. 100/090.
[53] Parsons Brinckerhoff and Engineering and Industrial Heritage, 2-26, 27.
[54] Ibid., 3-88. Harshbarger, 43.

economical section."[55] Steel reinforcement is placed at base of the T stem, where stress is the greatest, and runs the length of the beam. In addition, rods are placed in the deck, in tension, running the width of deck, perpendicular to those in the stem. The concrete railings are also integral.[56]

Broker's first T-Beam bridge design was very typical in form and style. Located in Croydon, Bridge No. 146/124 carried NH Route 10 over the Croydon Branch of Sugar River. Broker designed the bridge in May 1935 but others in bridge design drew, traced, and checked the plans in June and July 1935 (see A22).[57] The design featured standard type "B" concrete railing (though not specifically named as such on plan it is in the estimate of quantities and was used on many bridges designed by the department in the 1930s and identified as such on other plans).[58] This Trunk Line Bridge project replaced a narrower plank floor and I-beam bridge at this location at a cost of just under $11,000.[59]

One year later, in May 1936, Broker designed a considerably more complex T-Beam bridge, a three-span, continuous rigid frame, concrete slab on four frames with spread footings. The bridge carried NH Route 9 over the Soucook River between Concord and Pembroke (Bridge No. 160/188). This structure was one of two such types Broker designed while employed by the

[55] Harshbarger, 43.
[56] Robert McCullough, *Crossings: A History of Vermont Bridges* (Barre, VT: Vermont Agency of Transportation and the Vermont Historical Society, 2005), 207.
[57] Bridge design card, Croydon, No. 146/124. The bridge, built in 1936, was widened in 1993-1994 and a new deck and beams were added at the same time. Bridge card, Croydon, No. 146/124.
[58] For example, see plans for Bridge Nos. 102/074 and 103/074 in Exeter, New Hampshire, built 1935.
[59] Bridge design card, Croydon, No. 146/124.

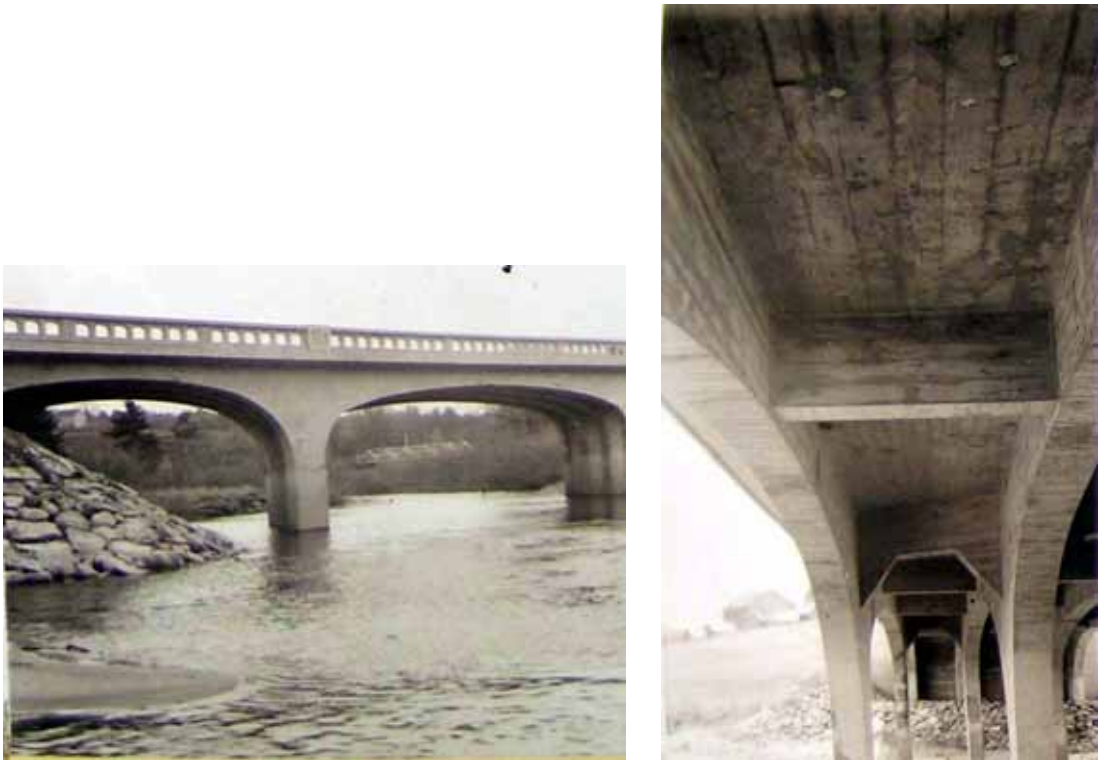

Figure 12

Concord-Pembroke, upstream elevation and underside showing diaphragms, Bridge No. 160/188 (NH Route 9 over Soucook River), designed 1936, built 1936-1937, photos ca. 1941. Source: NHDOT Bridge Design.

State Highway Department. The bridge replaced a comparatively new flat slab on steel I-beam bridge that had been destroyed in flooding 19 March 1936. While on first view from the side the bridge resembles a concrete rigid-frame bridge, upon inspection of the underside and examination of the plans, the bridge clearly features T-beam construction (see A23-A24). This bridge represents one of Broker's more complex reinforced-concrete bridge designs. With a skew of 38 degrees, the outer two spans measure 50' each while the middle span measures 70' with a total length of 177'-9-½".[60] The new structure was built by Hagan Thibodeau Construction Co. of Wolfeboro, New Hampshire.[61]

Broker was involved with a bridge in Webster in 1940-1941 that employed a similar design (see A25-A28). Bridge No. 099/123 carries NH Route 127 over the Blackwater River and also is a three-span T-beam rigid-frame bridge. Spanning a crossing with high embankments required

[60] Hagan-Thibodeau Construction Company of Wolfeboro, New Hampshire was the contractor for this bridge. Bridge design card, Concord-Pembroke, No. 160/188. Bridge card, Concord-Pembroke, No. 160/188.
[61] Ibid.

Figure 13

Webster, Upstream elevation, Bridge No. 099/123 (NH Route 127 over the Blackwater River), designed 1936, built 1940-1941, photos ca. 1941. Source: NHDOT Bridge Design.

high footings with cross bracing and features counterfort skeleton abutments. Though not visible in the above photograph they are apparent in the plan (see A25).[62] A counterfort abutment is one with ribs or perpendicular vertical walls braced against and extending from the back wall into the fill. Counterforts are ribs or bracing on the back wall of the abutment and covered with the fill. This form requires less concrete and has the stability comparable to earth fill over the footing. The wall must be reinforced to carry tension in the counterforts. A skeleton abutment, also known as a spill-through abutment, consists of columns supporting the vertical load rather than the more common curtain wall. This design was likely selected because the designer recognized that earth fill placed on both sides of the abutment negated the need for a full height curtain wall to retain the fill as it would be retained by the fill on the front of the abutment.[63] With an overall length of 166' the outer spans measure 48' and the middle span measures 65'. In contrast with the Concord-Pembroke bridge, however, the structure has no skew but otherwise resembles the earlier bridge. The railing is the standard pipe and pailings "BE" type rather than the earlier concrete styled railing. The contractor was Frederick Byron of Dedham, Massachusetts.[64]

Other miscellaneous reinforced-concrete bridge types

While concrete rigid-frame bridges and concrete T-beam bridges represent the majority of reinforced-concrete bridge types designed by Broker, he is known to have designed other types also. In 1941 he designed two concrete box culverts. The first, Bridge No. 147/136, is an 18 x 10 box that carries NH Route 25 over Libby Brook in Wentworth (see A29-A30).

[62] It appears that another engineer designed and drew the abutments so they have not been included here.
[63] Dave Powelson, Chief, Existing Bridge Section, Bureau of Bridge Design, New Hampshire Department of Transportation, email correspondence with author, 10 February 2011. Any inaccuracies are the responsibility of the author.
[64] Bridge design card, Webster, No. 099/123. Bridge card, Webster, No. 099/123.

Figure 14

Wentworth, downstream elevation, Bridge No. 147/136 (NH Route 25 over Libby Brook), designed and built 1941, photo ca. 1941. Source: NHDOT Bridge Design.

The 20'-long bridge was constructed by John Iafolla Construction Co. at an estimated materials cost of just under $4,000.[65]

Later that same year, Broker designed a reinforced concrete box for a crossing over an overflow of the South Branch of Sugar River in Newport (Bridge No. 136/099, removed 1985).

Figure 15

Newport, downstream elevation, Bridge No. 136/099 (NH Routes 11/103 over Libby Brook), designed and built 1941, photo ca. 1942. Source: NHDOT Bridge Design.

Like the Wentworth Bridge, the structure measured just 20' long.[66] The structure carried NH Routes 11/103 over the overflow of the South Branch of Sugar River.

[65] Bridge design card, Wentworth, Bridge No. 147/136.
[66] The plans designed and drawn by Broker in August 1941 could not be located.

Broker's very last known bridge design for the New Hampshire State Highway Department was for a reinforced-concrete arch bridge in Brookline (Bridge No. 083/076) at a new crossing. The

Figure 16

Brookline, upstream elevation, Bridge No. 083/076 (NH Routes 13 over Nissitissit River), designed 1945, built 1946, photo ca. 1950. Source: NHDOT Bridge Design.

bridge has a 30'-10-½" clear span and carries NH Route 13 over the Nissitissit River. The bridge, estimated to cost slightly less than $22,000, featured a solid spandrel, gravity abutments, and cantilever wings.[67] Broker computed the design in September 1945, and drew the plans, along with WHP in October and November 1945 (see A31-A32).

Through-plate girder bridge

Early in his career with Bridge Design Broker designed a thru-plate girder bridge in Rumney, his only known design of this type.[68] This 114' bridge (Bridge No. 132/070), built in 1934 and replaced in 1998, carried Main Street over Baker River in the southern end of town (see A33-A38). The single-span, two-girder bridge featured riveted girders; because of this feature the type was often referred to as a "plate-girder" bridge. This type was commonly used by railroads to cross waterways and for grade separation structures though neither condition applies to this setting. Broker's design featured an 8"-thick concrete slab set on 24"-87# wide-flange beams with girders flanking the comparatively narrow roadway (21').

[67] Bridge design card, Brookline, No. 083/076.

[68] Broker did check the plans for another through plate girder bridge, designed by Wesley E. Haynes, later the same year and built in 1935. Bridge design card, Haverhill, No. 169/159 (replaced).

Figure 17

Rumney, downstream elevation and south approach, Bridge No. 132/070 (Main Street over Baker River), designed and built 1934, photos 1972. Source: NHDOT Bridge Design.

Truss Bridges

While the majority of Broker's bridge designs for the State Highway Department were of different types of reinforced-concrete structures, he did design a few metal truss bridges. A defining characteristic of the truss bridges is the differentiation of the deck or road surface and the rest of the superstructure. Both of the truss designs Broker was associated with were for structures over the Connecticut River, replacing structures damaged or destroyed in the 1936 flooding.

The first of the two designs was for a steel truss bridge carrying US Route 4 over the Connecticut River between West Lebanon, New Hampshire, and Hartford, Vermont (Bridge No. 058/127). Constructed of three spans, with clear spans of 88', 140'-6", and 140'-7", it was designed by Clifford Broker, Wesley E. Haynes, and Gordon R. Whittum in September 1936 as an E.R. #10 Project, to replace an earlier steel truss bridge likely damaged or destroyed in the floods earlier that year (see A39-A41).

Figure 18

Lebanon, NH-Hartford, VT, downstream elevation and from New Hampshire approach, Bridge No. 058/127 (US Route 4 over Connecticut River), designed 1936, built 1936-1937, photos ca. 1941. Source: NHDOT Bridge Design.

The new structure, estimated to cost just under $98,000 was put out to bid in October 1936. Built by Simpson Brothers Corporation of Boston, the structure consists of a Pony Warren truss for the eastern-most span and thru-Pratt trusses for the two western spans.[69] The structure was erected on existing stone abutments and piers. Broker designed the westerly thru-Pratt truss spans, and the New Hampshire approach (with wooden guard rails) that led to the Pony Warren truss span designed by Wesley E. Haynes. A third engineer, Gordon R. Whittum (1910-1986) designed other portions of the bridge details.

The other truss bridge Broker worked on was designed just a month later in October 1936, just upstream from the Lebanon, NH-Hartford, VT, one. The structure carries East Thetford Road over the river between Lyme, New Hampshire, and Thetford, Vermont (Bridge No. 053/112). The bridge is a two-span through Parker Camelback truss bridge, a variation of the Pratt truss (which is recognizable by its diagonal web members forming a V-shape). While a true Parker Truss has sloping wrought iron end posts and a continuously curved wrought iron top chord, in

[69] Bridge design card, Lebanon, No. 058/127. Bridge card, Lebanon, No. 058/127.

later variations, the curving top chord is constructed from straight members with the incline changing at the panel points. In contrast with the traditional Pratt truss the use of a curved upper chord creates a lighter structure but maintains the necessary strength by lessening the dead load at the ends and distributing greater strength to the center. This bridge type, however, is complicated to build as the web lengths in each panel vary in length.[70]

Figure 19

Lyme, NH-Thetford, VT, downstream elevation, Bridge No. 053/112 (East Thetford Road over Connecticut River), designed 1936, built 1937, photo ca. 1941. Source: NHDOT Bridge

Broker designed this Works Progress Administration Project bridge and Gordon R. Whittum designed the other details of the structure such as the abutments and pilings (see A42-A43). The building contract was awarded to O.W. Miller Co. Inc and work began 9 March 1937. The American Bridge Company supplied the steel produced in its Elmira Plant.[71] Each span has nine panels each measuring 25'-9" with a clear span length of 227'. The joints are riveted rather than welded. The bridge is a rare surviving example in New Hampshire of this bridge type and is of noteworthy length.

I-beam Bridges, concrete decks

Broker is known to have designed at least two bridges with wide-flange stringers and reinforced-concrete decks, a bridge type that became increasingly common in State Department Highway designs for bridges of shorter lengths. In December 1939 Broker designed one in Weare, the John Connor Bridge (No. 079/153, replaced 2003) which carried John Connor Road over the Piscataquog River in North Weare. The bridge, constructed of four 33"-wide flange I-beams supporting a reinforced-concrete deck, measured 62'-6" in length from curb to curb, with an 18'-wide roadway. Estimated cost of the bridge was to be just under $7,000. Broker and Ralph Kenney drew the plans (A44-A45).

[70] "Bridge Basics," *Bridges and Tunnels of Allegheny County, Pennsylvania* <http://pghbridges.com/basics.htm> (accessed 18 February 2008).
[71] "Pratt Trusses, Thematic Review," on file at Bridge Design division, NHDOT.

Broker used a similar design for a bridge in Fremont in April 1941. The 47'-2"-long bridge

Figure 20

Fremont, downstream elevation, Bridge No. 106/076 (Scribner Road over Exeter River), designed 1941, photo 1979. Source: NHDOT Bridge Design.

carries Scribner Road over the Exeter River at Bassett's Mill (Bridge No. 106/076). The design however, used six smaller 24"-wide flange I-beams to carry the reinforced concrete deck, owing to the shorter crossing length (see A46-A47).

Timber Bridges

In 1941 Broker drew up plans for three timber bridges, all in Pittsburg and all three-span wood-pile-trestle bridges. Such bridges are one of the oldest known bridge types. In the United States such bridges were one of the earliest types to be used and remained in use on short spans into the twentieth century in spite of the introduction of more modern building materials such as metal and concrete and types. The construction consists of a wood plank deck supported by heavy rectangular or square sawn wood beams which are typically placed on low volume crossings. The use of such a bridge type in 1941 is the result of the absence of defense-critical materials such as steel as part of the industrial build-up in the period before World War II.[72]

Each bridge was identical in size and construction and consisted of three spans, each measuring 30' for a total length of 90'. The first of the bridges to be designed by Broker carried US Route 3 over Indian Stream (Bridge No. 070/032, replaced 1976). The new bridge was constructed of 4" plank on 10" x 18" stringers with 2" x 6" bridging centered on each span (see A48). The substructure was wood piles, five per bent. Broker designed the bridge and drew the plans in June 1941.

According to the bridge plan cards for the other two bridges (Bridge No. 090/120, replaced 2006 and Bridge No. 130/159, replaced 1996) those two bridges were nearly identical in construction

[72] The Louis Berger Group, 1, 4-5.

Figure 21

Pittsburg, downstream elevation, Bridge No. 130/059 (US Route 3 over Perry Stream), designed 1941, replaced 1996, photo ca. 1942. Source: NHDOT Bridge Design.

and length and were also designed in 1941.[73]

Miscellaneous other bridge types

Broker is known to have designed a small number of small bridges, of miscellaneous types. In March 1934 Broker was one of three engineers, along with Harold E. Langley and Nat S. Stevens, to work on the design for an Armco Multi-plate pipe #3 gage bridge in Crawford's Purchase (see A49). The structure for a 20' crossing, carries Mt. Clinton Road over Sokokis Brook (Bridge No. 090/179). The structure consists of eight 52"-wide sheets with 4-½" overlaps. Broker also drew and traced the plan.

Other bridges, girders

In at least one instance Broker worked on a particular aspect of a bridge's design, such as the piers and footings. This was the case in March 1934 for Bridge No. 109/134, a five-span deck plate girder bridge carrying NH Route 18 over the Connecticut River between Littleton, New Hampshire, and Waterford, Vermont, designed by Richard D. Field (see A50). Broker and Merritt P. Smith (1897-1967), a civil engineer educated at MIT (Class of 1919), designed the piers 1 March 1934 and Broker drew the plans the next day.[74]

Additions to existing bridges

While the majority of Broker's work while in Bridge Design was for new bridges, in a few instances he worked on projects involving additions to an existing structure. In August 1934 the department drew up plans to widen an existing masonry arch bridge in Merrimack, Bridge No. 116/120 (built 1921), carrying the Daniel Webster Highway/US Route 3 over the Souhegan

[73] See ibid., for state level documentation report of the former. At the time of this monograph the plans could not be located.

[74] Ancestry.com, *New Hampshire City Directories* [Concord 1933]. Ancestry.com, *World War I Draft Registration Cards, 1917-1918* [database on-line] (Provo, UT: Ancestry.com Operations Inc, 2005). "Report of the Alumni Committee on the Educational Endowment Fund," *Technology Review* XXII, no. 2 (April 1920): 212.

River (see A51-A56). The densely developed site included the International Shoe Company (now demolished) and its associated dam and canal and required some of the work to span or rebuild existing infrastructure. The existing two-span, stone-arch bridge was widened on the downstream side with a stone-faced, concrete-arch addition designed by Ralph R. Kenney and John H. Wells. This required widening the roadway immediately adjacent to the International Shoe Company building, incorporation of a sidewalk along the road and bridge, and construction of a loading platform to the shoe company. Broker and Wesley E. Haynes designed all

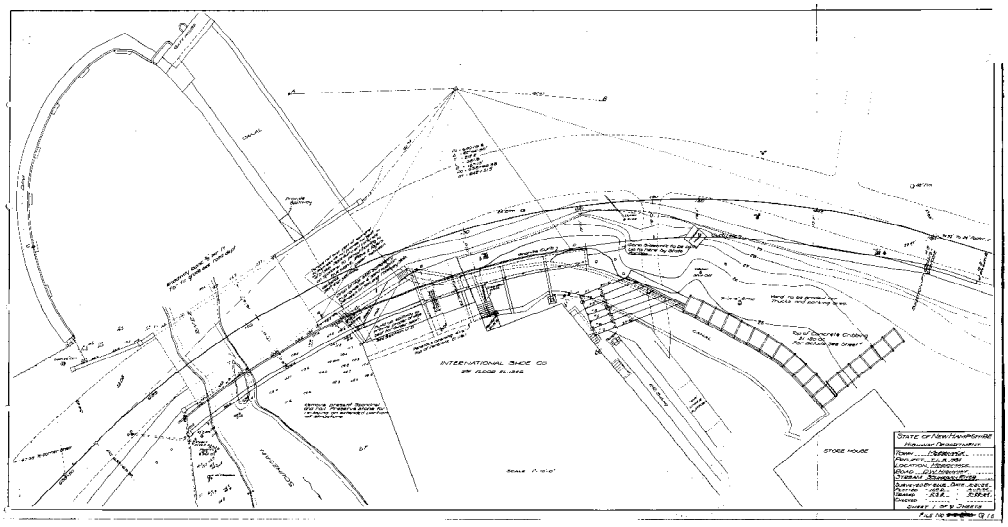

Figure 22

Plan, bridge widening, Bridge No. 116/120 (US Route 3 over Souhegan River), Merrimack, designed by Wesley E. Haynes, Ralph R. Kenney, Clifford Broker, 1934. Source: NHDOT Bridge Design.

elements of the expansion of the roadway, some constructed of concrete slab and girders, and some with 21" WF beams. Their plans included layout of beams, wall, etc., reinforcing in the slab, details of the beams, the loading platform, the concrete crib adjacent to the loading platform, and the guard rail.

Clifford Broker; Clifford Broker Associates, ca. 1946-ca. 1985

Broker set up his own engineering practice as a consulting and structural engineer by 1947, after leaving the State Highway Department.

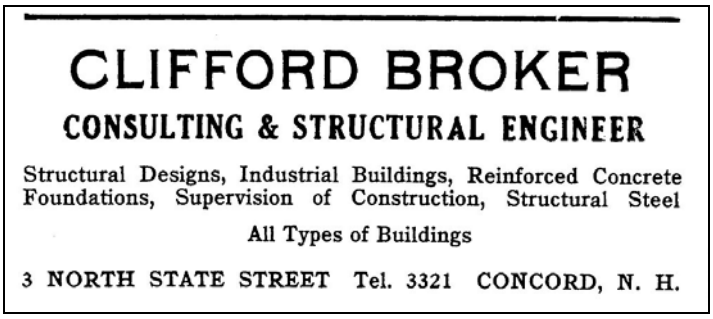

Figure 23

Clifford Broker advertisement, 1947 Concord Directory, p. 450.

By ca. 1950 the business became Clifford Broker Associates and would be known as such for roughly forty years. By the time of the name change the small firm employed a small number of engineers and architects.

Figure 24

Clifford Broker Associates, advertisement, 1953 Concord Directory, p. 59.

The firm designed many buildings locally and throughout the Northeast but comparatively few of the firm's designs have been specifically identified and the dates of construction are generally not known. Of the identified projects in Concord, New Hampshire, most are multi-story rectangular brick-faced buildings, often with contrasting concrete trim. Some appear to be the result of urban renewal in downtown Concord or state and federally funded building projects. Others are office buildings for large corporations, constructed on the edge of the downtown core in the 1960s and 1970s.

Over the years Broker also was a part-time structural engineering instructor at New England College in Henniker.

The bulk of identified projects designed by Clifford Broker Associates are located in Concord, New Hampshire.[75] The firm was the associate architect on the John F. Kennedy Apartments, a high-rise brick apartment block commissioned by the Concord Housing Authority and completed in 1965 on the corner of South Main and Thompson streets. The ten-story building provided

Figure 25

John F. Kennedy Apartments, 1 Thompson Street, Concord, NH, 1974. Photograph James L. Garvin, 2010.

housing for the elderly, containing eighty-two studio, one-, and two-bedroom apartments. Two other known designs from the 1960s are the now-altered Blue Cross-Blue Shield Building (1 Pillsbury Street, ca. 1961, gutted, altered fenestration ca. 2003) and the former Christian Mutual Building (6 Loudon Road).[76]

Two of the projects in Concord are associated with urban renewal in that city in the 1970s. One is the Capital Plaza Towers, a Concord Housing Authority project developed by Massachusetts General Housing Corp and built by Herbert Engineering Co. in 1974. The structure, a federally-

[75] A special thanks to James L. Garvin, State Architectural Historian, New Hampshire Division of Cultural Resources, for kindly providing photographs of many of the buildings known to have been designed by Clifford Broker Associates.

[76] "Clifford Broker '29," 19. "Clifford Broker, 89, noted architect, engineer."

Figure 26

Capital Plaza Towers, 15 Pitman Street, Concord, NH, 1974. Photograph James L. Garvin, 2010.

funded apartment complex for the elderly, was initially intended to have commercial space at the ground level.[77] The complex is located in a large block at the intersection of North Main and Centre streets that underwent urban renewal in the early 1970s.[78]

[77] "Capitol Plaza Towers Dedicated," *Concord Monitor*, 27 July 1974, p. 9. Broker Associates is not listed on the dedication plaque or in the newspaper article but his obituary listed this building as one of the firm's designs.
[78] Elizabeth Durfee Hengen, "A History of Development," prepared for the Concord Housing Authority, n.d. http://www.concordha.com/HistoryofCHA.pdf (accessed December 2010).

Following completion of the apartment building, a large two-story pre-cast concrete building

Figure 27

Front (east) and rear (west) elevations, Bank of New Hampshire, North Main and Centre streets, Concord, NH, 1975. Photograph James L. Garvin, 2010.

was erected on an adjacent parcel on the northwest corner of North Main and Centre streets, also designed by Clifford Broker Associates. The Bank of New Hampshire was the initial primary tenant. The 240' office building contained 40,000 square feet of office space.[79]

A third major project in the mid-1970s by the firm and completed in 1975 was the Municipal Services Complex on Green Street.[80] This included a new one-story police station on Green Street (since expanded), to the south of Concord City Hall, and a one-story addition and an elevator addition on the south side of the ca. 1903 Georgian Revival style city hall. This was the

[79] Hengen.

[80] "Hassle Erupts Over Ceiling in Concord," *Nashua Telegraph*, 3 October 1975, p. 2. All articles from the *Nashua Telegraph* and *Portsmouth Herald* were found online at Ancestry.com.

Figure 28

Concord Police Station, part of Municipal Services Complex, with later additions, Green Street, 1975. Photograph James L. Garvin, 2010.

last major project by the firm. The project architects were Emil Laufik and Paul Hedstron. John Johnson, an architect, also worked on the project.[81] Broker and the project architects made a special effort to incorporate design elements that duplicated those on the original building, such as water tables and belt courses, but did them in concrete so as to clearly distinguish between the old and new work.[82]

Some additional projects by Broker or by the firm have been identified from Nashua and Portsmouth newspapers available online. Broker was hired as the structural consultant on the Manchester Housing Project to be constructed in the late 1940s.[83] This project likely pre-dated the establishment of Clifford Broker Associates.

In the 1950s the firm was one of twenty-four under consideration for the design of a 125-unit low-rent housing project in Portsmouth. In the end the city selected John D. Betley to design the housing.[84] Broker also supervised the demolition of the Christ Episcopal Church parish house in 1954, on Madison and Lovell streets in Portsmouth, New Hampshire. The building, a four-story stucco structure, which extended from the southeast side of the sanctuary, had been added sometime before the First World War. Its removal allowed for the 1882 early English styled church to be restored to its original appearance. Broker's supervision also included restoration of that elevation of the church to match the other elevations.[85] The firm also designed a new building for the Church of the Nazarene in Nashua in 1955. The proposed 36' x 60', one-story frame building, on the corner of Main Street and Montgomery Avenue was to be in keeping with the largely residential neighborhood.[86]

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[81] Emil Laufik, phone interview by author, 6 December 2010. Johnson subsequently moved to Ohio. Ibid.
[82] Linda Wilson, email correspondence with author, 3 December 2010.
[83] "PC Profit on Queen City Homes Charges Carlson," *Nashua Telegraph*, 21 October 1948, p. 14.
[84] "Housing Authority to Meet Tonight," *Portsmouth Herald*, 9 April 1956. "Manchester Man To Be Architect For Housing Job," *Portsmouth Herald*, 26 April 1956.
[85] "Christ Church Levels Parish House," *Portsmouth Herald*, 23 December 1954. Fire destroyed the church in 1963.
[86] "Plan New Church for South End," *Nashua Telegraph*, 16 May 1955, p. 1. The structure, which has a later addition, is now occupied by the Salvation Army.

In the 1950s the firm also did some bridge design work. One known project is the Peirce Island Bridge, an I-beam with concrete deck bridge built in 1958. The 281'-long, 32.3'-wide,

Figure 29

Portsmouth, Bridge No. 241/069, Pierce Island Road over Little Harbor, 1958. Photo ca. 1959. NHDOT Bridge Design.

four-span bridge runs between the South End of Portsmouth and Peirce Island over Little Harbor.[87]

Known work from the 1960s outside of Concord includes a three-story wing addition to Kingsbury Hall for the College of Technology at University of New Hampshire in 1966. The addition was to house the mathematics department and the university's computer center. The wing, built by Franchi Brothers Construction Co., a Wellesley Hills, Massachusetts, contractor, is a brick and pre-cast concrete structure totaling roughly 26,000 square feet.[88] The project was part of a long-range expansion program by the university in the mid-1960s.

Only one commission outside of New Hampshire has been identified to date. In 1964 the firm designed a new brick neo-colonial church for the Central Baptist Church in Middleborough, Massachusetts.[89]

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[87] "Portsmouth City Council," *Portsmouth Herald*, 3 December 1957, p. 1. "Design Sought for New Bridge," *Portsmouth Herald*, 5 December 1957, p. 30. "Council Delays Action on Traffic Plan Until Meeting Next Month," *Portsmouth Herald*, 10 December 1957, p. 1-2. "Council to Decide on Bridge Span Early Tomorrow," *Portsmouth Herald*, 5 February 1958, p. 1. "Violette Seeking Information on Three Problems," *Portsmouth Herald*, 6 March 1958, p. 1. "Contract Documents and Specifications for Peirce Island Bridge Rail Replacement Project Bid Proposal #09-10" http://www.cityofportsmouth.com/finance/bids/09-10.pdf (accessed November 2010). New Hampshire Department of Transportation, Bridge Summary (30 March 2010) http://www.nh.gov/dot/bureaus/bridgedesign/BridgeInspection.htm (accessed April 2010). The bridge was rebuilt in 1968 and the bridge railings and W-beams guard rails were replaced in 2010.

[88] "Campus Development Costing $22 Million," *Portsmouth Herald*, 10 February 1966, p. 2. The building including the wing was renovated 2003-2007.

[89] William McKenzie Woodward with Betsy Friedberg, "Middleborough Center Historic District," National Register of Historic Places (May 2000), 7:20. The nomination identifies the architect as Broker, MacKay Associates of Concord, New Hampshire. No information has been located on MacKay as this point.

Figure 30

Central Baptist Church, Nickerson Avenue, Middleborough, MA, 1964. Bing Maps.

Clifford Broker Associates Staff

Some of the engineers and architects who worked for the firm over the years have been identified, predominantly from city directories. Historically, the firm remained small with only a few architects and engineers on staff. One of the earliest known engineers employed by Broker is Marshall M. Moyer (1916-2002) who remained at the firm briefly but is identified as an associate in the 1950 Concord Directory advertisement.[90] By the following year Adolphus Holton (1912-2003), a mechanical and electrical engineer, had joined the firm. Holton, who resided in Henniker, remained with the firm for less than five years. By 1953 Todd Bryce Wallace (d. 7 June, 1958), an architect, had joined the firm. Wallace seems to have been with the firm for just a couple of years. Edwin I. Carlson (1920-2005), a 1942 graduate of University of New Hampshire (B.A. architecture), was a World War II veteran who began to work with the firm by 1960.[91] The Concord architect Guy K.C. Wilson (1925-1982) worked with the firm for a time before establishing his own practice.[92] The engineer Thomas C. Philip seems to be working for the firm by 1962.[93] The architects Paul Hedstron and Emil Laufik joined the firm within a

[90] Moyer was subsequently involved in the designs of the Legislative Office Building, Legislative Parking Garage, the Sherman Adams Building at the summit of Mount Washington, in addition to flood control projects and office buildings over his forty-year career as an engineer. "Marshall M. Moyer Sr., designed buildings in New Hampshire," *Manchester Union Leader*, 17 October 2002, p. A6.

[91] "Edwin I. Carlson, Concord; WW II Veteran Was an Architect for the State," *Concord Monitor*, 2 November 2005, p. B2. Carlson worked for various private architectural firms up to 1973 at which time he became architect for the New Hampshire Bureau of Public Works, retiring in 1987. Ibid.

[92] Emil Laufik, 6 December 2010. Wilson's designs include the Prescription Center Building on the southwest corner of North Main and Centre streets, built 1971, across the street from several projects Clifford Broker Associates worked on as part of urban renewal in Concord in the early 1970s. "The Prescription Center, Concord," *Granite State Architect* VIII, no. 3 (October 1971): 14-19.

[93] Ancestry.com, *New Hampshire City Directories* [1962 Concord Directory]. There is no individual listing for Philip and no biographical information has been established at this time.

month of each other in 1972, moving to Concord from Philadelphia to do so. They were the project architects for the firm's last major project, the Municipal Services Complex in Concord.

The firm always had at least one secretarial and/or administrative person in its employ. The first was Genevieve A. Pynn (1928-2008), who remained until ca. 1950-51. In the 1953, 1955, and 1957 directories Iris N. Gray is listed as a bookkeeper-typist working at Clifford Broker Associates. By 1962 Mrs. Alice D. Besse appears to be the administrative person on staff.[94]

By the late 1970s Clifford Broker was looking to retire and hoped to a pass along the firm to someone with a similar work ethic. By that time Broker's firm was associated with Ken Perry & Associates, an architectural firm in Weymouth, New Hampshire, run by a close friend of Broker. The hope was Perry might take over the firm.[95] He was unsuccessful in this endeavor and by the early 1980s the firm had largely closed down.

More to be researched

There is still much to be learned about Broker's career after he left the State Highway Department and many of the firms' designs remain unidentified. This monograph is meant to be a beginning, establishing what is known about Broker's work at the Highway Department and briefly examining his work after he established his own firm. As additional Broker commissions are identified that information should be added to this monograph as an addendum, possibly maintained by New Hampshire Division of Historical Resources.

[94] Ibid.
[95] Emil Laufik, 6 December 2010.

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Portfolio of Bridge Designs

Methodology Note

The following table was compiled from the bridge design plan cards and bridge plans at the offices of Bridge Design, New Hampshire Department of Transportation, Concord, New Hampshire. This chronological list represents the majority of projects Clifford Broker worked on while employed at the State Highway Department, ca. 1933-1941 and ca. 1945-1946. The majority of the projects are ones where he was the principal designer or where he worked on an aspect of the design. It does not include the small number (8) of projects where he did the drawings for a project, traced the drawings, or checked the drawings. While fully representative, it is in all likelihood not entirely complete.

Selections from most of those projects are included with this appendix and are arranged by bridge type, according to how they have been discussed in the text. A very special thank you to NHDOT Bridge Design staff, most notably Lynn Paquette and Robin Brown, who oversaw the pulling of the plans for scanning for inclusion in this monograph. Without their considerable assistance this project would not have been possible.

SAB: State Aid Bridge Project
TLB: Trunk Line Bridge Project
ER: Emergency Relief Project

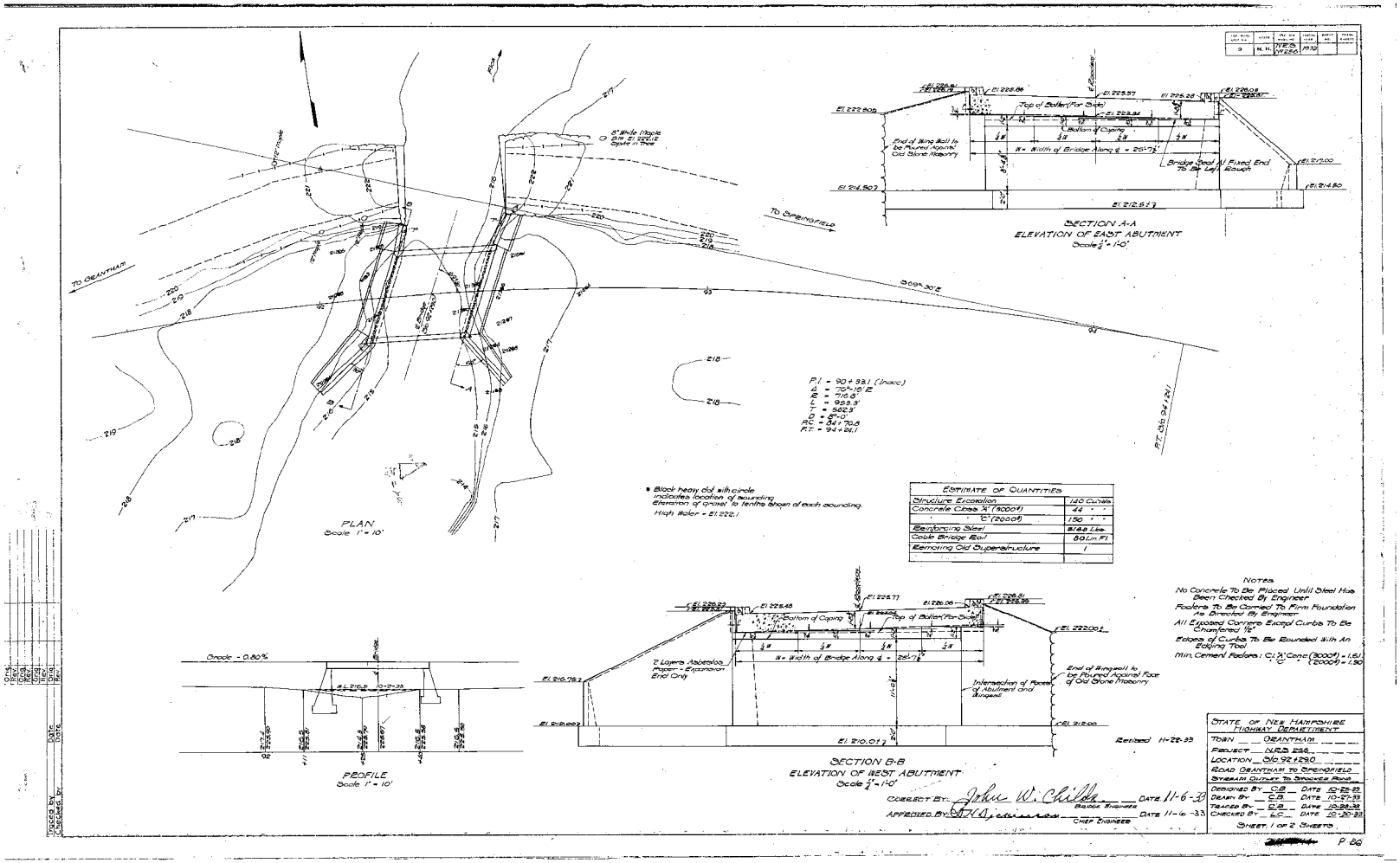
Date	Town/ Bridge No.	Bridge Type	Crossing location	Notes
1933	Grantham No. 140/069	Reinforced concrete slab (CS), cable rail, mass concrete abutments and wing walls	NH 114 over Stocker Pond Outlet	NRS Project 256. Designed by CB 10-25-33, drawn by CB 10-27-33, traced by CB 10-28-33
1933	Holderness No. 109/109	Reinforced concrete slab (CS) , cable rail, mass concrete abutments and wing walls Widened 1983	NH 175 over Owl Brook	SAB Project. Designed by LCM (Leon C. Marshall) & CB 11-06-33, drawn by LCM & CB 11-07-33, traced by CB 11-08-33
1934	Woodstock No. 170/159	Reinforced concrete rigid-frame (CRF), stone faced, wings	NH 112 (Lincoln Road) over Pemigewasset River, North Woodstock	Designed by RK (Ralph Kenney) & CB 01-18-34. Sheet 2 (drawn by CB & ES [E.W.G. Smith?] 01-22-34, traced by E.W.G.S. 01-24-34 Sheet 2—plan, elevation, half-sections, reinforcement of bridge, wing walls
1934	Littleton-Waterford VT No. 109/134	Deck plate girder (DPG), 5 spans, continuous for 3 larger spans, steel rail, reinforced concrete floor, abutments, piers Work done 1980	NH 18 over Connecticut River	Interstate Bridge Project No. 263, Theodore Roosevelt Highway. Bridge designed by RDF (R. D. Fields), MRS (M. R. Smith), & CB. Sheet 25, piers and footings, designed by MRS & CB 03-01-34, drawn by CB 03-02-34, traced by EWGS

Date	Town/ Bridge No.	Bridge Type	Crossing location	Notes
1934	Crawford's Purchase No. 090/179	Armco Multi-plate Pipe (MP-A), #3 gage	Mt Clinton Road over Sokokis Brook	SRB 1934. Designed by HEL (Harold E. Langley), NS (Nat S. Stevens), & CB 03-21-34. Drawn by CB 03-22-34, traced by CB 03-23-34
1934	Rumney No. 132/070 (replaced 1998)	Thru-plate girder, reinforced concrete slab, reinforced concrete counterfort, cantilever walls Replaced 1998	Main Street over Baker River	SAB 1934 Designed and drawn by CB 06-22-1934 sheets 2-7
1934	Merrimack No. 116/120	Widening of existing (1921) masonry arch bridge plus new wall, beams to support new sidewalk and roadway slab, new truck & loading platforms, concrete cribbing & grading of parking area.	US Route 3 over Souhegan River Adjacent to International Shoe Company Building	TLB 1934 Arch extension designed by RK & JW (John H. Wells) Layout of beams, walls, etc., reinforcing in slab, details of beams designed and drawn by CB & WH (Wesley E. Haynes), sheets 4-6. Sheets 7 & 8, loading platform, designed by CB & WH, drawn by CB. Sheet 9, concrete crib & guardrail, designed & drawn by CB. All August 1934
1934	Manchester No. 176/119	Reinforced concrete rigid-frame, stone faced Work done 2003	NH Route 28A (Mammoth Road) over Cohas Brook	US Public Works Project 1935 CB designed 10-15-1934, drew plans 10-16-1934
1935	Durham No. 095/121	Reinforced concrete rigid-frame (CRF), stone faced, reinforced concrete stone-faced cantilevered wings	Old US Route 4 over B&M RR	US Works Program Grade Crossing Project CB designed, drew plans for many aspects of bridge, Sept-Nov 1935 WEH & others did some also
1935	Hopkinton (Contoocook Village) No. 102/143 Leroy R. Kimball Bridge	Reinforced concrete rigid-frame (CRF), stone faced, gravity wings	NH Routes 103/127 over Contoocook River	TLB 1935 Designed by RSB (Roland S. Burlingame) & CB Sheet 3, reinforcement, designed and drawn by CB March 1935
1935	Croydon No. 146/124	Reinforced concrete T-beam (CTB), concrete rail, mass concrete abutments and wings Widened, new deck & beams 1993-94	NH Route 10 over Croydon Branch of Sugar River	TLB 1935 Designed by CB May 1935 Drawings by RHW (Robert H. Whitaker)

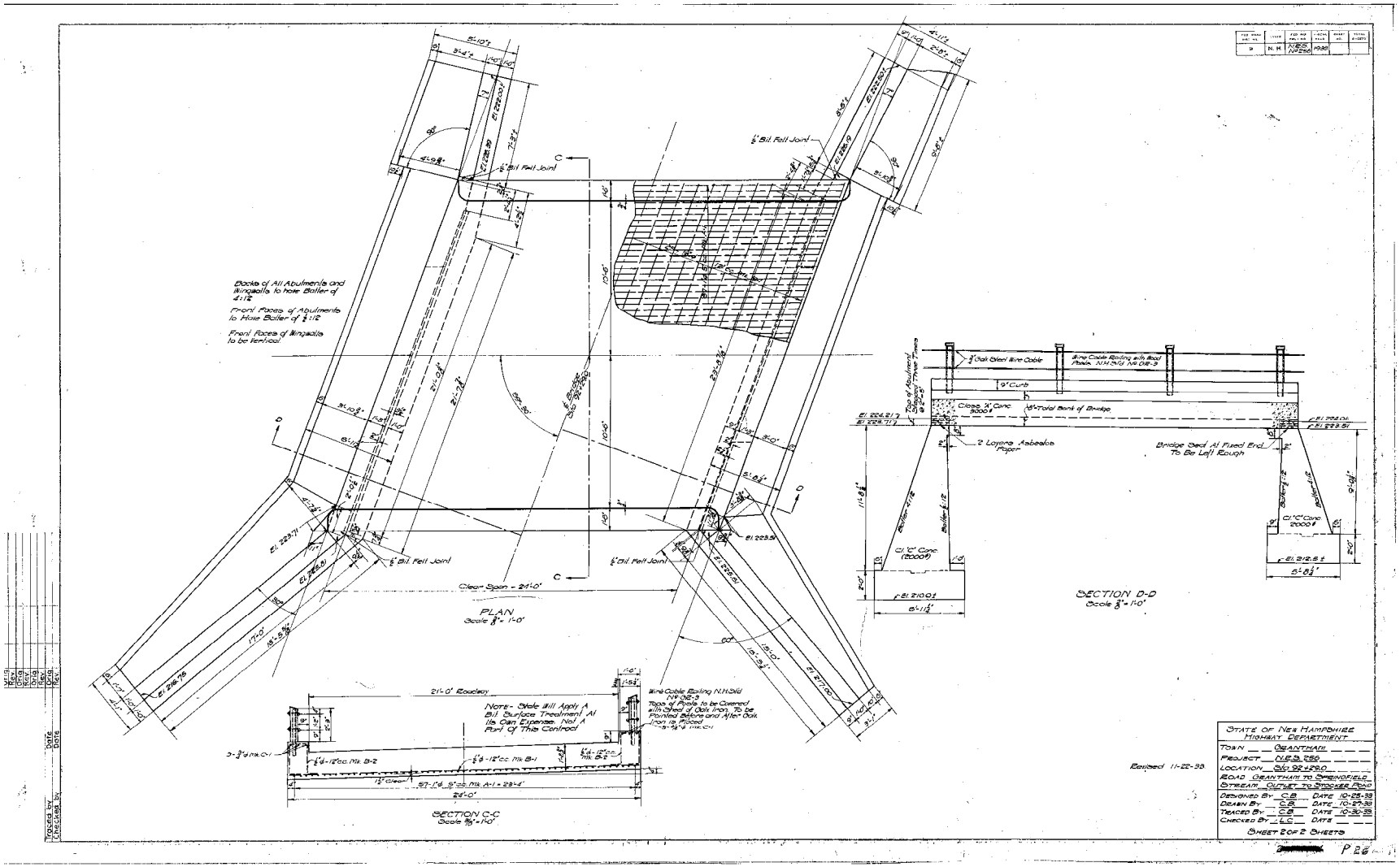
Date	Town/ Bridge No.	Bridge Type	Crossing location	Notes
1936	Concord-Pembroke No. 160/188	Rigid-frame concrete slab, 3-span, 4 frames, spread footings Widened 1988	NH Route 9 over Soucook River	ER No. 2 Designed by CB May 1936 Drawn by RMA (R. M. Averill) RMA designed, drew wing walls and their reinforcement WJB (Willard Baldwin?) designed, drew railing
1936	Lebanon No. 058/127	3 spans-2-span through Pratt truss and 1span low Warren truss New deck 1976	US Route 4 over Connecticut River to Hartford, Vermont	ER No. 10 CB designed 2-span through Pratt truss August 1936 and New Hampshire approach; WEH designed low Warren truss, piers; GRW (G.R. Whittum) designed abutments
1936	Lyme No. 053/112	Parker Camelback truss bridge, 2-span	East Thetford Road over Connecticut River to East Thetford, Vermont	WPA Project Designed by CB 10-20-36, details by CB & HCN (Henry C. Newell) 10-20-36; GRW designed riprap, pier, abutments,
1939	Weare No. 079/153 John Connor Bridge	I-beam bridge, concrete deck Replaced 2003	John Connor Road over Piscataquog River	TH 438 Designed by CB, drawn by CB & RK Dec 1939
1940	Hill No. 157/108	Reinforced concrete rigid-frame, ashlar stone facing	NH Route 3A over Needle Shop Brook	Designed and drawn by CB April 1940—General plan & elevation, general layout & steel; GRW designed, drew general layout & steel for wingwalls
1940	Webster (Swett's Mill) No. 099/123	T-beam rigid frame, concrete, 3 spans	NH Route 127 over Blackwater River	CB designed & drew plan & section, masonry sections, reinforcing girders & legs, reinforcing details, Jan 1941; CB & RWM designed cable rail Jan 1941; GWW designed, drew layout & profile, abutment masonry details Nov 1940
1941	Wentworth No. 147/136	Concrete box Work done 1985	NH Route 25 over Libby Brook	CB & RWM designed masonry plan & sections and Reinforcing details Feb 1941, RWM drew them Feb 1941
1941	Fremont (Bassett's Mill) No. 106/076	I-beam bridge, concrete deck	Scribner Road over Exeter River	CB designed and drew plans, Apr 1941
1941	Pittsburg No. 070/033	Wood stringer bridge, plank deck, 3 spans Replaced 1976	US Route 3 over Indian Stream	Per Bridge Plan card (written by CB), CB designed & drew plans April 1941. Plans say June 1941

Date	Town/ Bridge No.	Bridge Type	Crossing location	Notes
1941	Brentwood No. 073/065	Concrete rigid-frame, arch effect	Crawley Falls Road over Exeter River (originally NH Route 125)	CB designed May 1941, drew masonry & reinforcement details May 1941
1941	Clarksville-Pittsburg No. 090/120	Wood stringer bridge, plank deck, 3 spans Replaced 2006	NH Route 145 over Connecticut River	Plans not seen. Per Bridge Plan card, CB designed June 1941. WHP drew plans 8-13-1941
1941	Pittsburg No. 130/059	Wood stringer bridge, plank deck, 3 spans Replaced 1996	NH Route 3 over Perry Stream	Plans not seen. Per Bridge Plan card, CB designed & drew plans June 1941
1941	Newport No. 136/099	Reinforced concrete box Removed 1985	Overflow bridge near Sugar River	Plans not seen. Per Bridge Plan card, CB designed & drew plans August 1941
1945	Orford No. 100/090	Reinforced concrete rigid-frame, arch effect	Dame Hill Road over Jacobs Brook	SAB CB designed Jan 1945, drew some plans, drew some with WHP
1945	Randolph No. 155/057	Reinforced concrete slab	Pinkham B Road over Bumpus Brook	CB designed, drew plans July 1945
1945	Brookline No. 083/076	Reinforced concrete arch, solid spandrel	NH Route 13 over Nissitissit River	CB designed Sept & Nov 1945, drew some of the plans Oct 1945, calculated some quantities Nov 1945

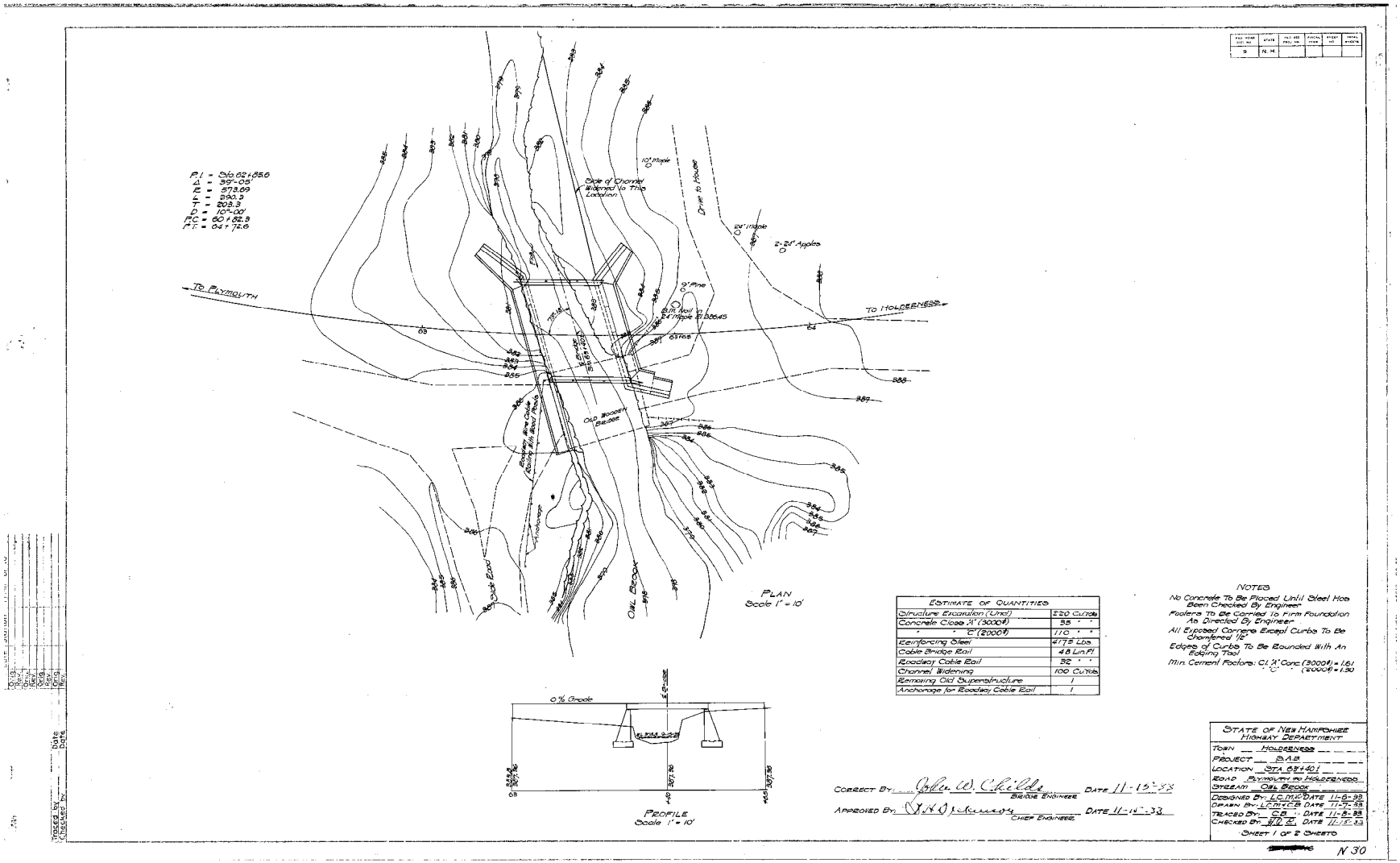
Bridge Plans



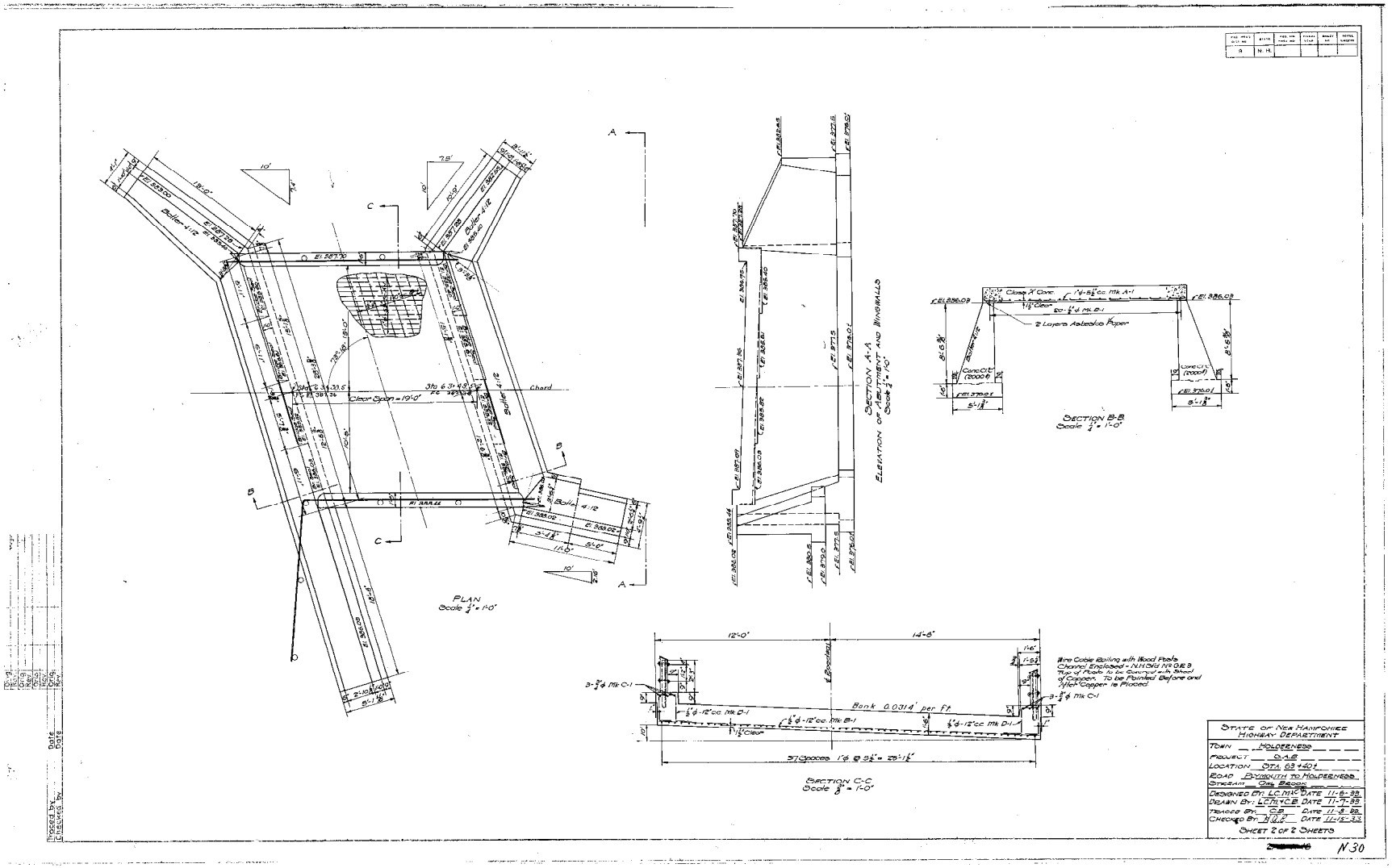
A-1) Bridge No. 140/069, Grantham, NH Route 114 over Stocker Pond Outlet, Sheet 1 of 2, 1933. NHDOT Bridge Design.



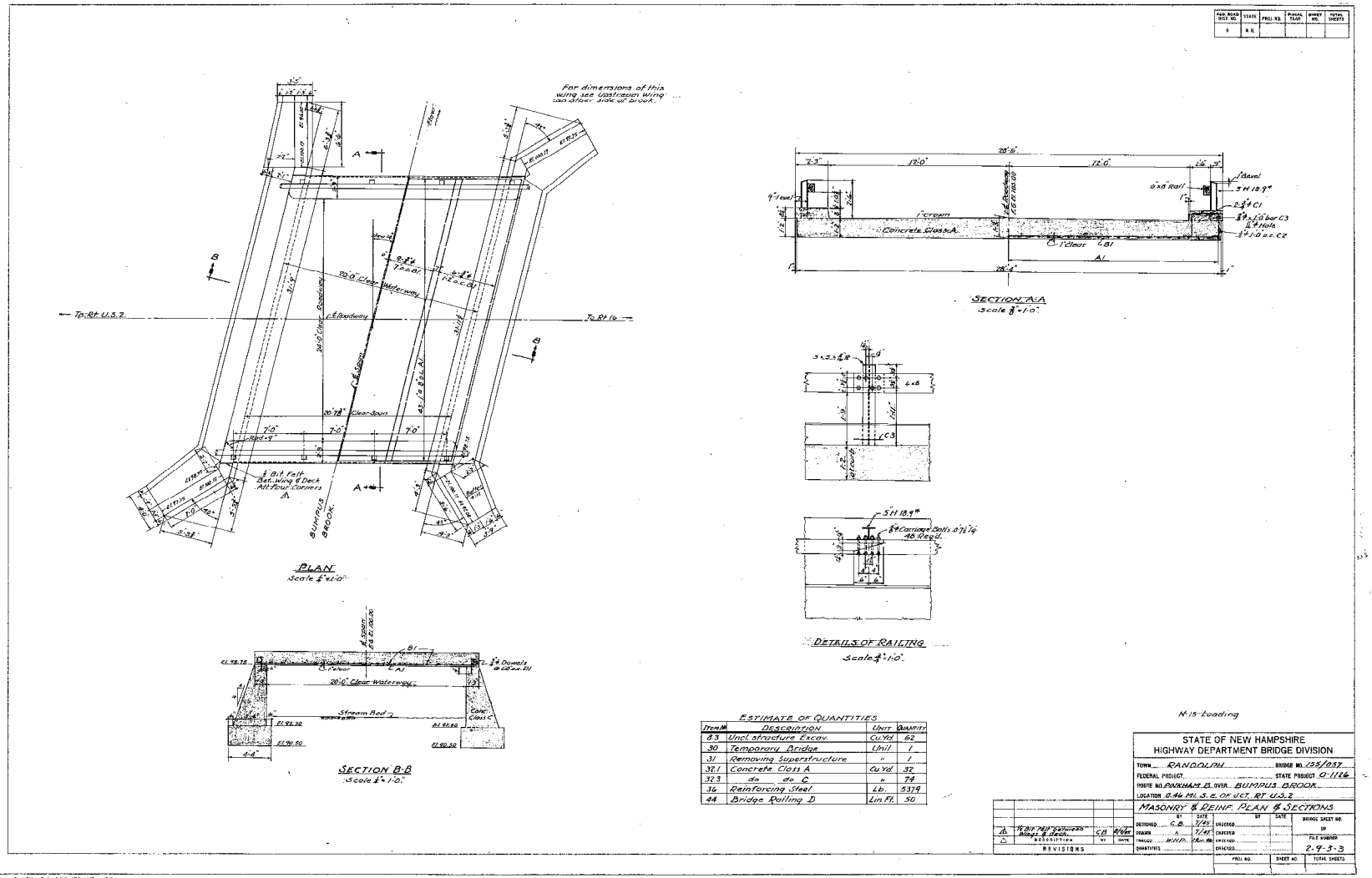
A-2) Bridge No. 140/069, Grantham, NH Route 114 over Stocker Pond Outlet, Sheet 2 of 2, 1933. NHDOT Bridge Design.



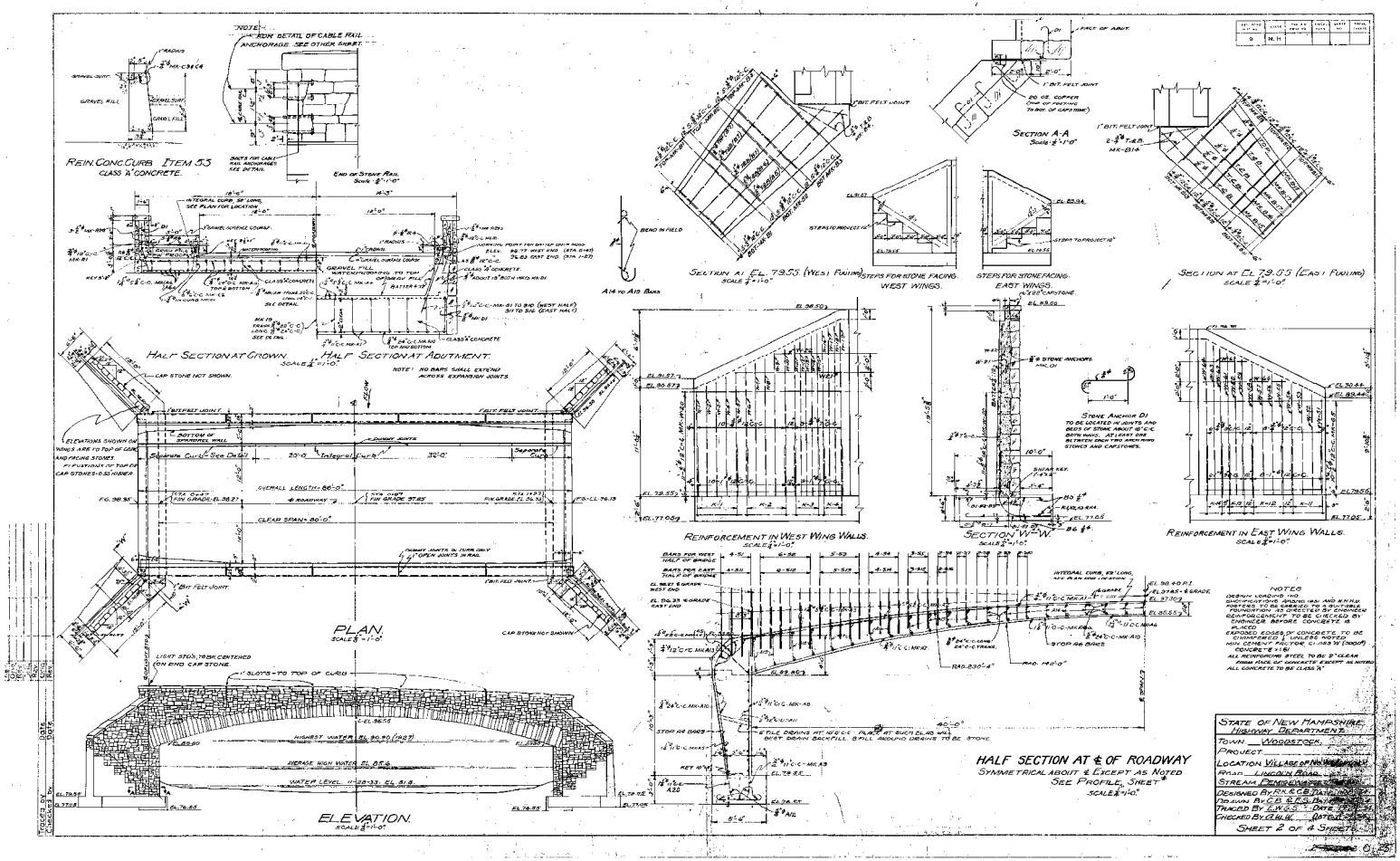
A-3) Bridge No. 109/109, Holderness, NH Route 175 over Owl Brook, Sheet 1 of 2, 1933. NHDOT Bridge Design.



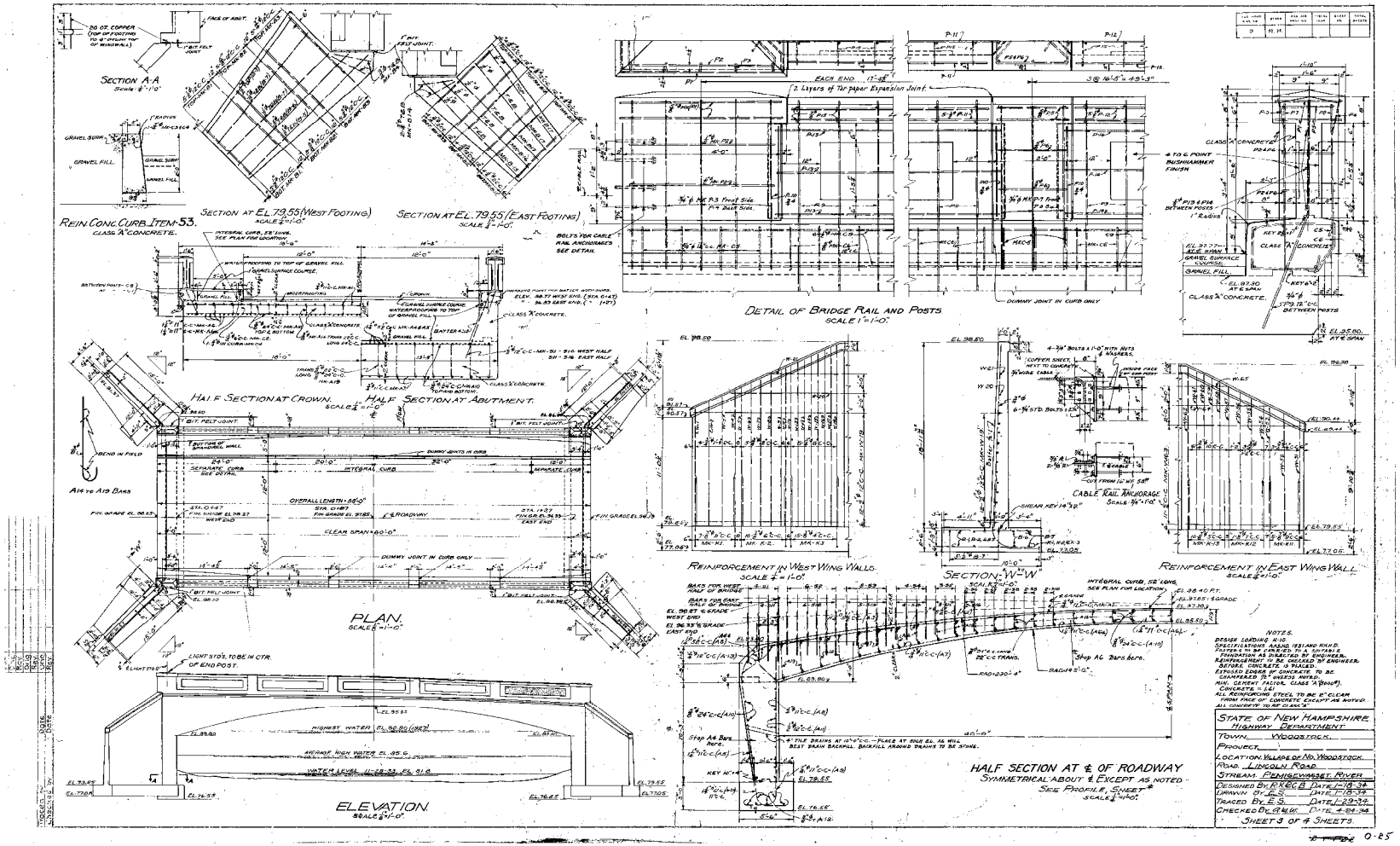
A-4) Bridge No. 109/109, Holderness, NH Route 175 over Owl Brook, Sheet 2 of 2, 1933. NHDOT Bridge Design.



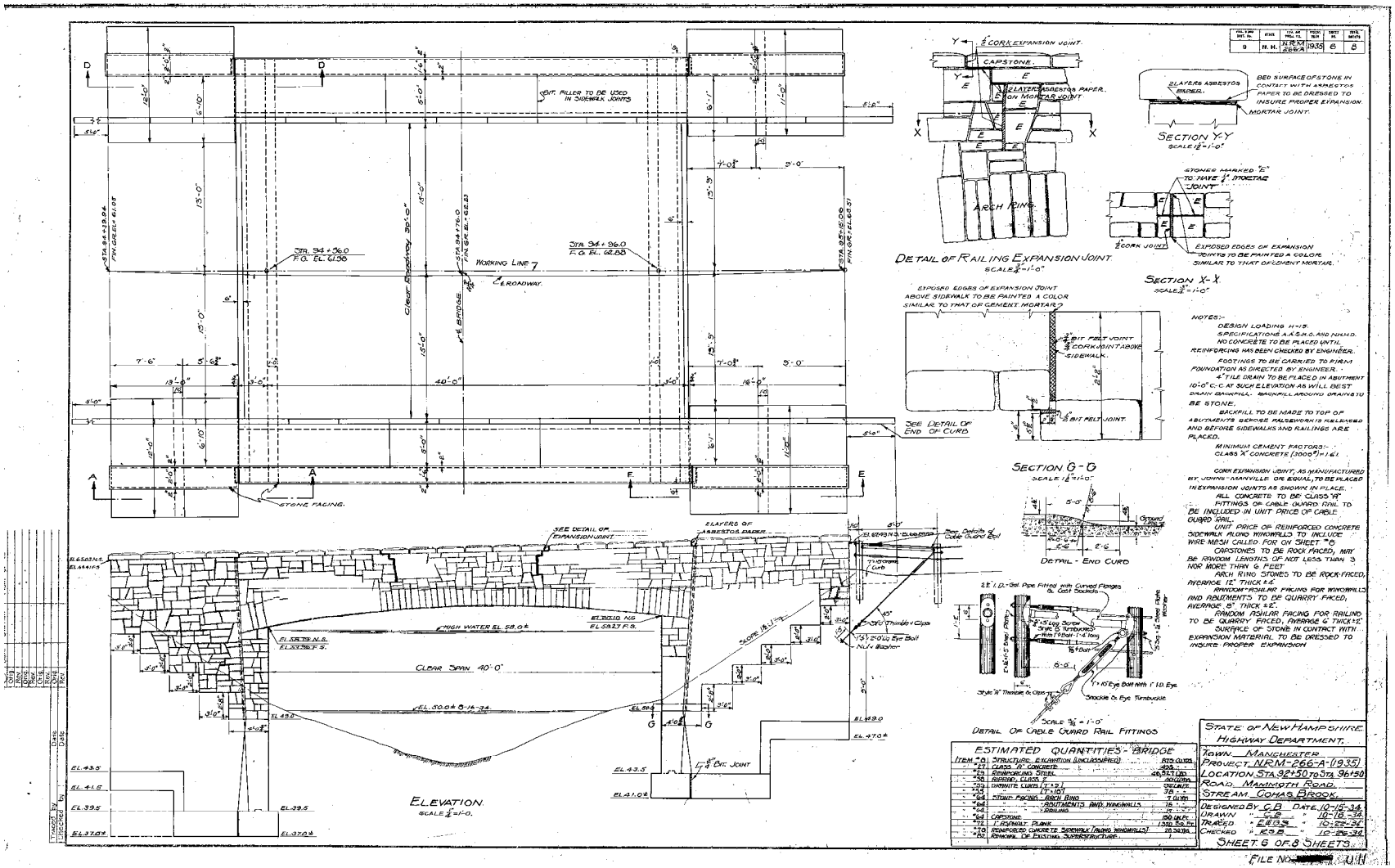
A-5) Bridge No. 155/057, Randolph, Pinkham B Road over Bumpus Brook, Sheet 1of 1, 1945. NHDOT Bridge Design.



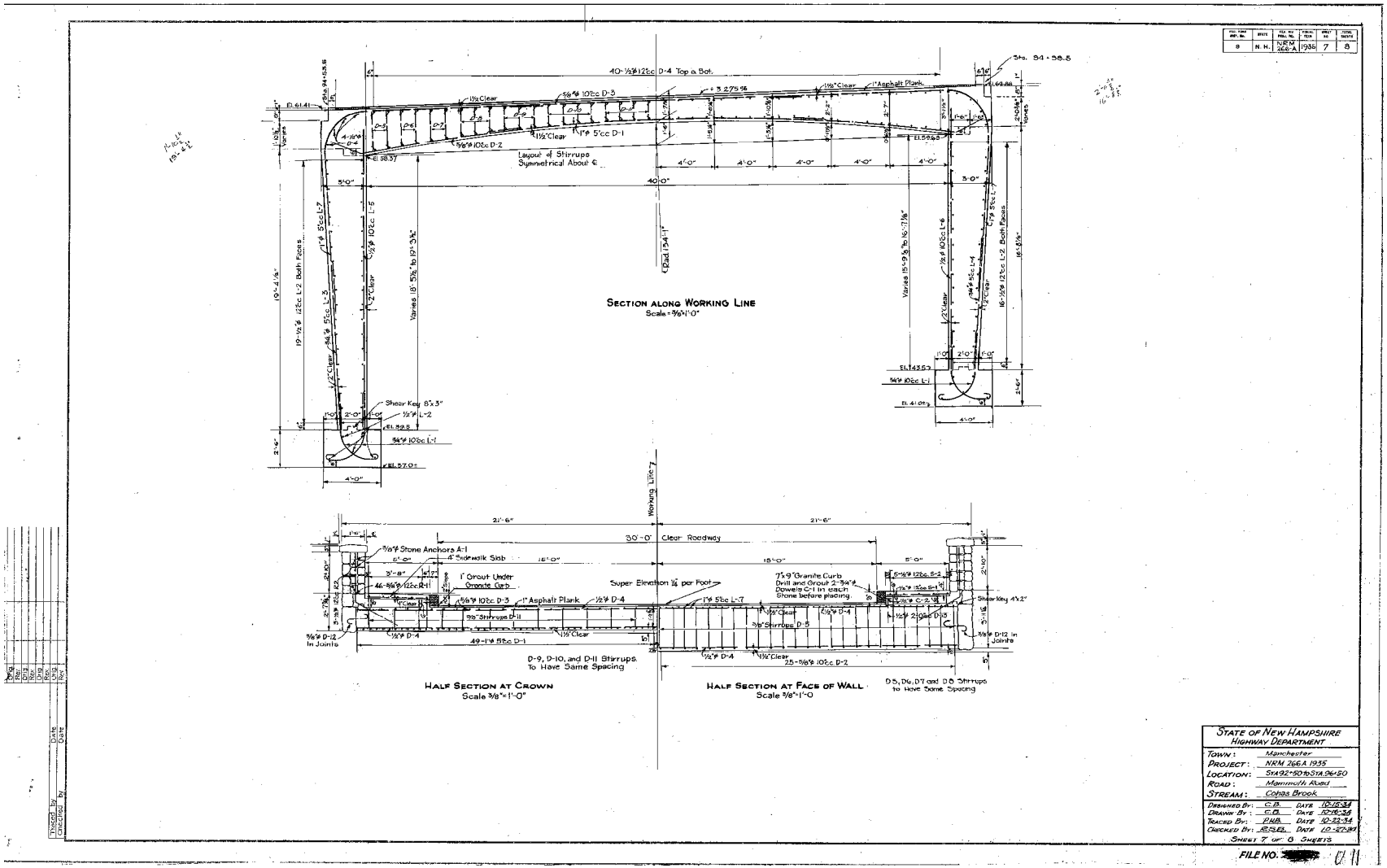
A-6) Bridge No. 170/159, Woodstock, NH Route 112 over Pemigewasset River, Sheet 2 of 4, 1934. NHDOT Bridge Design.



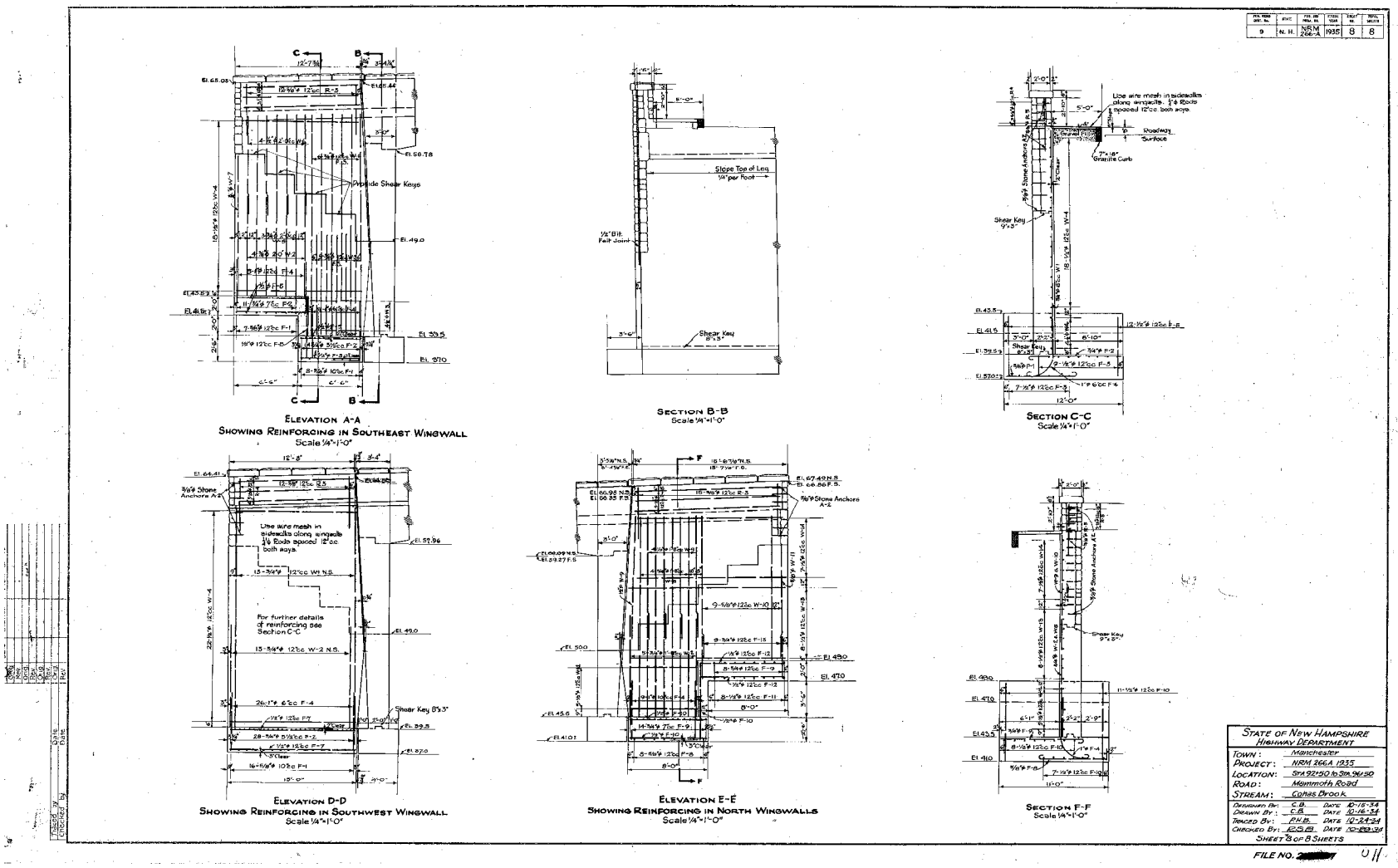
A-7) Bridge No. 170/159, Woodstock, NH Route 112 over Pemigewasset River, Sheet 3 of 4, 1934, showing design without stone facing (not built). NHDOT Bridge Design.



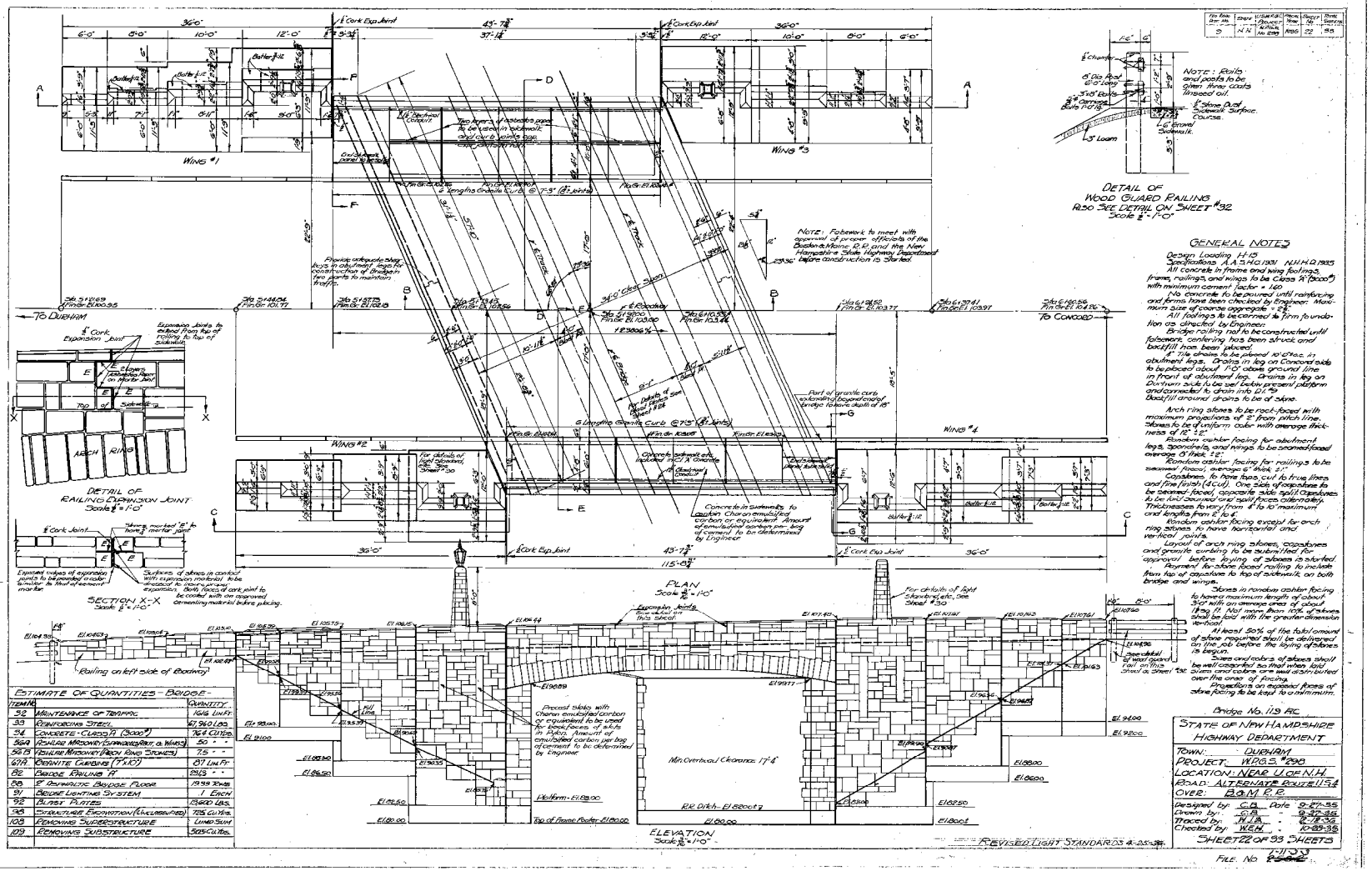
A-8) Bridge No. 176/119, Manchester NH Route 28A over Cohas Brook, Sheet 6 of 8, 1934. NHDOT Bridge Design.



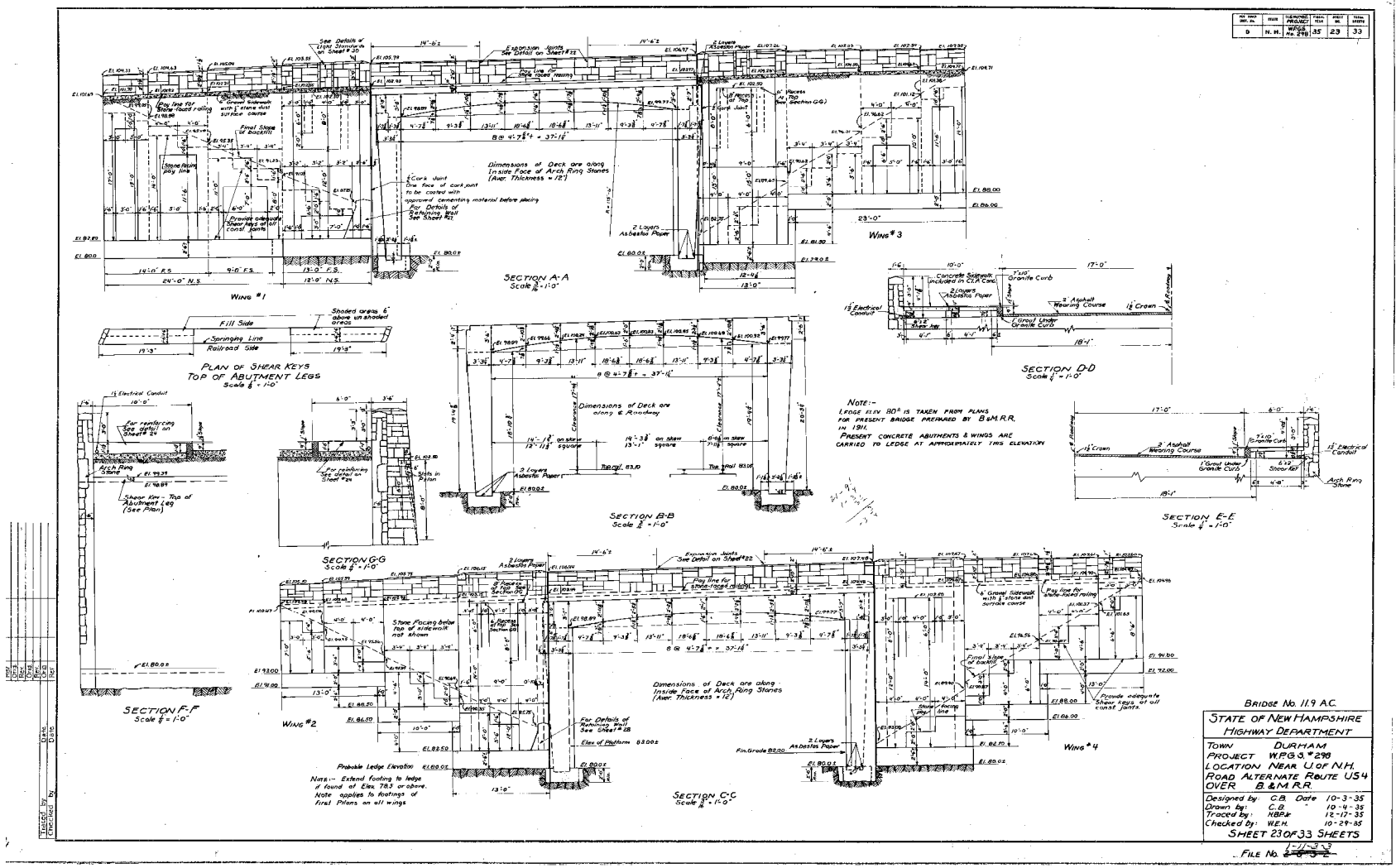
A-9) Bridge No. 176/119, Manchester NH Route 28A over Cohas Brook, Sheet 7 of 8, 1934. NHDOT Bridge Design.



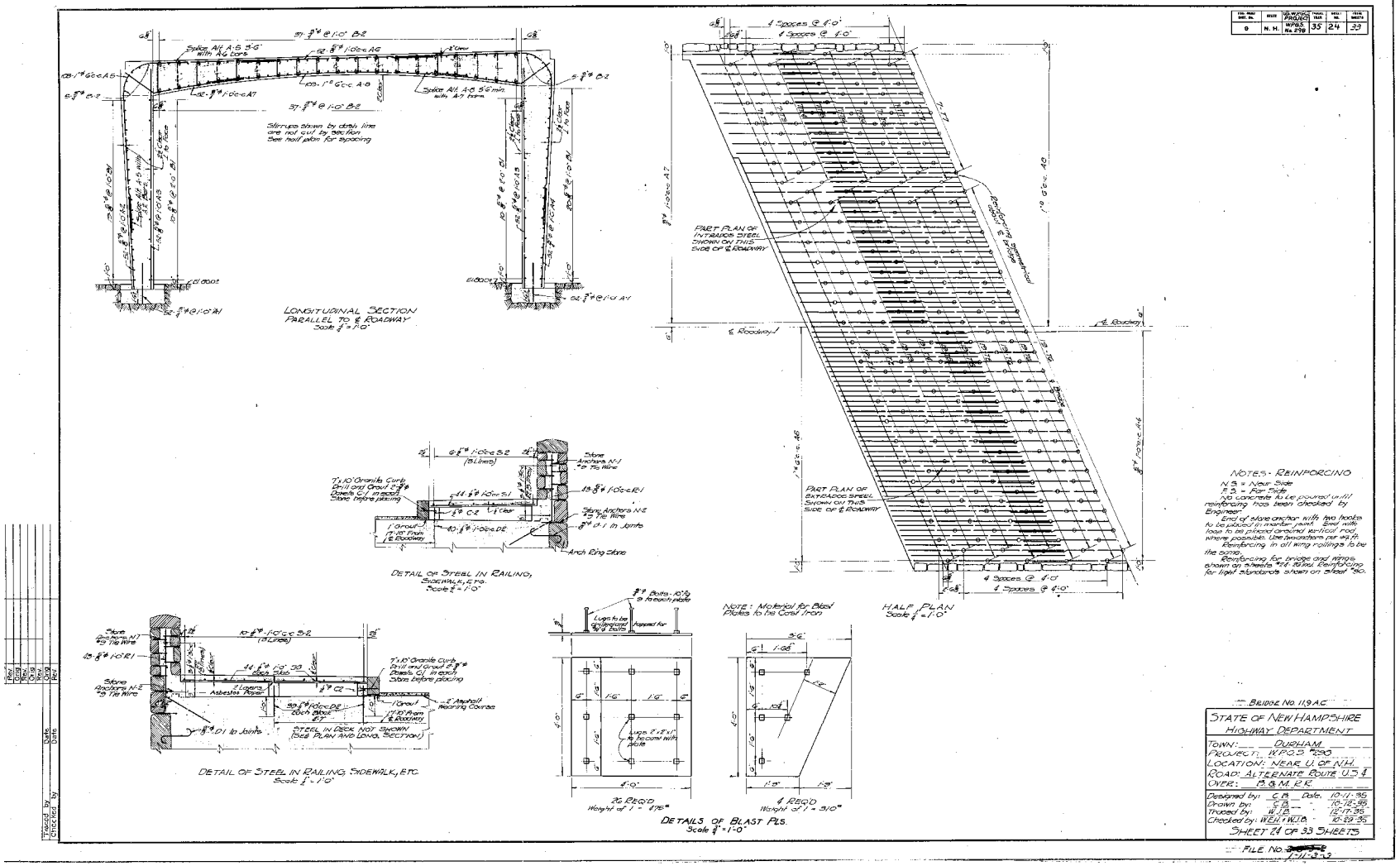
A-10) Bridge No. 176/119, Manchester NH Route 28A over Cohas Brook, Sheet 8 of 8, 1934. NHDOT Bridge Design.



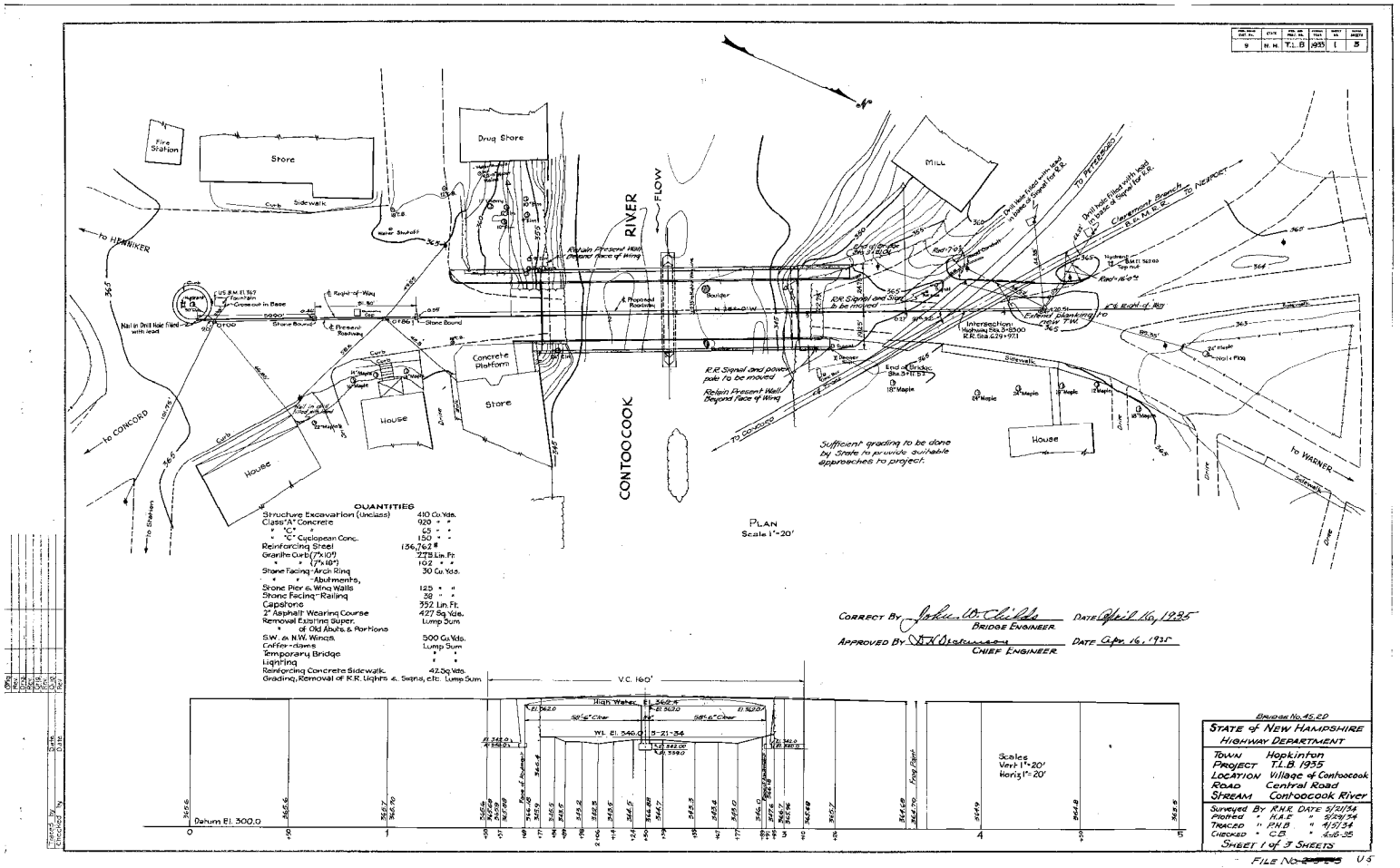
A-11) Bridge No. 095/121, Durham Old US Route 4 over B&M RR, Sheet 22 of 33, 1935. NHDOT Bridge Design.



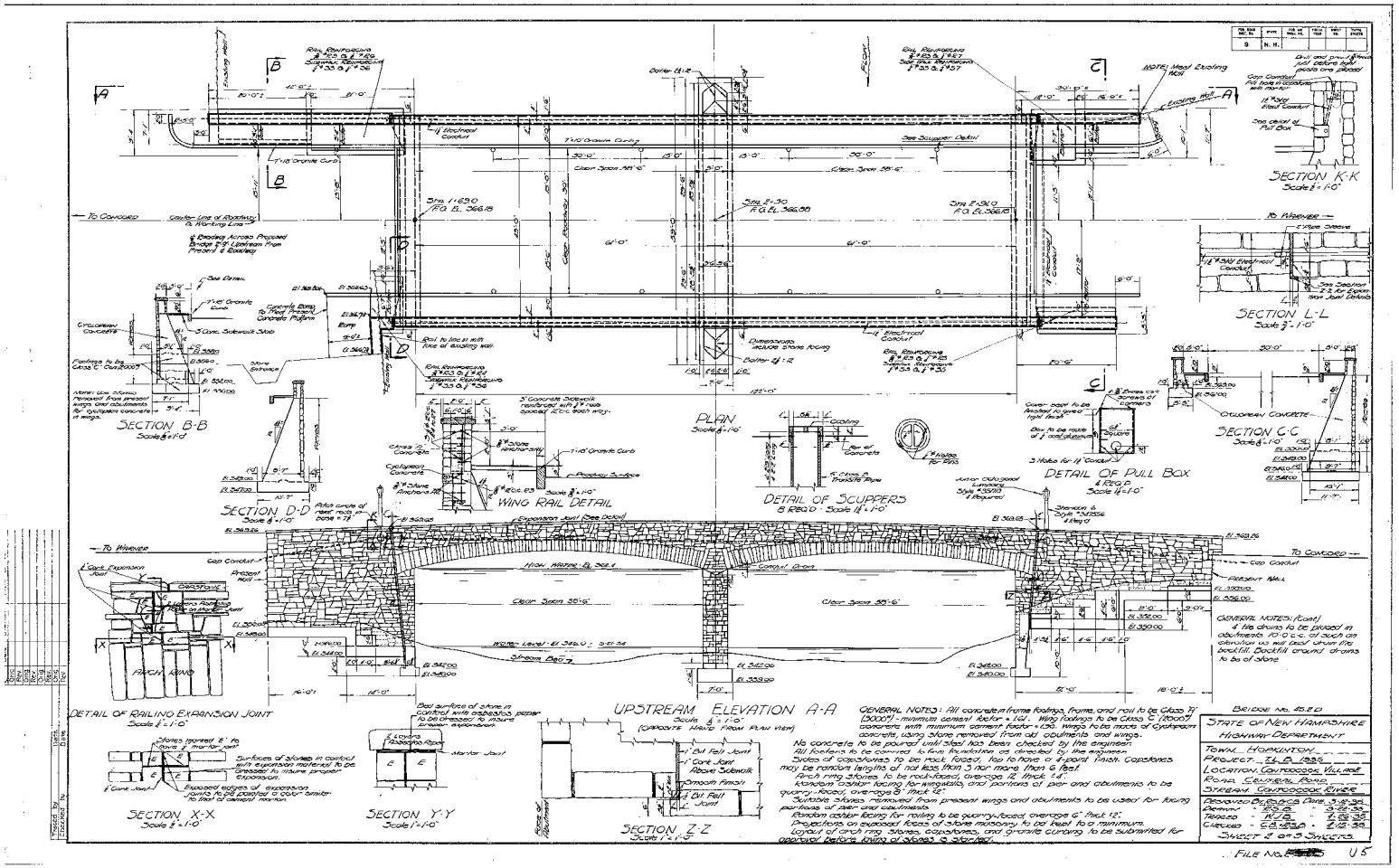
A-12) Bridge No. 095/121, Durham Old US Route 4 over B&M RR, Sheet 23 of 33, 1935. NHDOT Bridge Design.



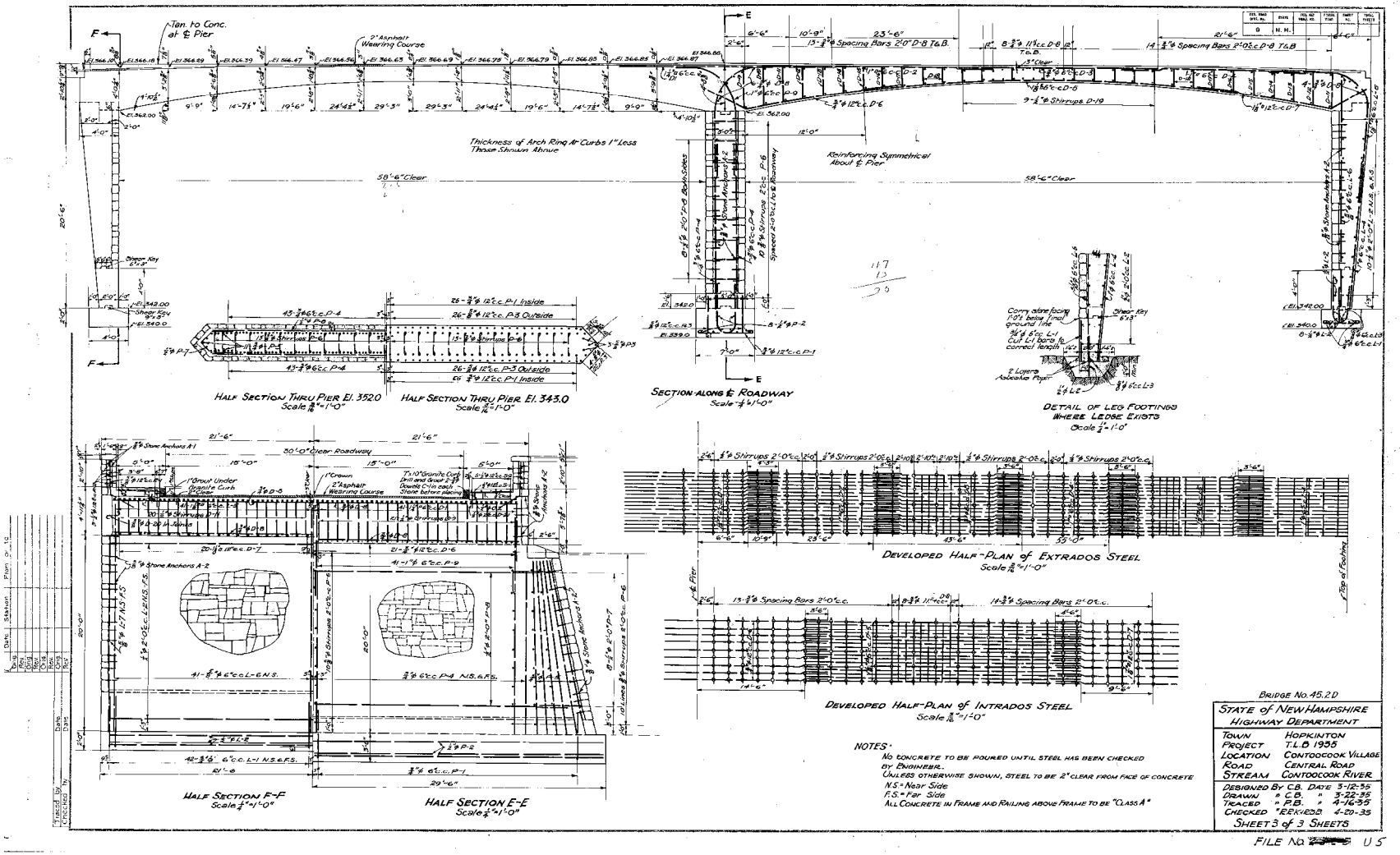
A-13) Bridge No. 095/121, Durham Old US Route 4 over B&M RR, Sheet 24 of 33, 1935. NHDOT Bridge Design.



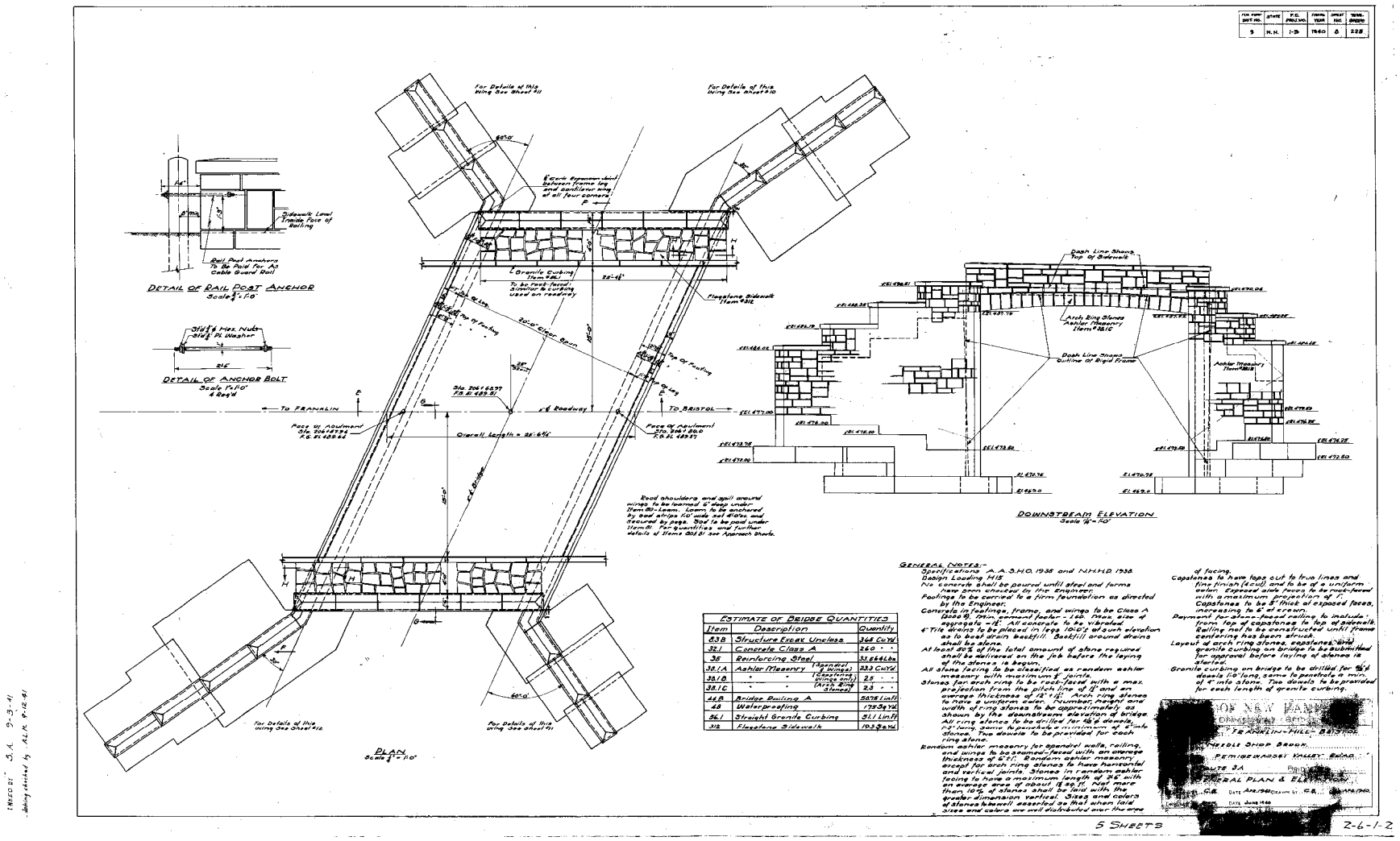
A-14) Bridge No. 102/143, Hopkinton, Leroy R. Kimball Bridge, NH Route 103/NH Route 127 over Contoocook River, Sheet 1 of 3, 1934-35. NHDOT Bridge Design.



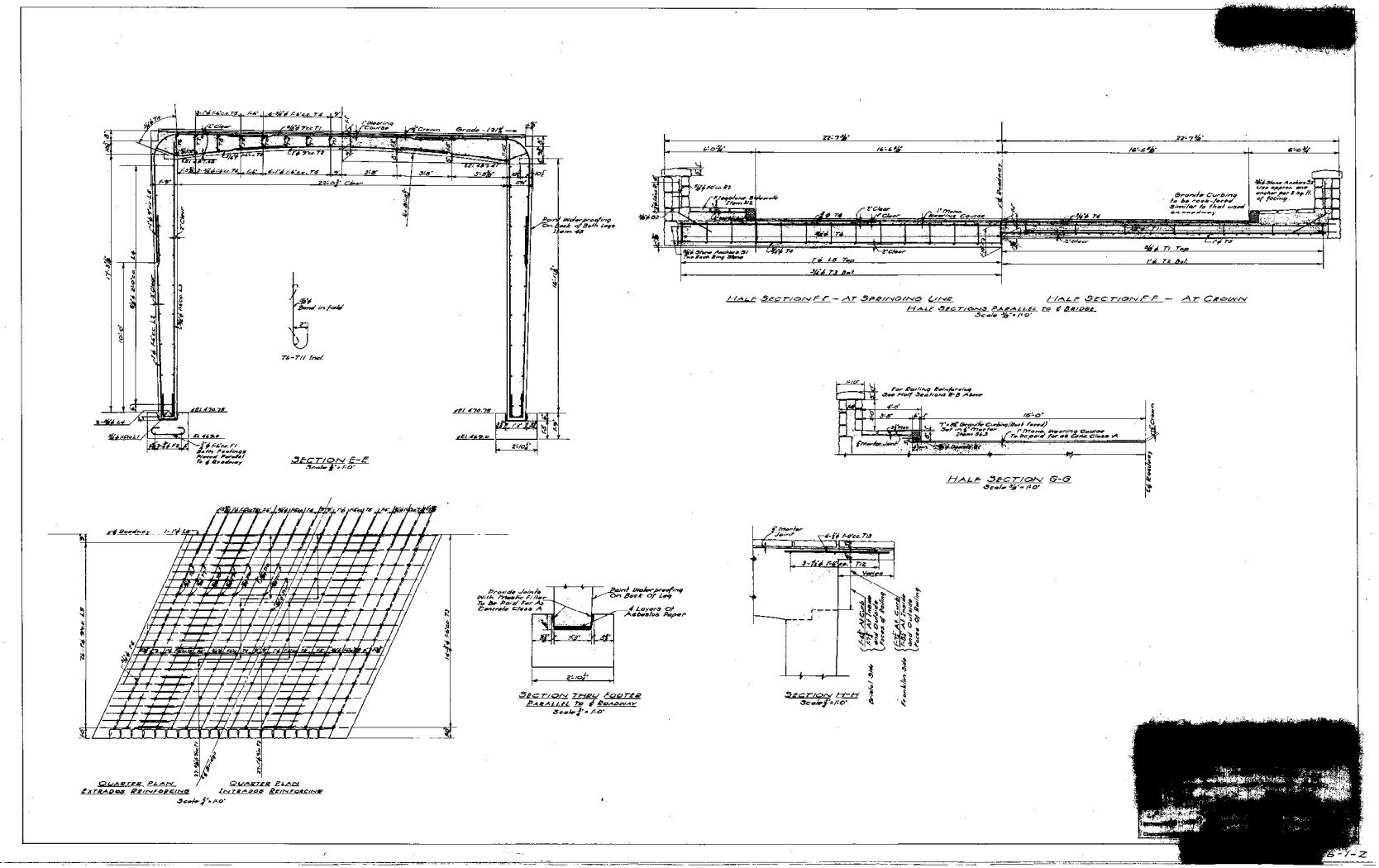
A-15) Bridge No. 102/143, Hopkinton, Leroy R. Kimball Bridge, NH Route 103/NH Route 127 over Contoocook River, Sheet 2 of 3, 1934-35. NHDOT Bridge Design.



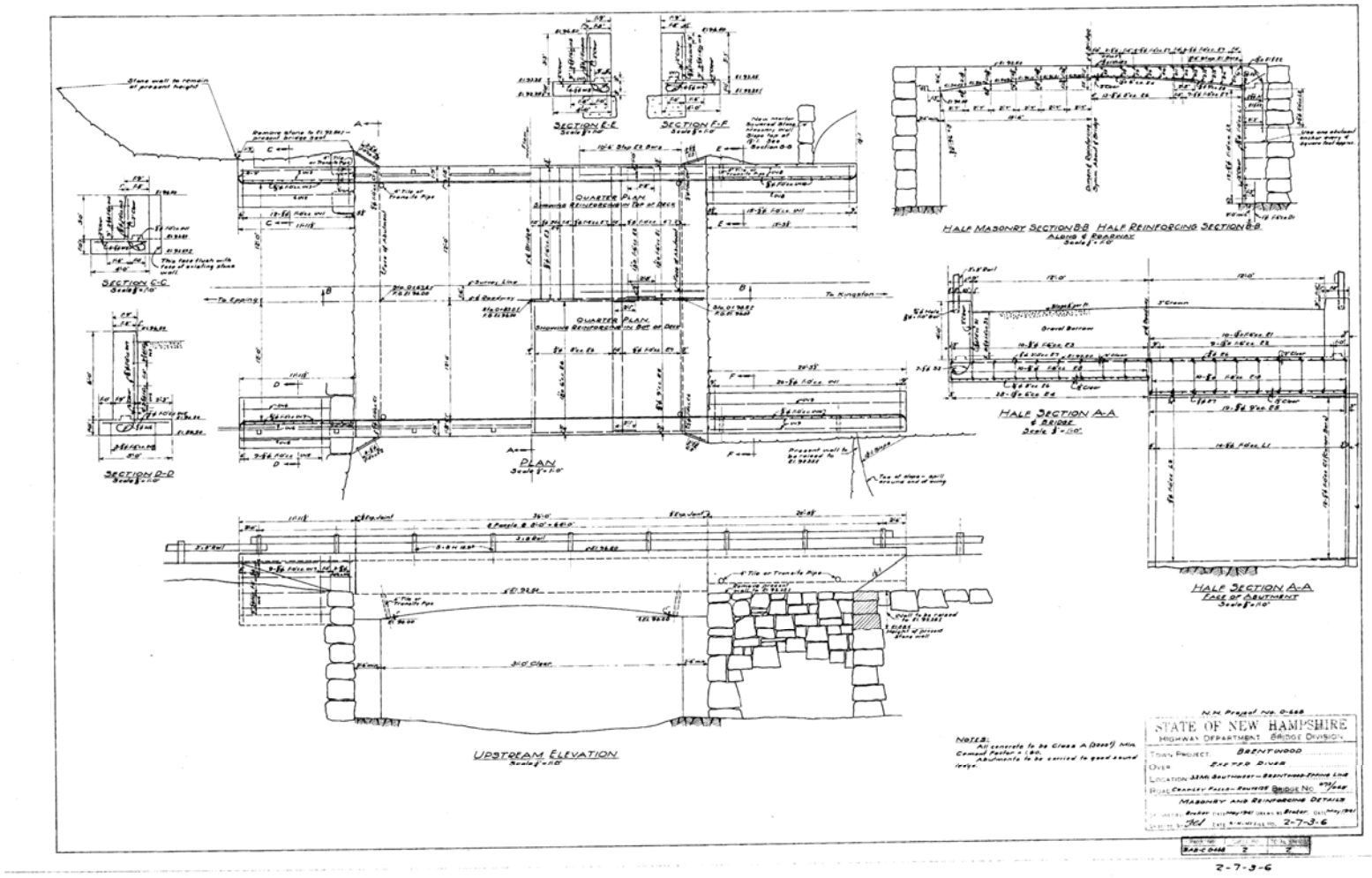
A-16) Bridge No. 102/143, Hopkinton, Leroy R. Kimball Bridge, NH Route 103/NH Route 127 over Contoocook River, Sheet 3of 3, 1934-35. NHDOT Bridge Design.



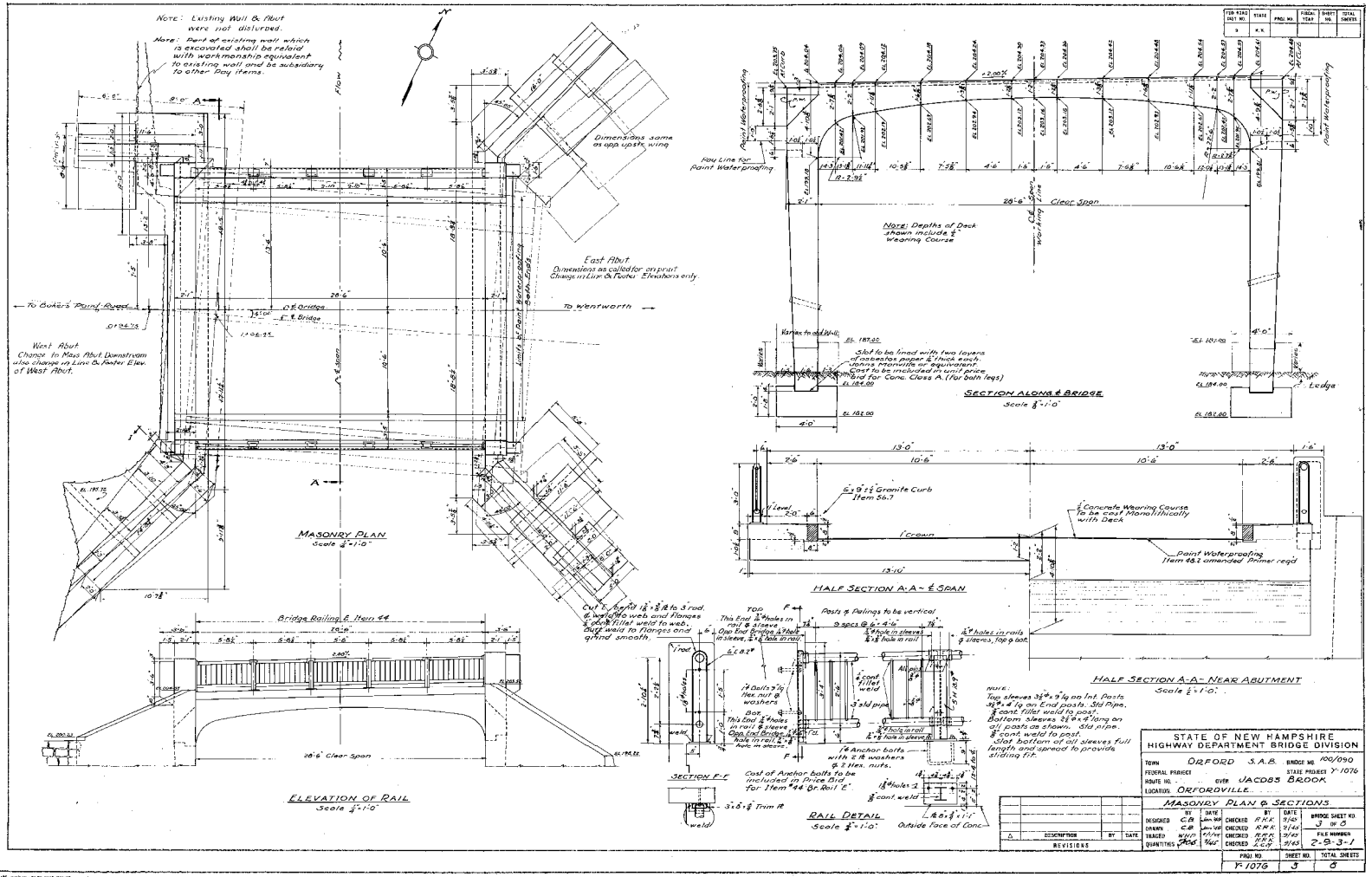
A-17) Bridge No. 157/108, Hill, NH Route 3A over Needle Shop Brook, 1 of 5 sheets, 1940. NHDOT Bridge Design.



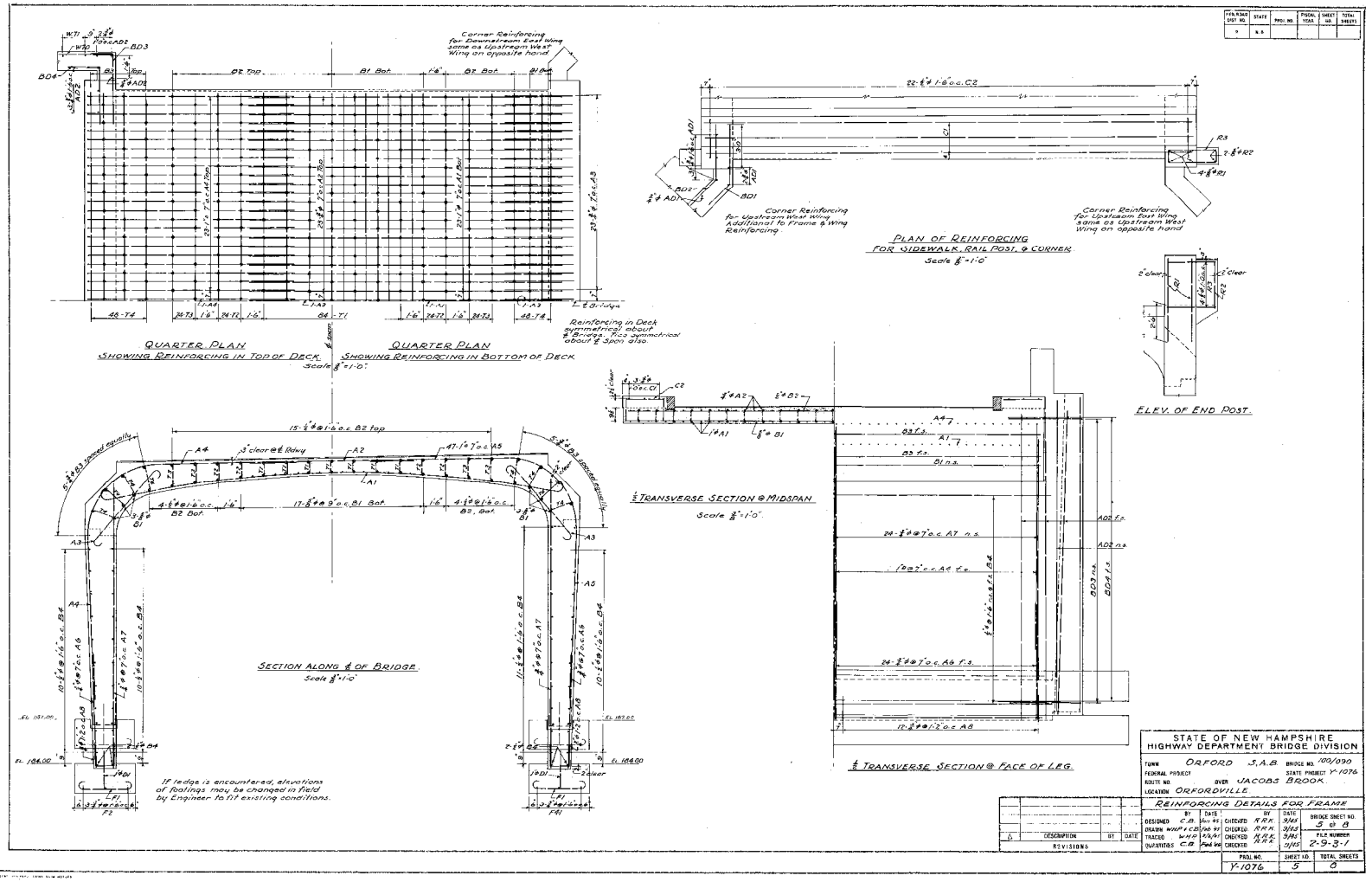
A-18) Bridge No. 157/108, Hill, NH Route 3A over Needle Shop Brook, 2 of 5 sheets, 1940. NHDOT Bridge Design.



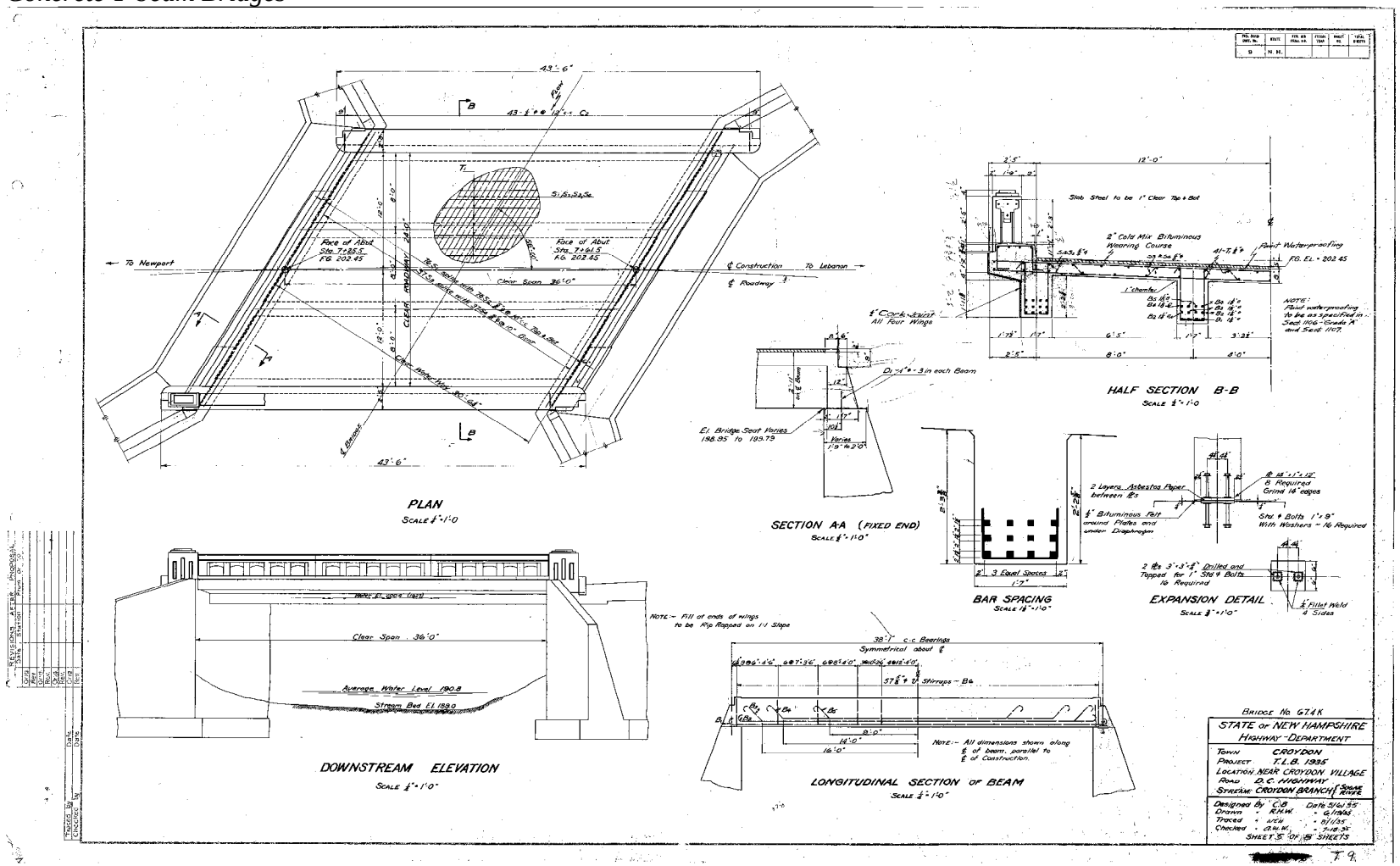
A-19) Bridge No. 073/065, Brentwood, Crawley Falls Road over Exeter River, 2 of 2 sheets, 1941. NHDOT Bridge Design.



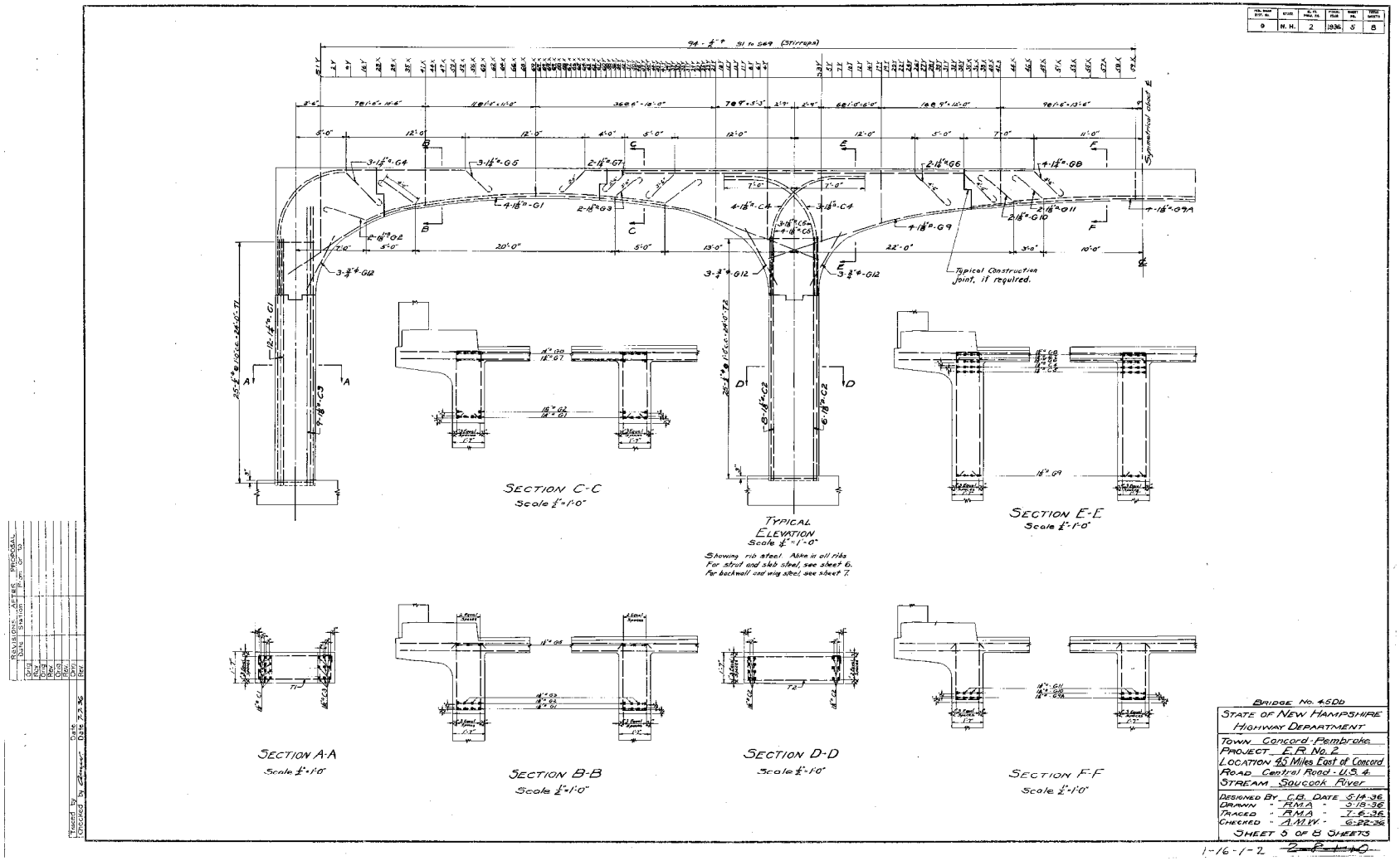
A-20) Bridge No. 100/090, Orford, Dame Hill Road over Jacobs Brook, 3of 8 sheets, designed 1945, built 1947. NHDOT Bridge Design.



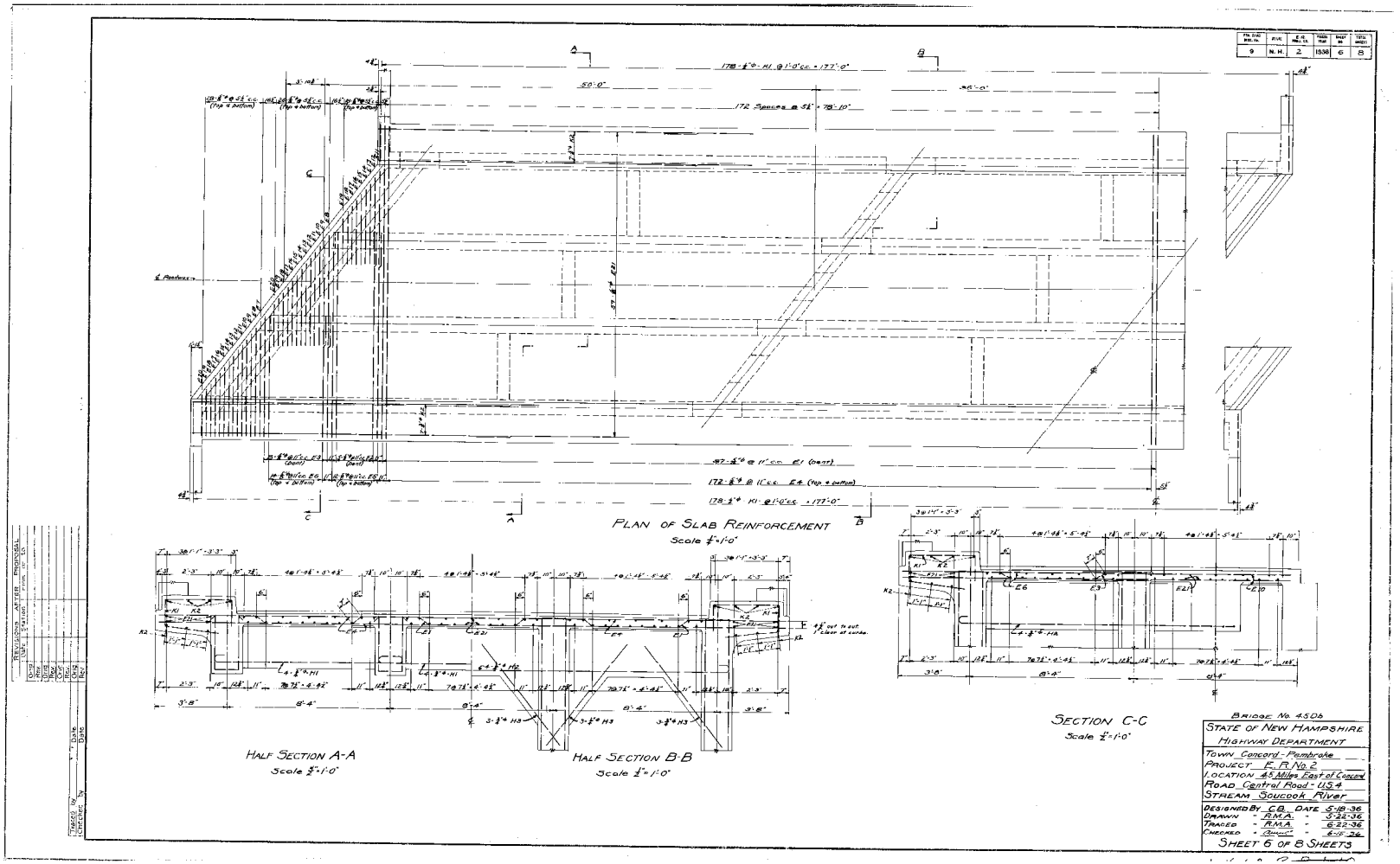
A-21) Bridge No. 100/090, Orford, Dame Hill Road over Jacobs Brook, 5of 8 sheets, designed 1945, built 1947. NHDOT Bridge Design.



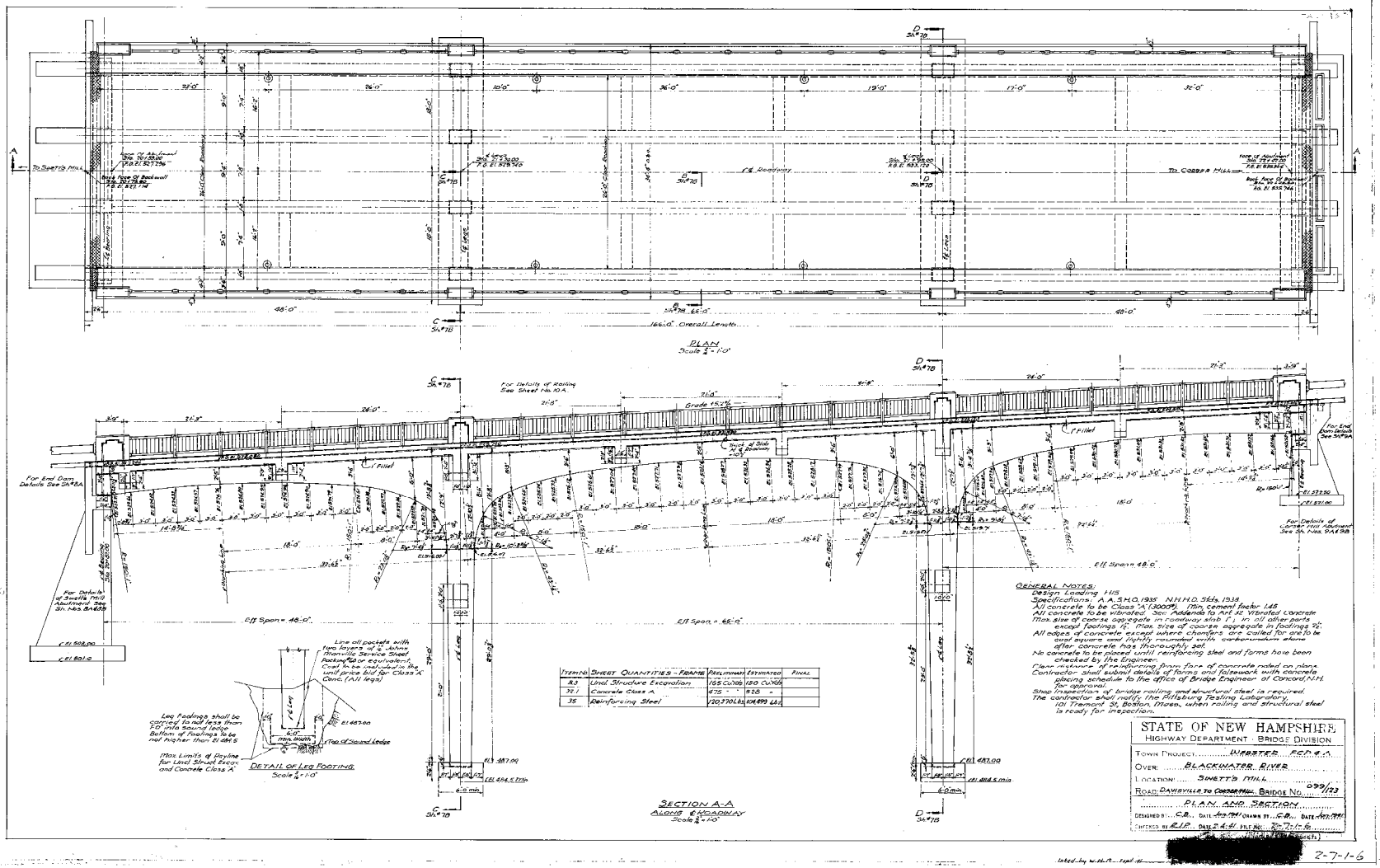
A-22) Bridge No. 146/124, Croydon, NH Route 10 over Croydon Branch of Sugar River, Sheet 5 of 8, 1935, built 1936. NHDOT Bridge Design.



A-23) Bridge No. 160/188, Concord-Pembroke, NH Route 9 over Soucook River, Sheet 5 of 8, 1936. NHDOT Bridge Design.

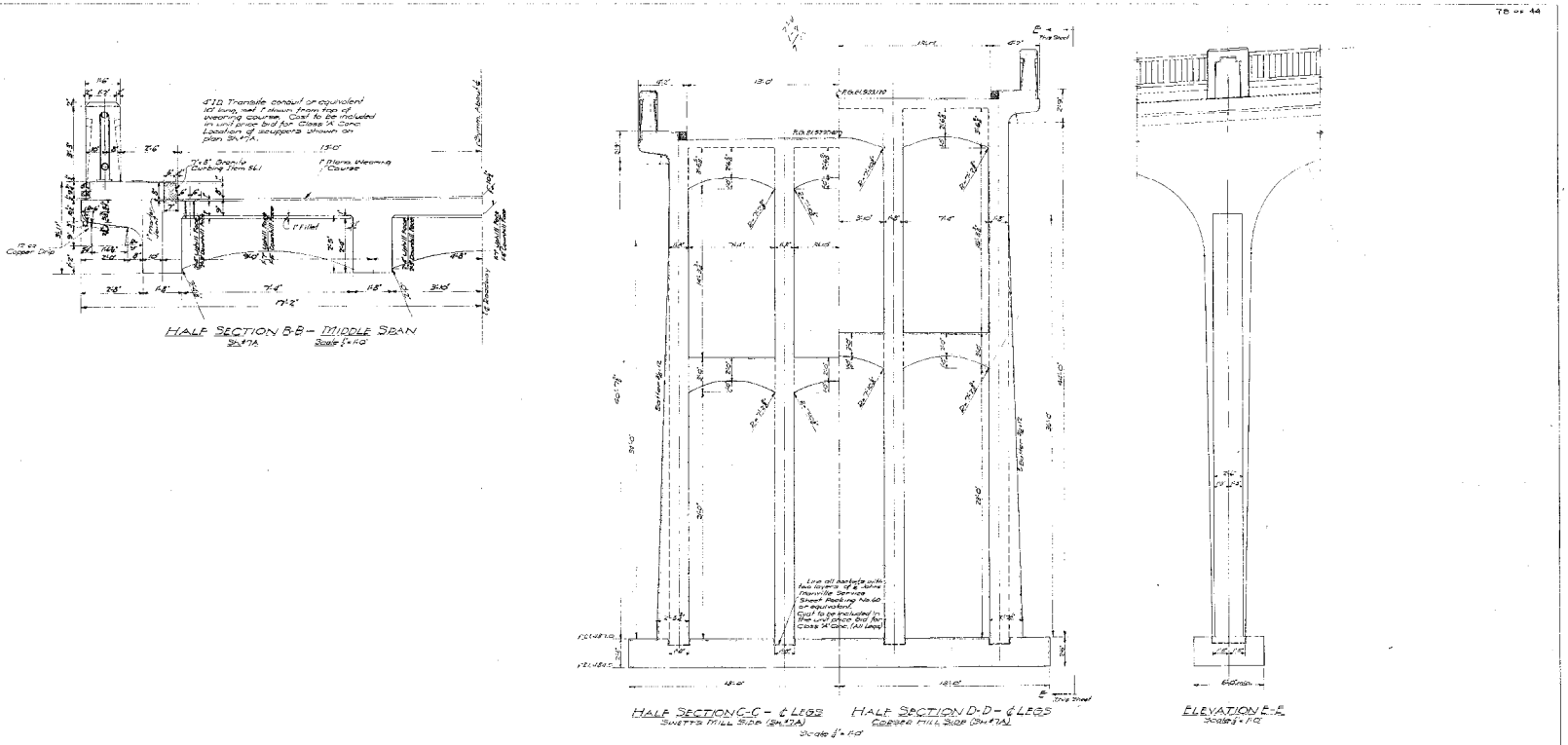


A-24) Bridge No. 160/188, Concord-Pembroke, NH Route 9 over Soucook River, Sheet 6 of 8, 1936. NHDOT Bridge Design.

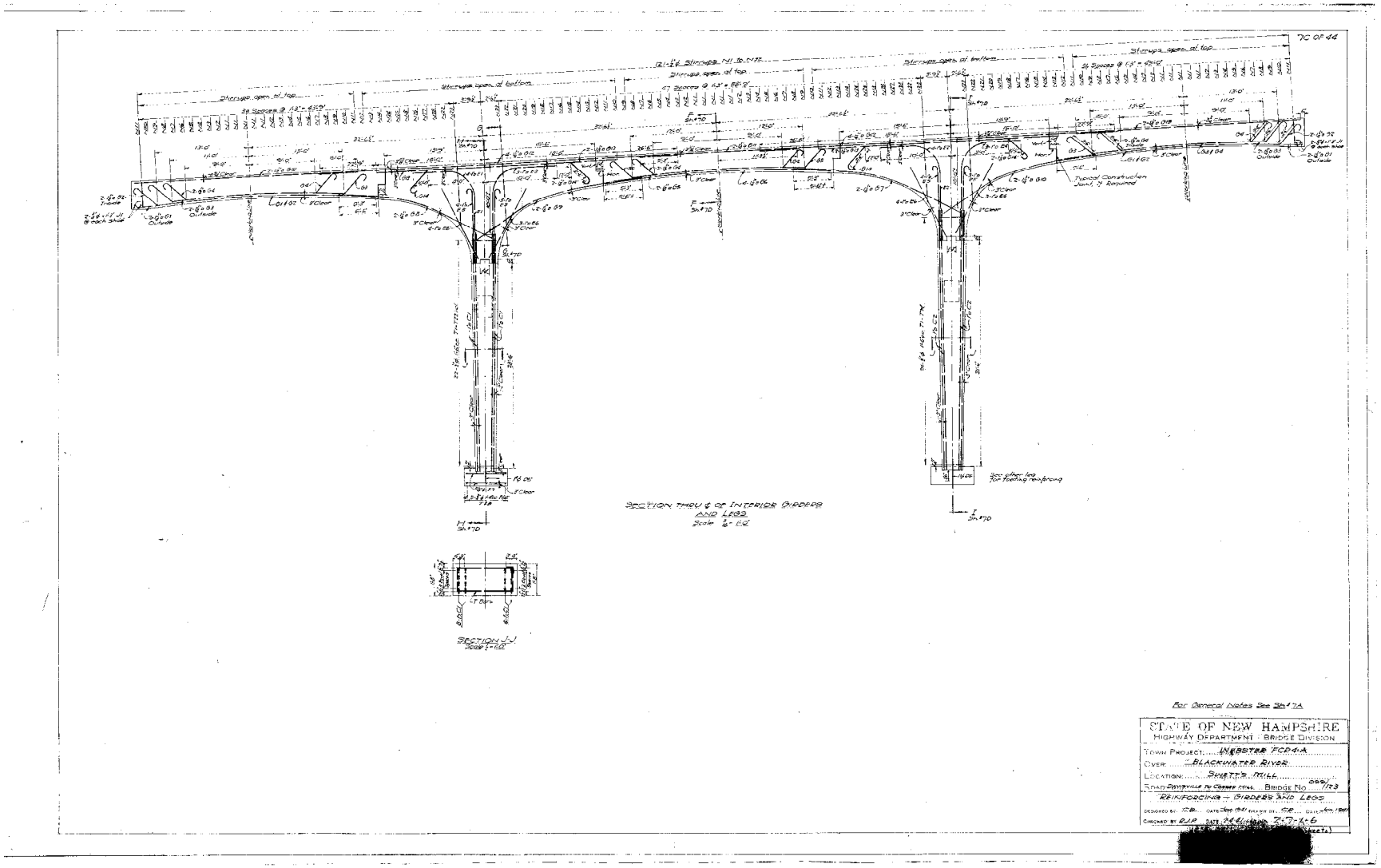


ITEM NO	SHEET QUANTITIES - FRAME	PRELIMINARY	ESTIMATED	FINAL
83	Und. Structure Excavation	165 CU YDS	180 CU YDS	
91	Concrete Class A	475 "	938 "	
35	Reinforcing Steel	70,370 LBS	104,499 LBS	

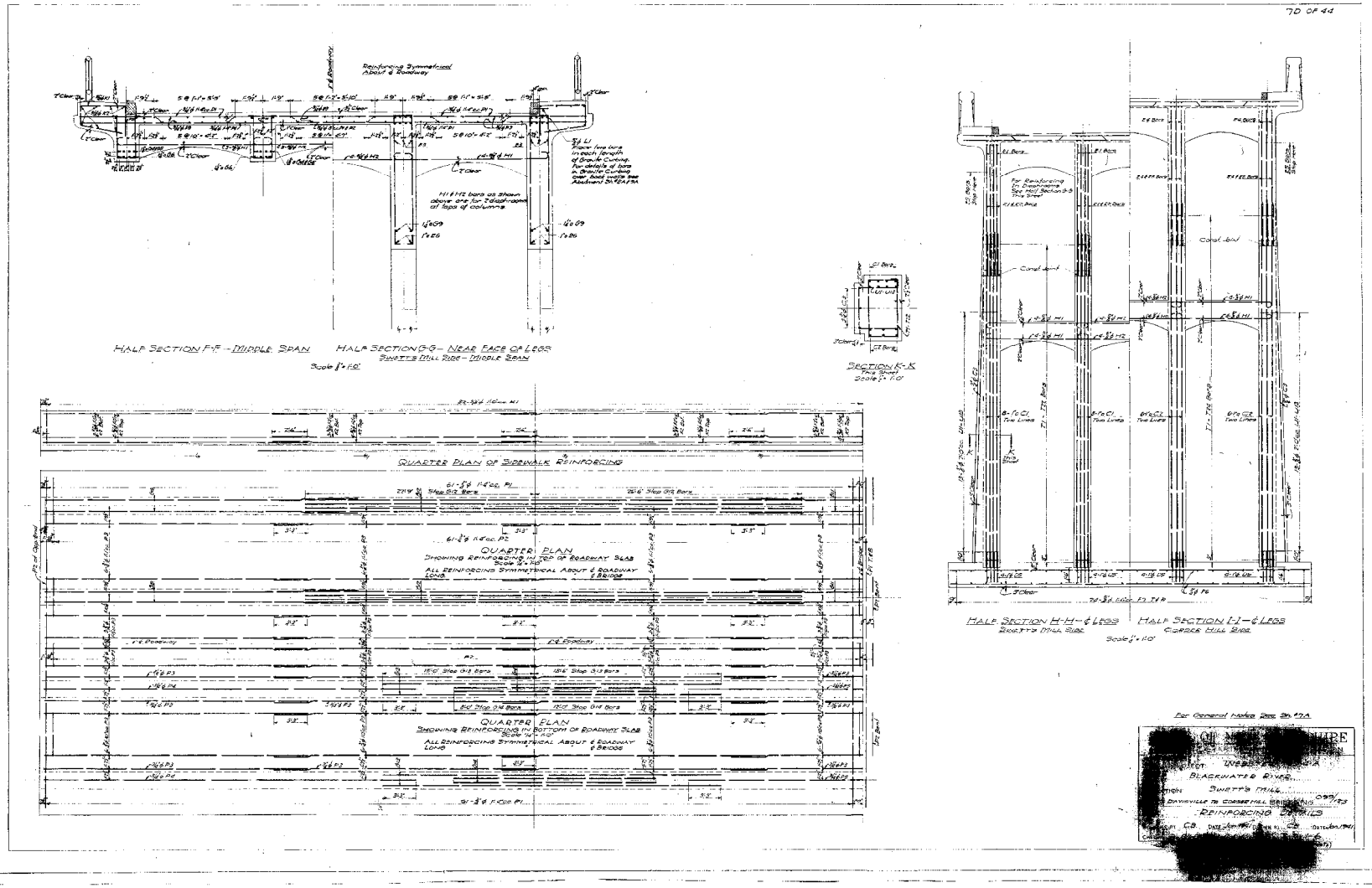
A-25) Bridge No. 093/173, Webster, NH Route 127 over Blackwater River, Sheet 7A, 1940-1941. NHDOT Bridge Design.



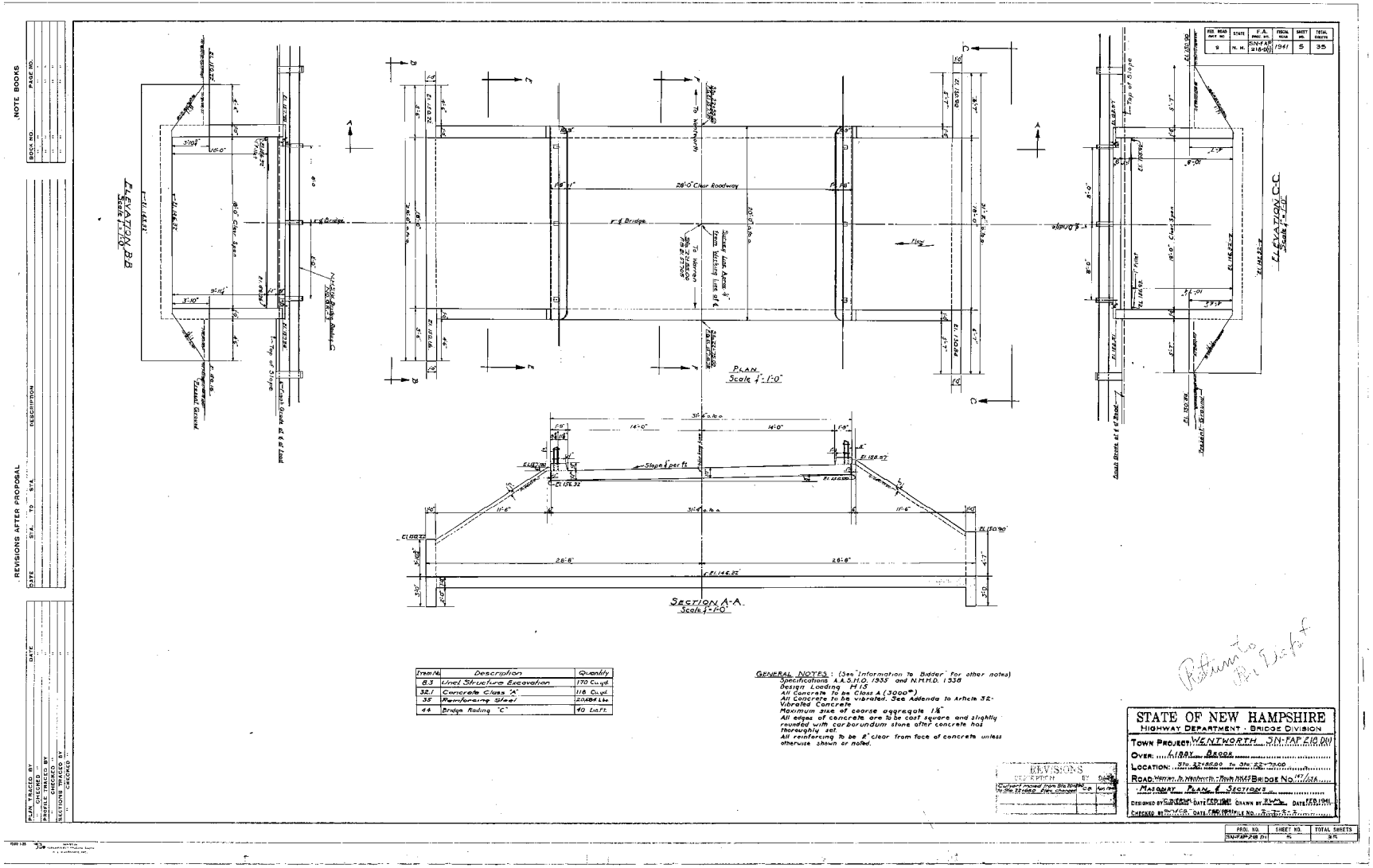
A-26) Bridge No. 099/123, Webster, NH Route 127 over Blackwater River, Sheet 7B, 1940-1941. NHDOT Bridge Design.



A-27) Bridge No. 099/123, Webster, NH Route 127 over Blackwater River, Sheet 7C, 1940-1941. NHDOT Bridge Design.



A-28) Bridge No. 099/123, Webster, NH Route 127 over Blackwater River, Sheet 7D, 1940-1941. NHDOT Bridge Design.

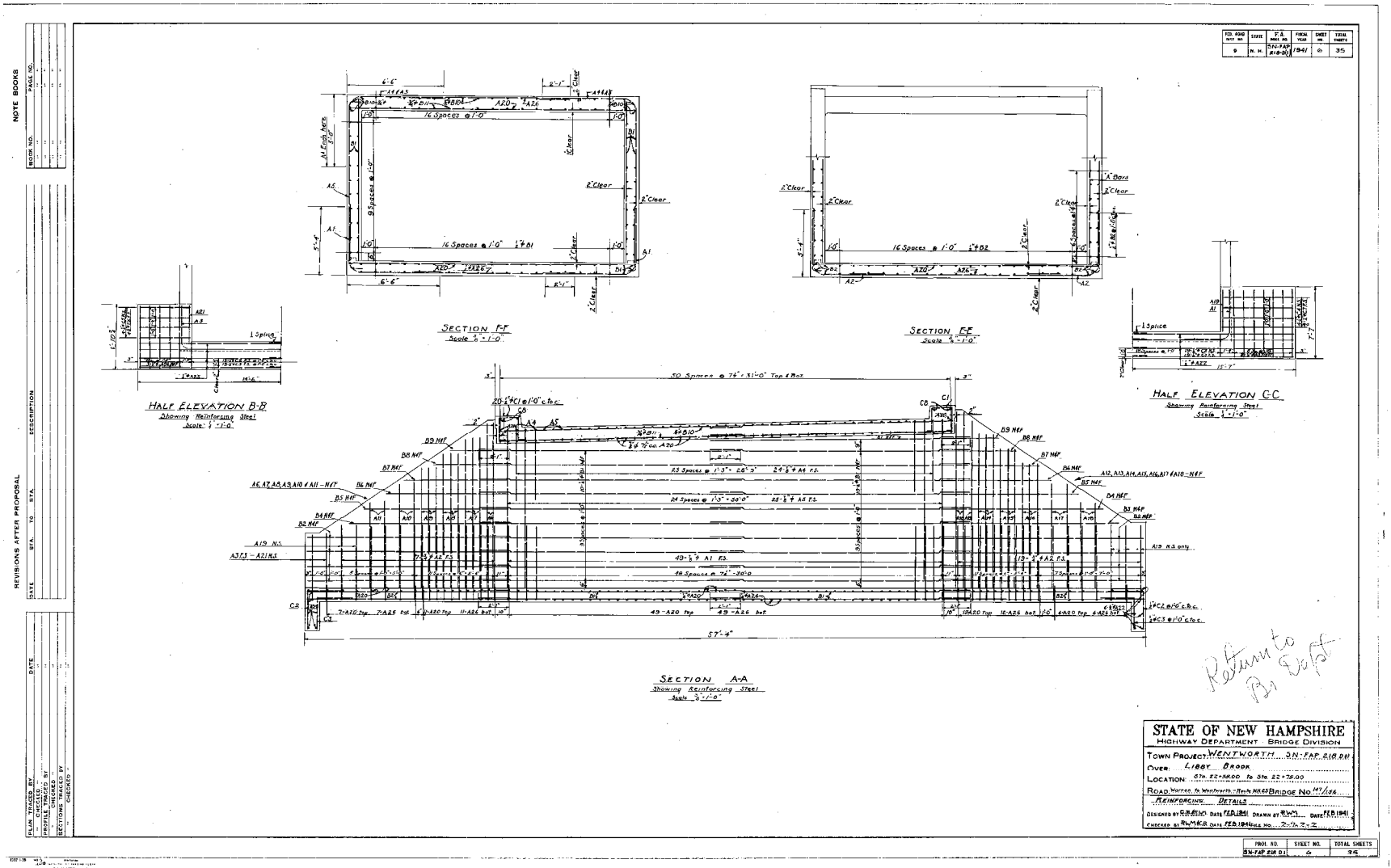


Item No.	Description	Quantity
8.3	Lineal Structure Excavation	170 Cu.yd.
32.1	Concrete Class 'A'	118 Cu.yd.
35	Reinforcing Steel	20,684 Lbs.
44	Bridge Railing 'C'	90 Lin.ft.

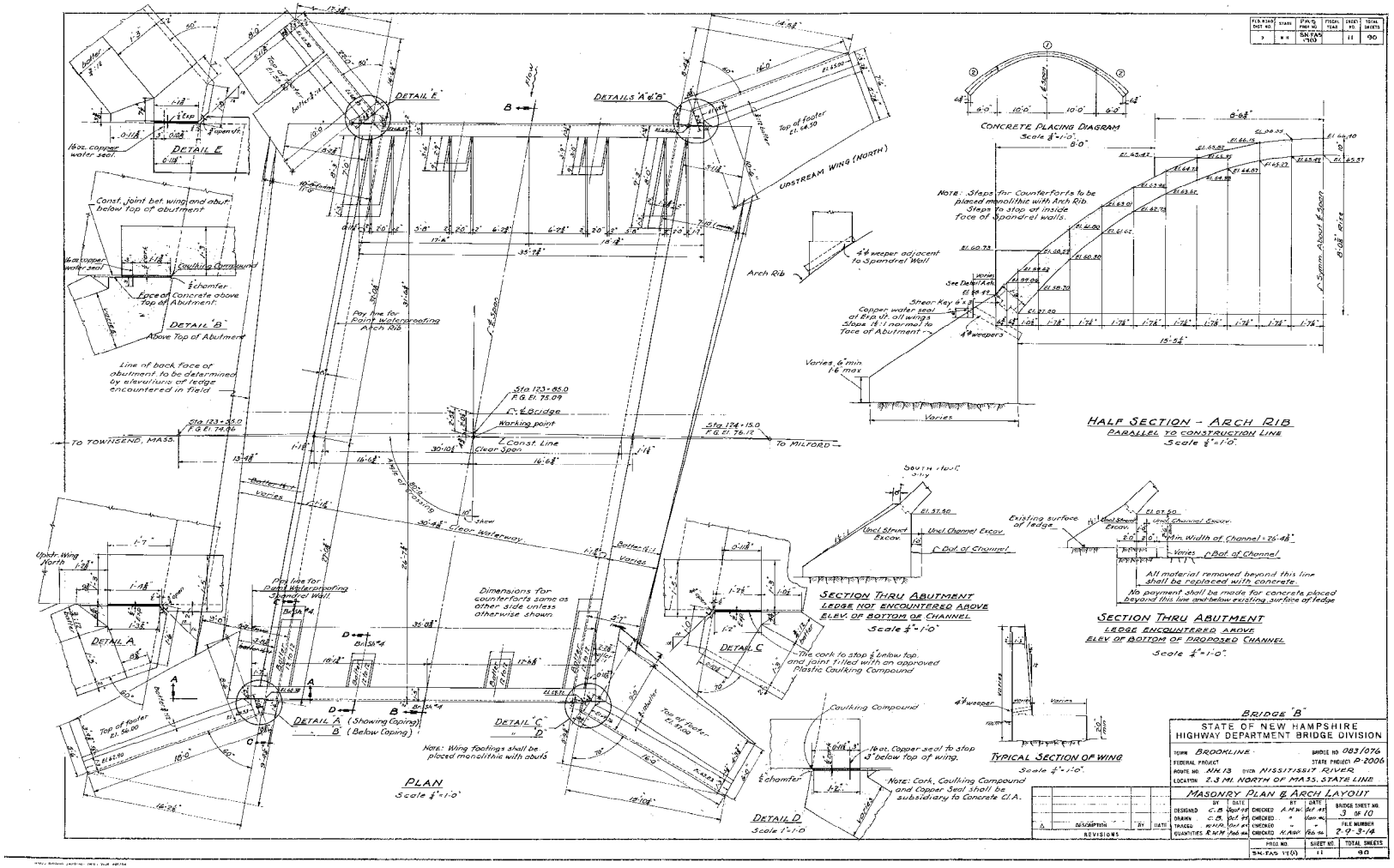
GENERAL NOTES: (See "Information To Bidder" for other notes)
Specifications A.A.S.H.O. 1935 and N.H.H.D. 1938
Design Loading H 15
All Concrete to be Class A (3000#)
All Concrete to be vibrated. See Addenda to Article 32-Vibrated Concrete
Maximum size of coarse aggregate 1½"
All edges of concrete are to be cast square and slightly rounded with carborundum stone after concrete has thoroughly set.
All reinforcing to be 2" clear from face of concrete unless otherwise shown or noted.

Return to R. Bisbee

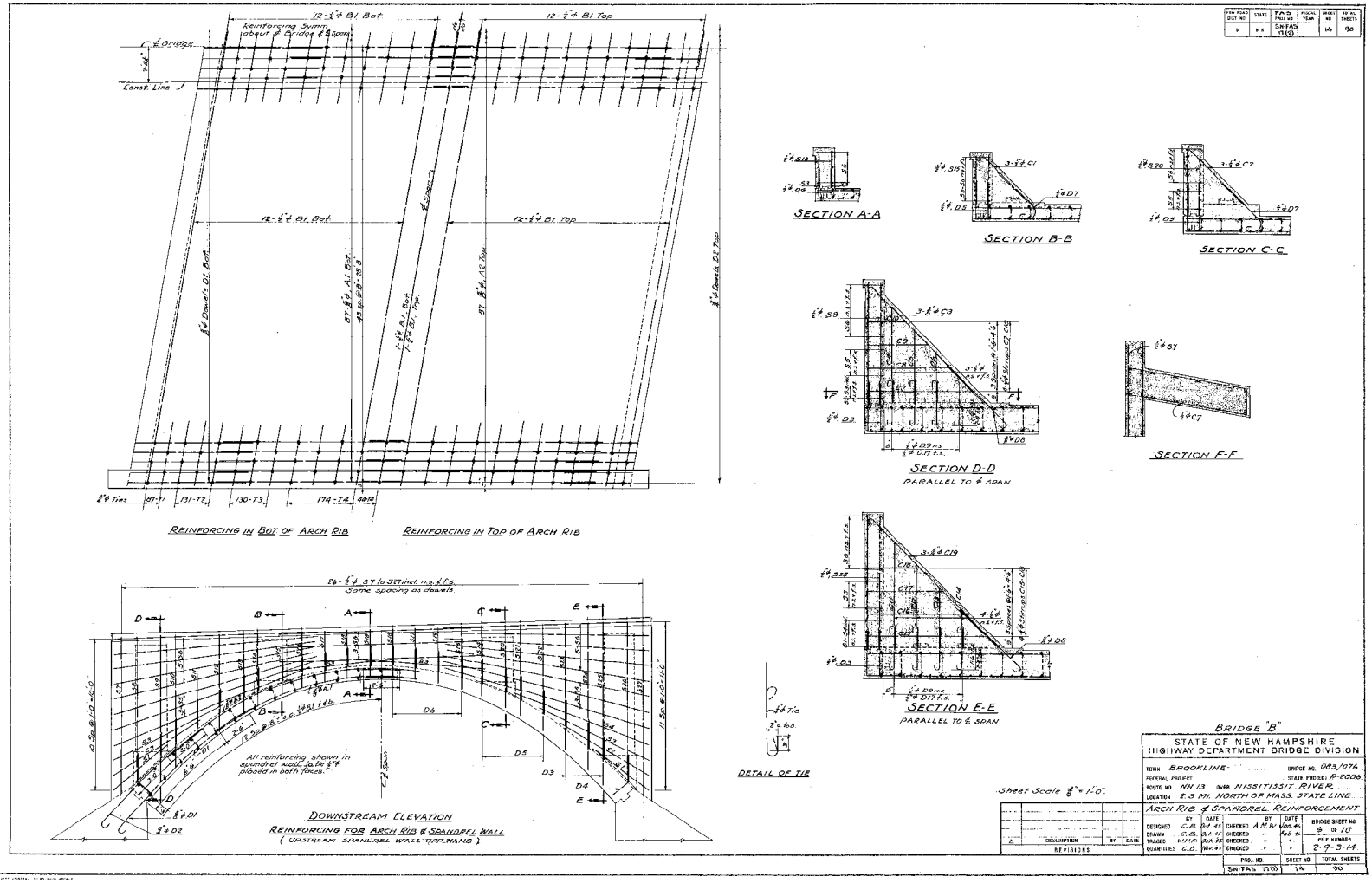
A-29) Bridge No. 147/136, Wentworth, NH Route 25 over Libby Brook, 1941. NHDOT Bridge Design.



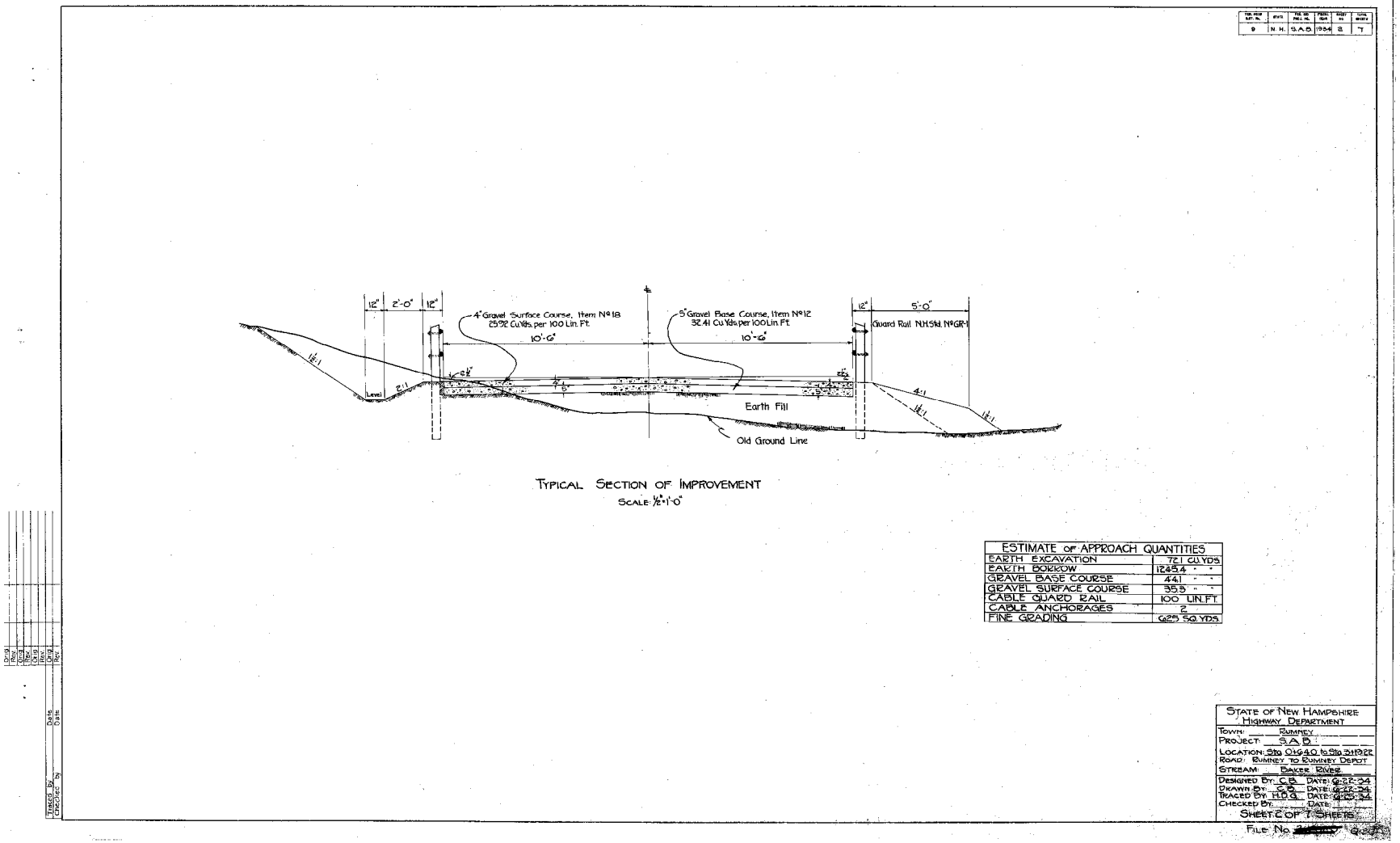
A-30) Bridge No. 147/136, Wentworth, NH Route 25 over Libby Brook, 1941. NHDOT Bridge Design.



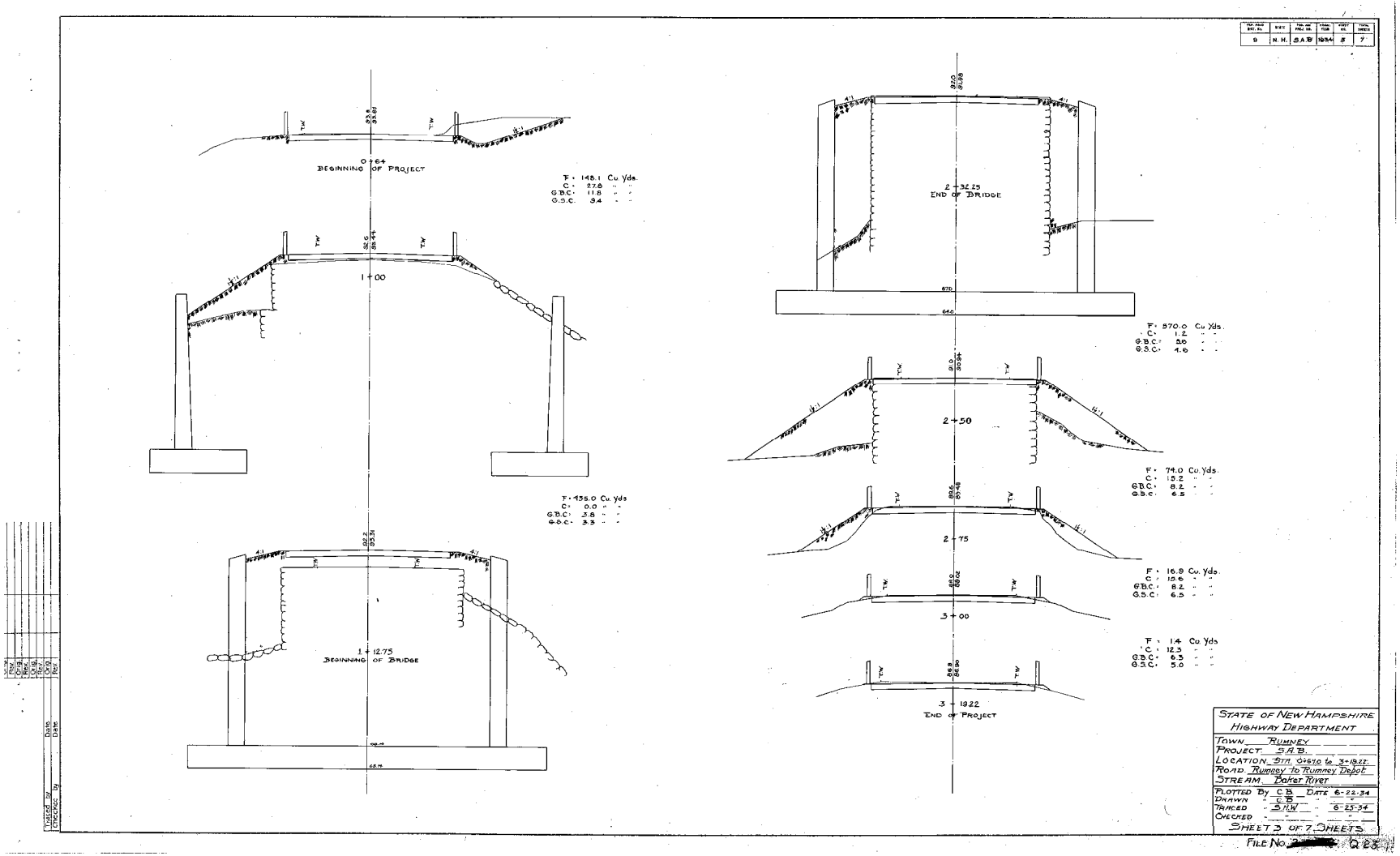
A-31) Bridge No. 083/076, Brookline, NH Route 13 over Nissitissit River, masonry plan and arch layout, designed 1945, built 1946. NHDOT Bridge Design.



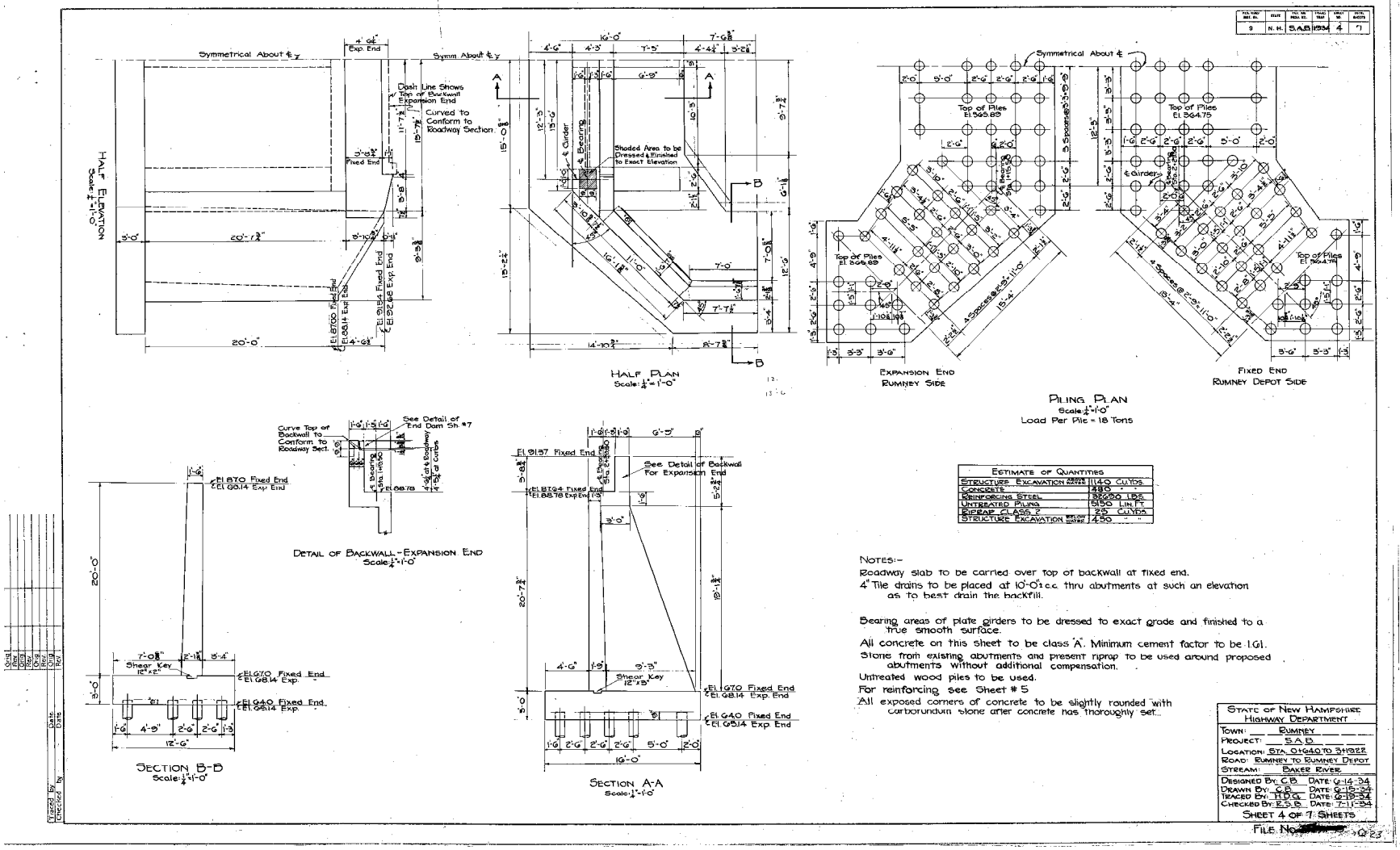
A-32) Bridge No. 083/076, Brookline, NH Route 13 over Nissitissit River, arch rib and spandrel reinforcement, designed 1945, built 1946. NHDOT Bridge Design.



A-33) Bridge No. 132/070, Rumney, Main Street over Baker River, Sheet 2 of 7, 1934 (replaced 1998). NHDOT Bridge Design.



A-34) Bridge No. 132/070, Rumney, Main Street over Baker River, Sheet 3 of 7, 1934 (replaced 1998). NHDOT Bridge Design.



ESTIMATE OF QUANTITIES	
STRUCTURE EXCAVATION (CIVIL)	1140 CU YDS.
CONCRETE	430 "
REINFORCING STEEL	32690 LBS.
UNTREATED PILING	6150 LIN FT.
RIPRAP CLASS 2	20 CU YDS.
STRUCTURE EXCAVATION (BELOW WATER)	450 " "

NOTES:-

Roadway slab to be carried over top of backwall at fixed end.

4" Tile drains to be placed at 10'-0" c.c. thru abutments at such an elevation as to best drain the backfill.

Bearing areas of plate girders to be dressed to exact grade and finished to a true smooth surface.

All concrete on this sheet to be class "A". Minimum cement factor to be 1.61.

Stone from existing abutments and present riprap to be used around proposed abutments without additional compensation.

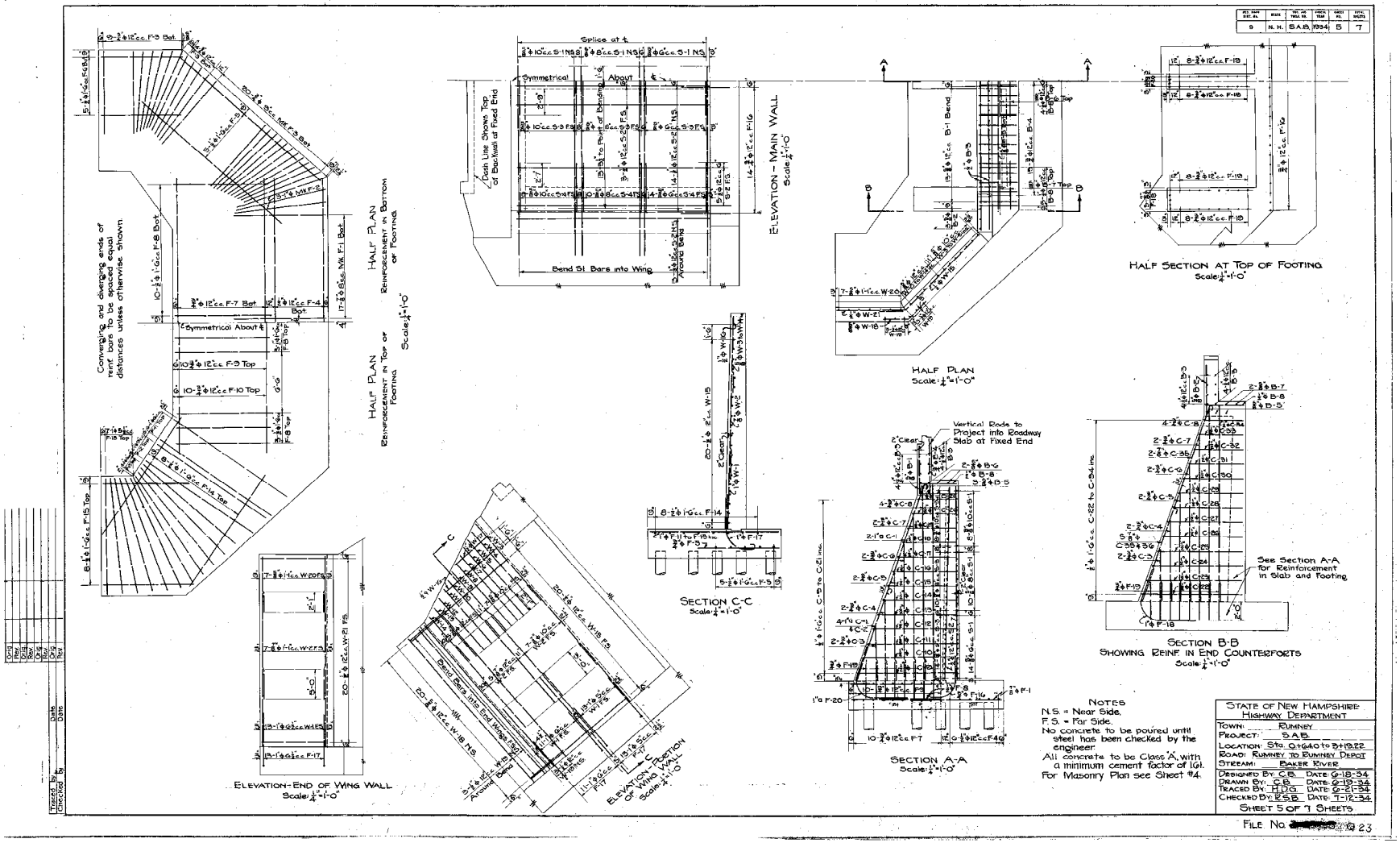
Untreated wood piles to be used.

For reinforcing see Sheet # 5

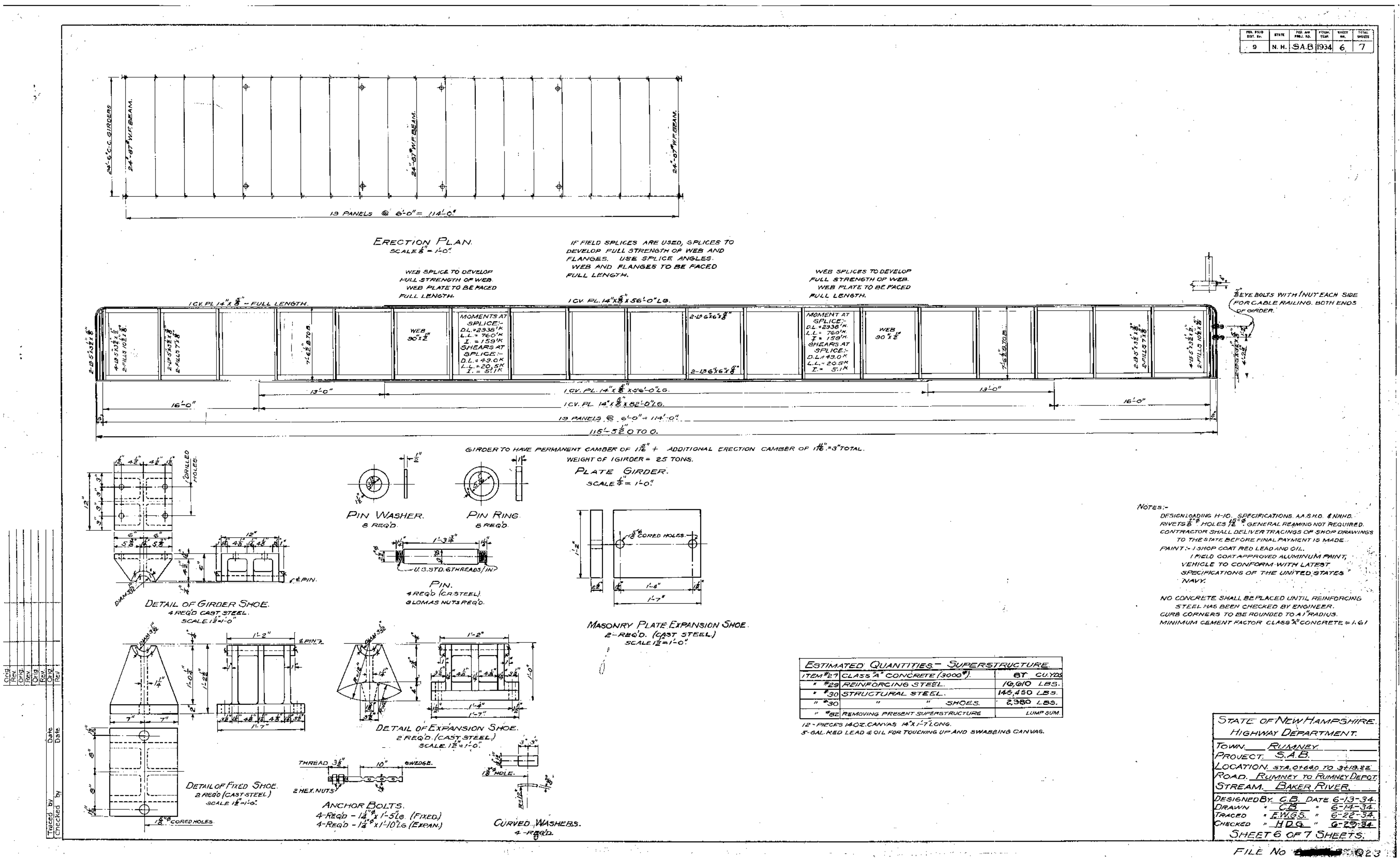
All exposed corners of concrete to be slightly rounded with carborundum stone after concrete has thoroughly set.

STATE OF NEW HAMPSHIRE HIGHWAY DEPARTMENT	
TOWN:	RUMNEY
PROJECT:	S.A.B.
LOCATION:	STA. 0+940.0 TO 3+192.2
ROAD:	RUMNEY TO RUMNEY DEPOT
STREAM:	BAKER RIVER
DESIGNED BY: C.B.	DATE: 6-14-34
DRAWN BY: C.B.	DATE: 6-15-34
TRACED BY: J.D.G.	DATE: 6-28-34
CHECKED BY: E.S.B.	DATE: 7-11-34
SHEET 4 OF 7 SHEETS	
FILE NO. [redacted]	

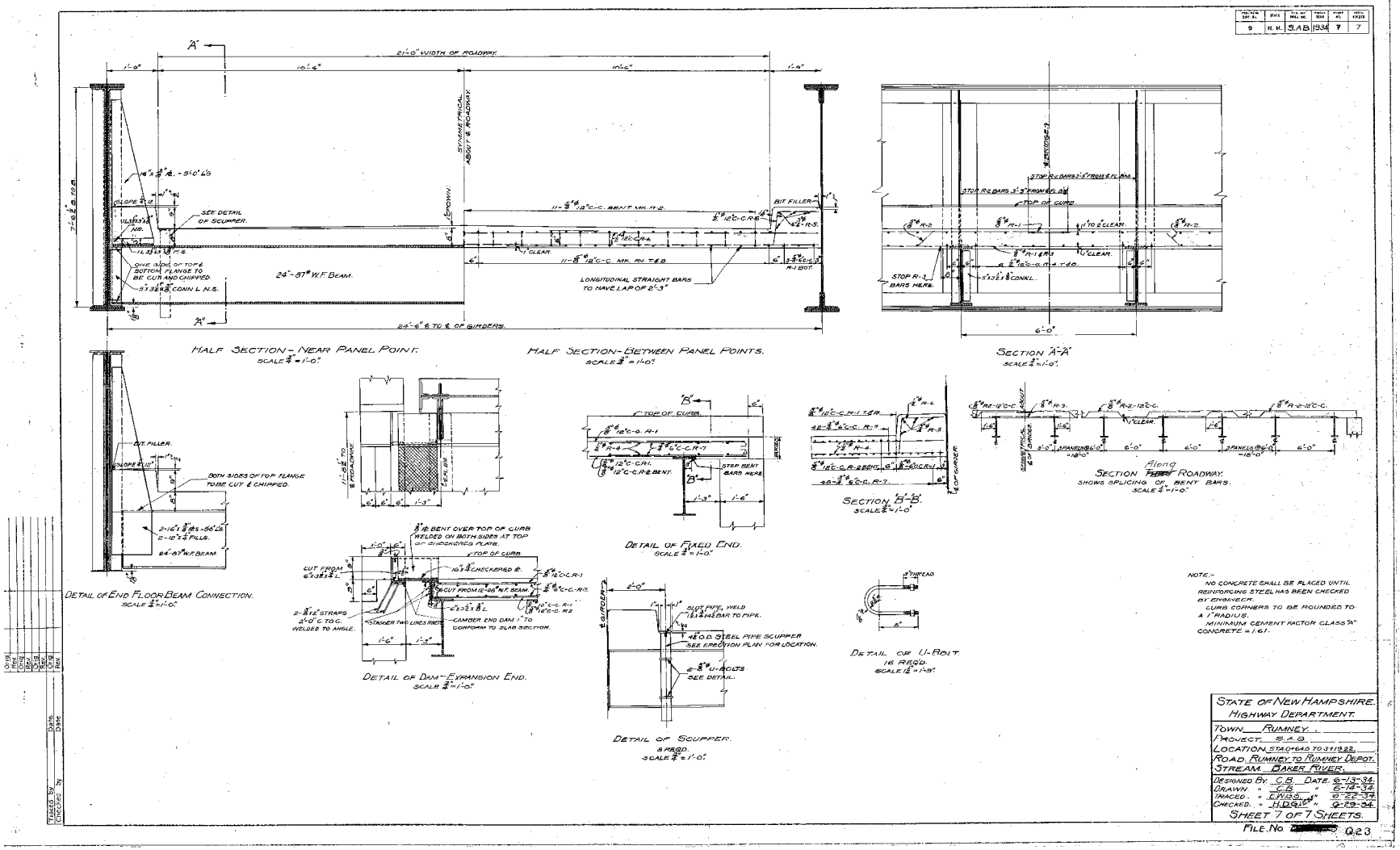
A-35) Bridge No. 132/070, Rumney, Main Street over Baker River, Sheet 4 of 7, 1934 (replaced 1998). NHDOT Bridge Design.



A-36) Bridge No. 132/070, Rumney, Main Street over Baker River, Sheet 5 of 7, 1934 (replaced 1998). NHDOT Bridge Design.



A-37) Bridge No. 132/070, Rumney, Main Street over Baker River, Sheet 6 of 7, 1934 (replaced 1998). NHDOT Bridge Design.



PROJECT NO. DIV. EL.	DATE	SHT. NO. REL. NO.	FINISH DATE	PRINT NO.	SHEETS
9	N.H. S.A.B.	1934	7		7

STATE OF NEW HAMPSHIRE.
HIGHWAY DEPARTMENT.

TOWN RUMNEY.
PROJECT. S.A.B.
LOCATION STA 0+64.0 TO 3+19.22.
ROAD RUMNEY TO RUMNEY DEPOT.
STREAM. BAKER RIVER.

DESIGNED BY C.B. DATE. 6-13-34.
DRAWN " C.B. " 6-14-34.
TRACED " E.P.H.S. " 6-22-34.
CHECKED " H.D.G. " 6-29-34.

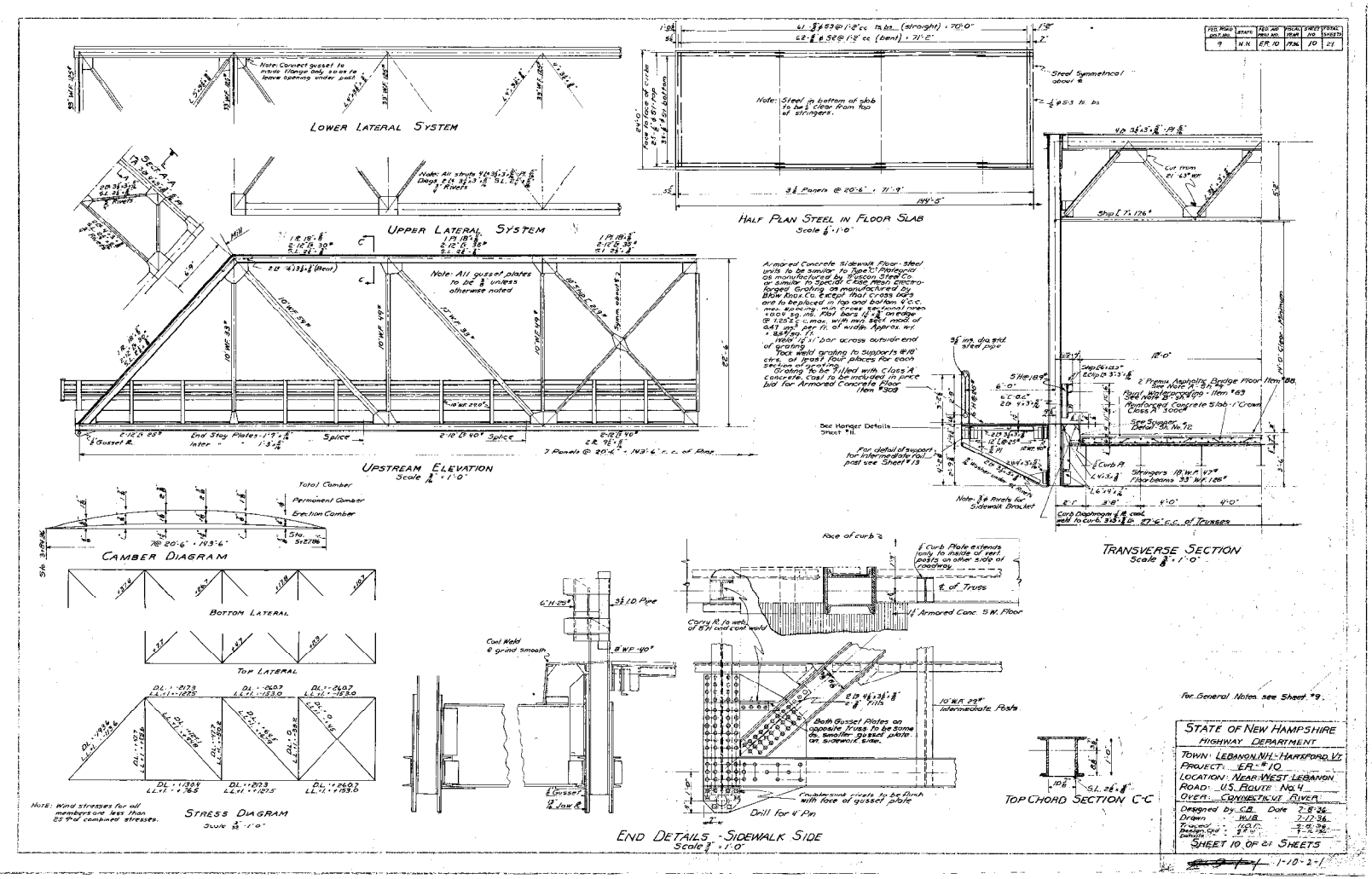
SHEET 7 OF 7 SHEETS.

FILE NO. [redacted] Q.23

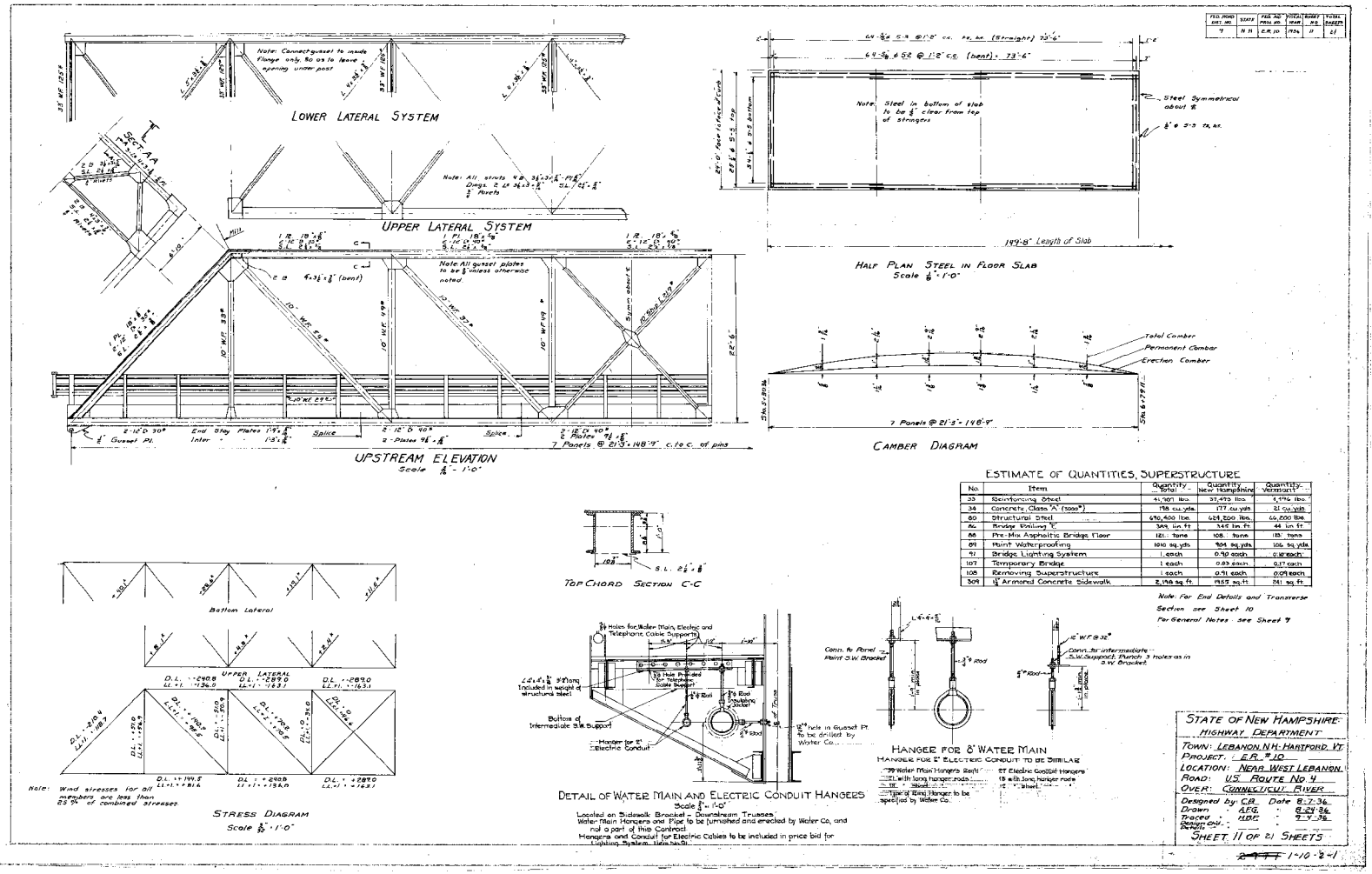
Traced by
Checked by

Date
Date

A-38) Bridge No. 132/070, Rumney, Main Street over Baker River, Sheet 7 of 7, 1934 (replaced 1998). NHDOT Bridge Design.



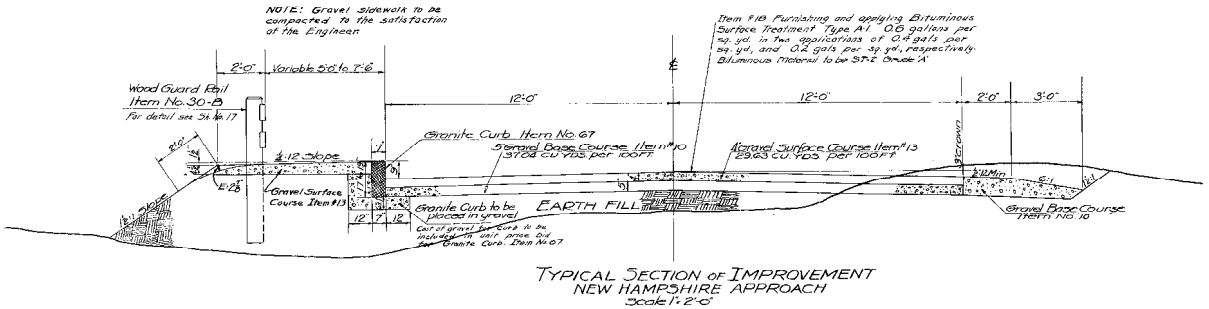
A-39) Bridge No. 058/127, Lebanon, NH-Hartford, VT, US Route 4 over Connecticut River, Sheet 10 of 21, 1936. NHDOT Bridge Design.



No.	Item	Quantity Total	Quantity New Hampshire	Quantity Vermont
33	Reinforcing Steel	41,901 lbs.	37,673 lbs.	4,196 lbs.
34	Concrete, Class "A" (1:2:4)	198 cu. yds.	177 cu. yds.	21 cu. yds.
60	Structural Steel	676,400 lbs.	634,200 lbs.	42,200 lbs.
64	Bridge Railing "C"	394 lin. ft.	348 lin. ft.	46 lin. ft.
88	Pre-Mix Asphaltic Bridge Floor	121. tons	108. tons	13. tons
89	Paint Waterproofing	1010 sq. yds.	904 sq. yds.	106 sq. yds.
91	Bridge Lighting System	1 each	0.90 each	0.10 each
107	Temporary Bridge	1 each	0.83 each	0.17 each
108	Removing Superstructure	1 each	0.91 each	0.09 each
309	4½" Armored Concrete Sidewalk	2,198 sq. ft.	1957 sq. ft.	241 sq. ft.

Note: For End Details and Transverse Section see Sheet 10
For General Notes see Sheet 9

A-40) Bridge No. 058/127, Lebanon, NH-Hartford, VT, US Route 4 over Connecticut River, Sheet 11 of 21, 1936. NHDOT Bridge Design.



TYPICAL SECTION OF IMPROVEMENT
NEW HAMPSHIRE APPROACH
Scale 1: 2'-0"

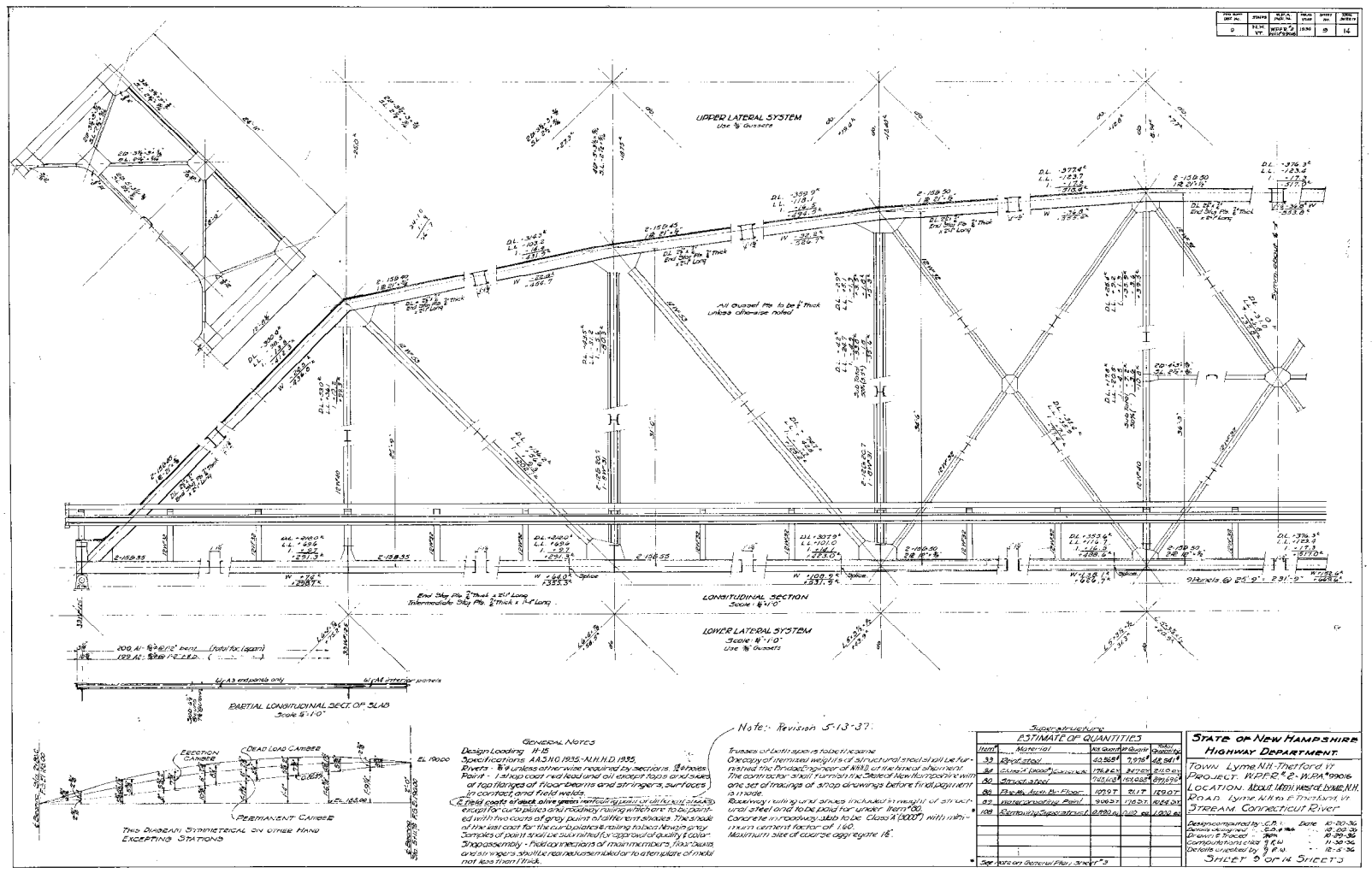
ESTIMATE OF QUANTITIES (N.H. APPR.)

No.	ITEM	QUANTITY
3	Fine Grading	266 lin. ft.
4	Earth Excavation	100 cu. yds.
6	Earth Borrow	800 cu. yds.
10	Gravel Base Course	150 cu. yds.
13	Gravel Surface Course	110 cu. yds.
18	Furnishing and Applying Bituminous Surface Treatment Type A1	428 gals.
21	Catch Basins	1.67 each
24	Granite Curb Inlets	1 each
30A	Wood Guard Railing (One rail type)	59 lin. ft.
30-B	Wood Guard Railing (Two rail type)	183 lin. ft.
40	Furnishing & Laying 14" Spiral Cast Iron Pipe	20 lin. ft.
67	Granite Curbing	212 lin. ft.
76	Rip Rap "A"	67 cu. yds.

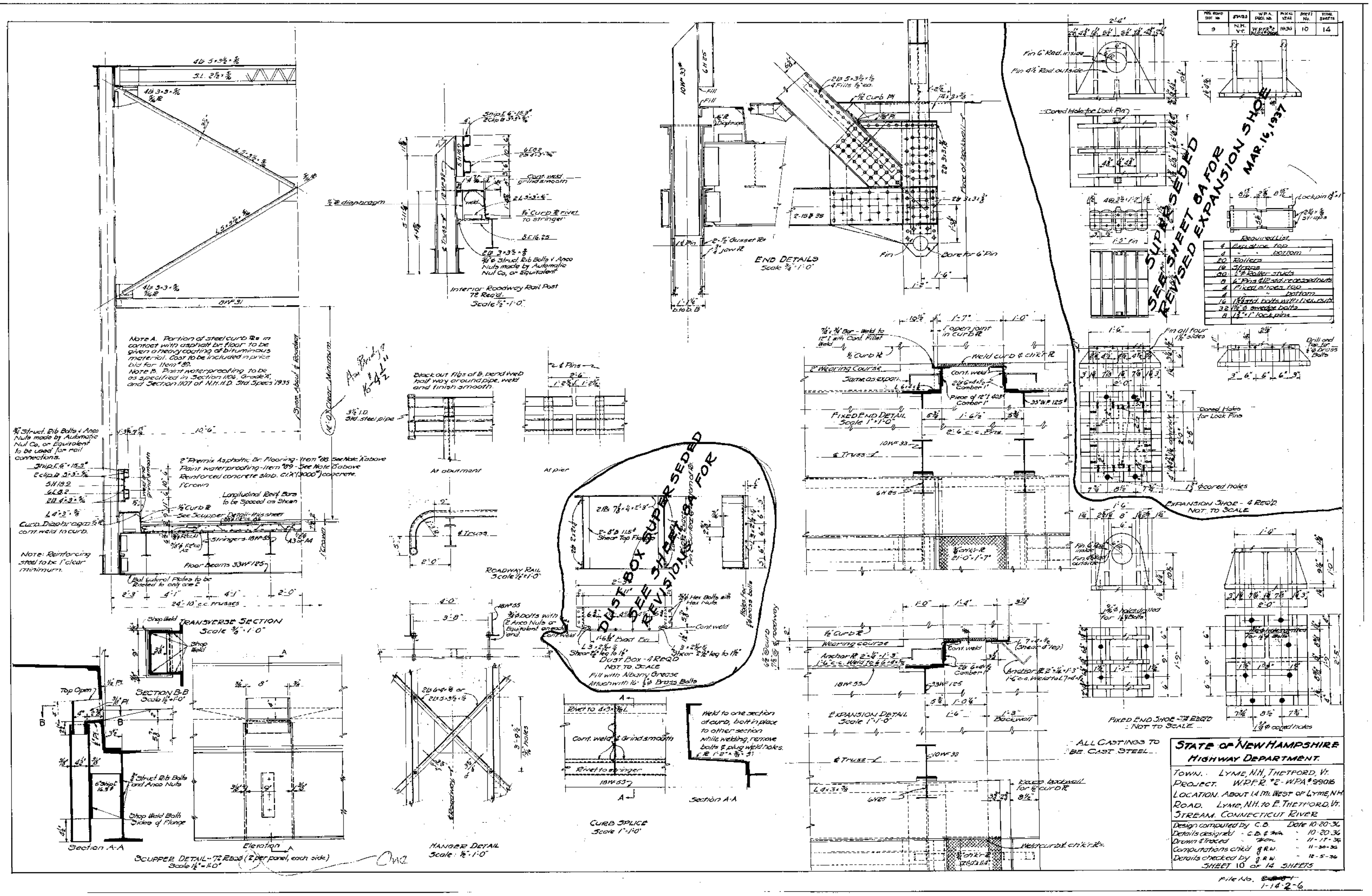
For Summary of Quantities for Vermont Approach see Sheet 3A

STATE OF NEW HAMPSHIRE
HIGHWAY DEPARTMENT
TOWN LEBANON N.H.-HARTFORD VT.
PROJECT E.R. 10
LOCATION NEAR WEST LEBANON
ROAD U.S. Route No. 4
STREAM CONNECTICUT RIVER
DESIGNED BY C.B. DATE 6-23-36
DRAWN T.H.M. " 6-24-36
TRACED T.H.M. " 9-13-36
CHECKED A.M.L. " 9-14-36
SHEET 2 OF 21 SHEETS

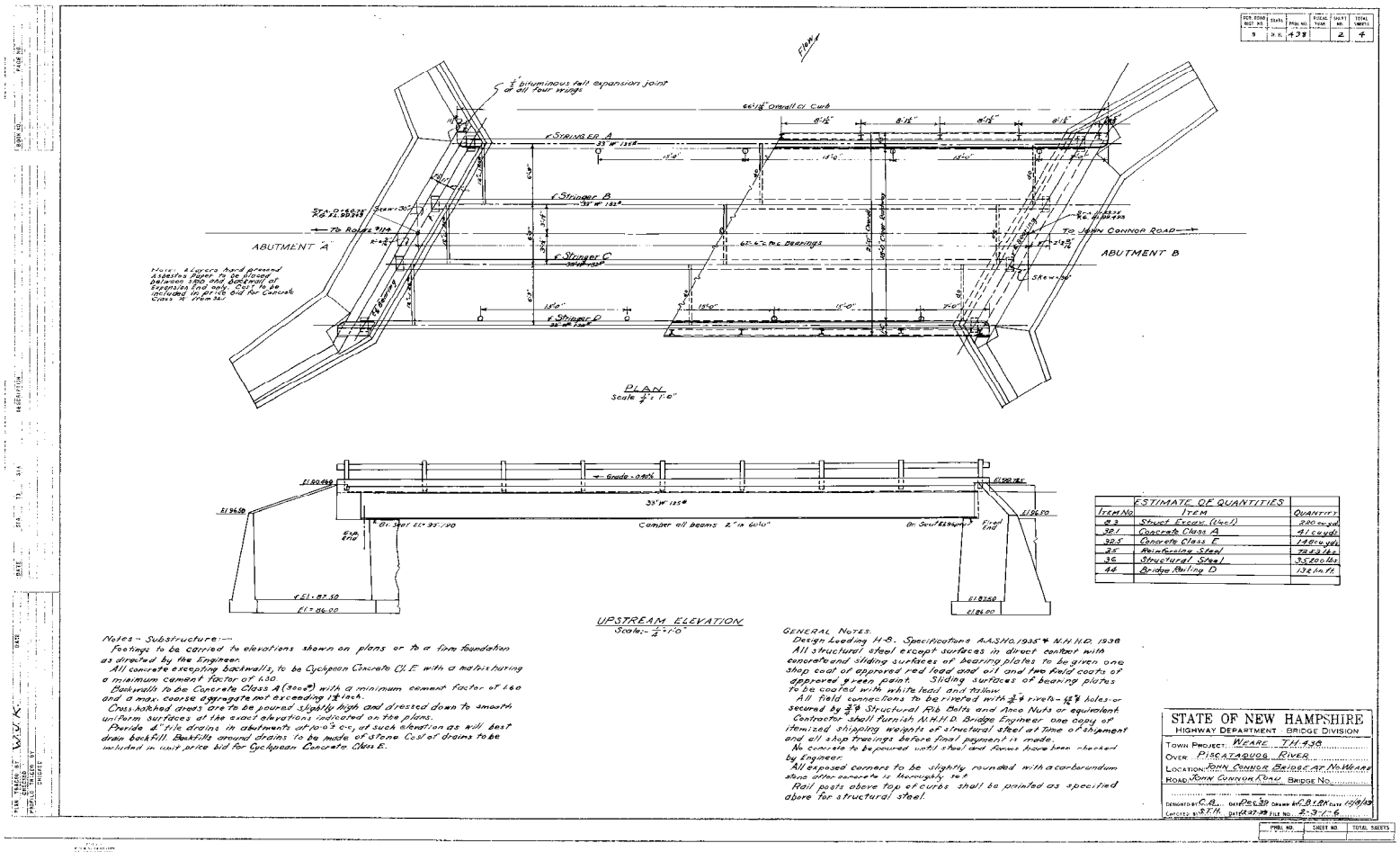
A-41) Bridge No. 058/127, Lebanon, NH-Hartford, VT, US Route 4 over Connecticut River, Sheet 2 of 21, 1936. NHDOT Bridge Design.



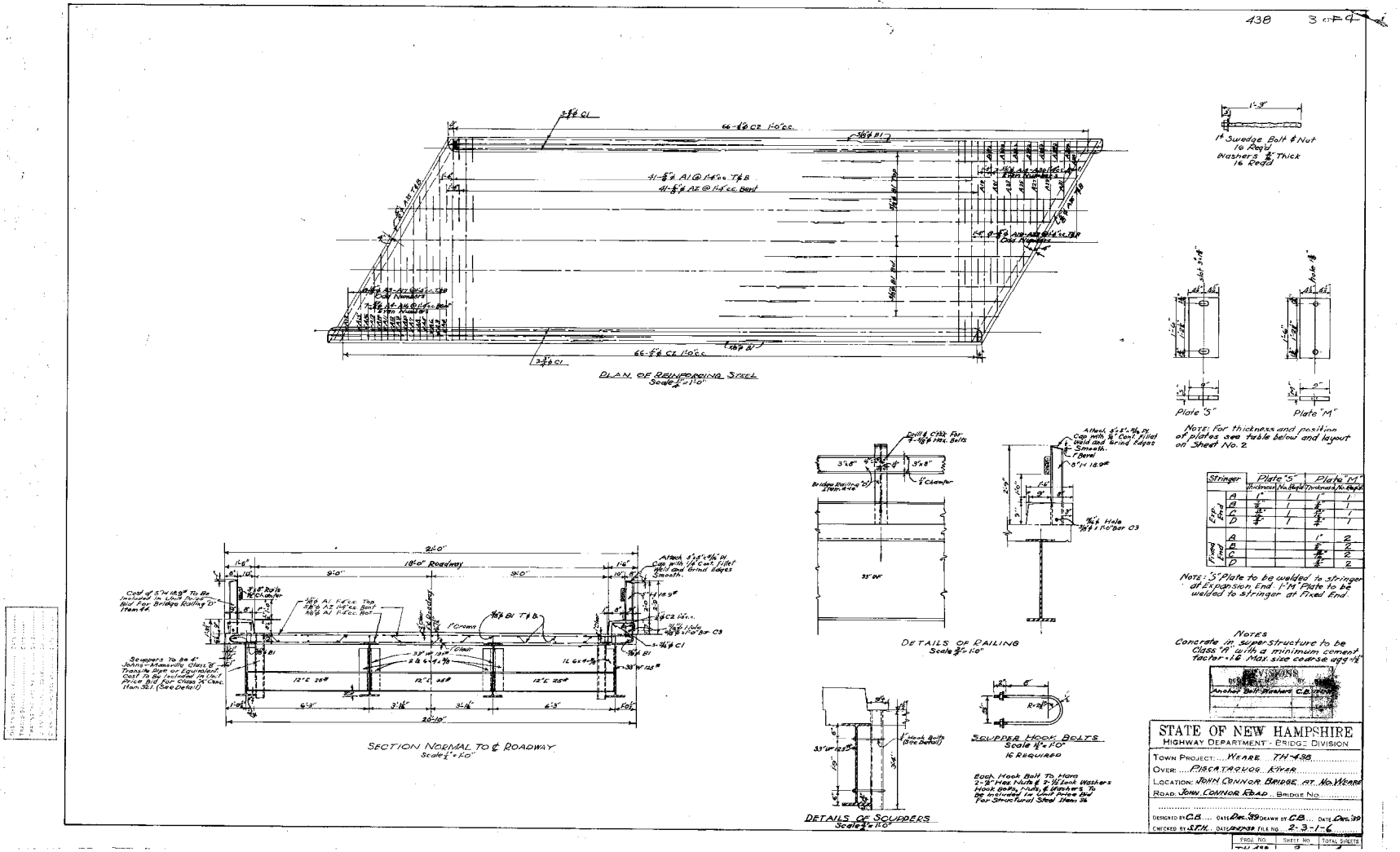
A-42) Bridge No. 053/112, Lyme, NH-Thetford, VT, East Thetford Road over Connecticut River, Sheet 9 of 14, 1936. NHDOT Bridge Design.



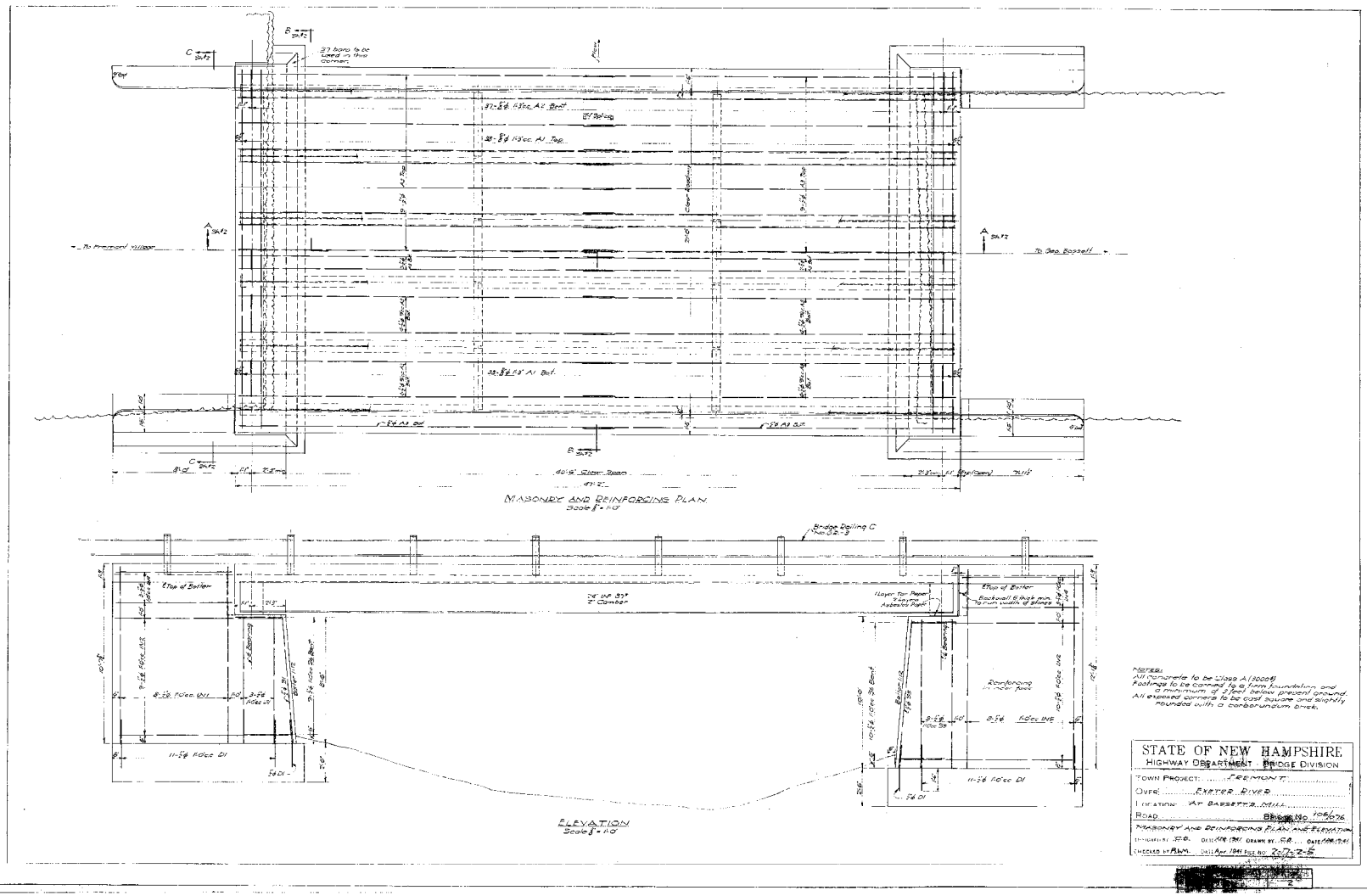
A-43) Bridge No. 053/112, Lyme, NH-Thetford, VT, East Thetford Road over Connecticut River, Sheet 10 of 14, 1936. NHDOT Bridge Design.



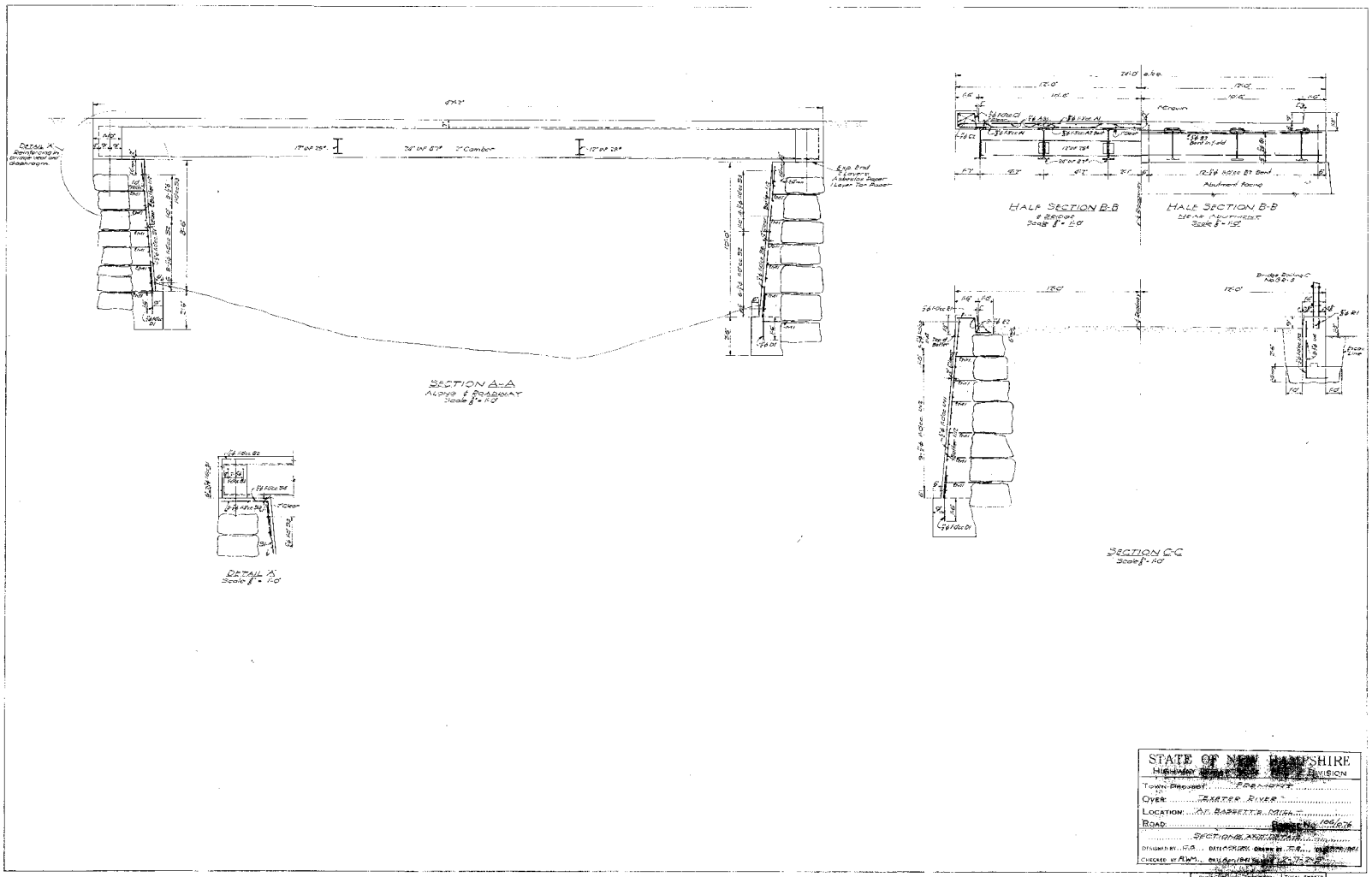
A-44) Bridge No. 079/153, Weare, John Connor Road over Piscataquog River, Sheet 2 of 4, 1939. NHDOT Bridge Design.



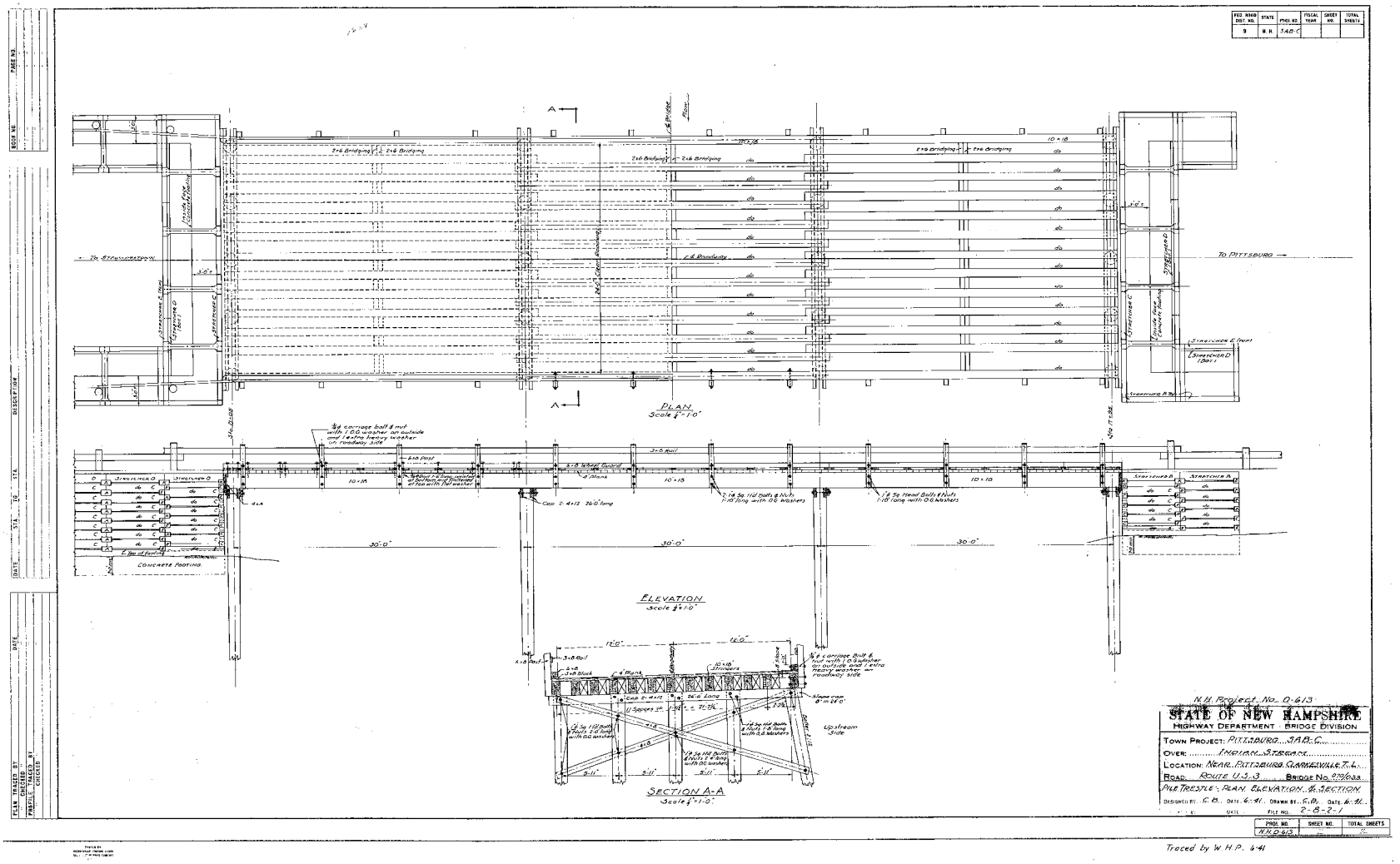
A-45) Bridge No. 079/153, Weare, John Connor Road over Piscataquog River, Sheet 2 of 4, 1939. NHDOT Bridge Design.



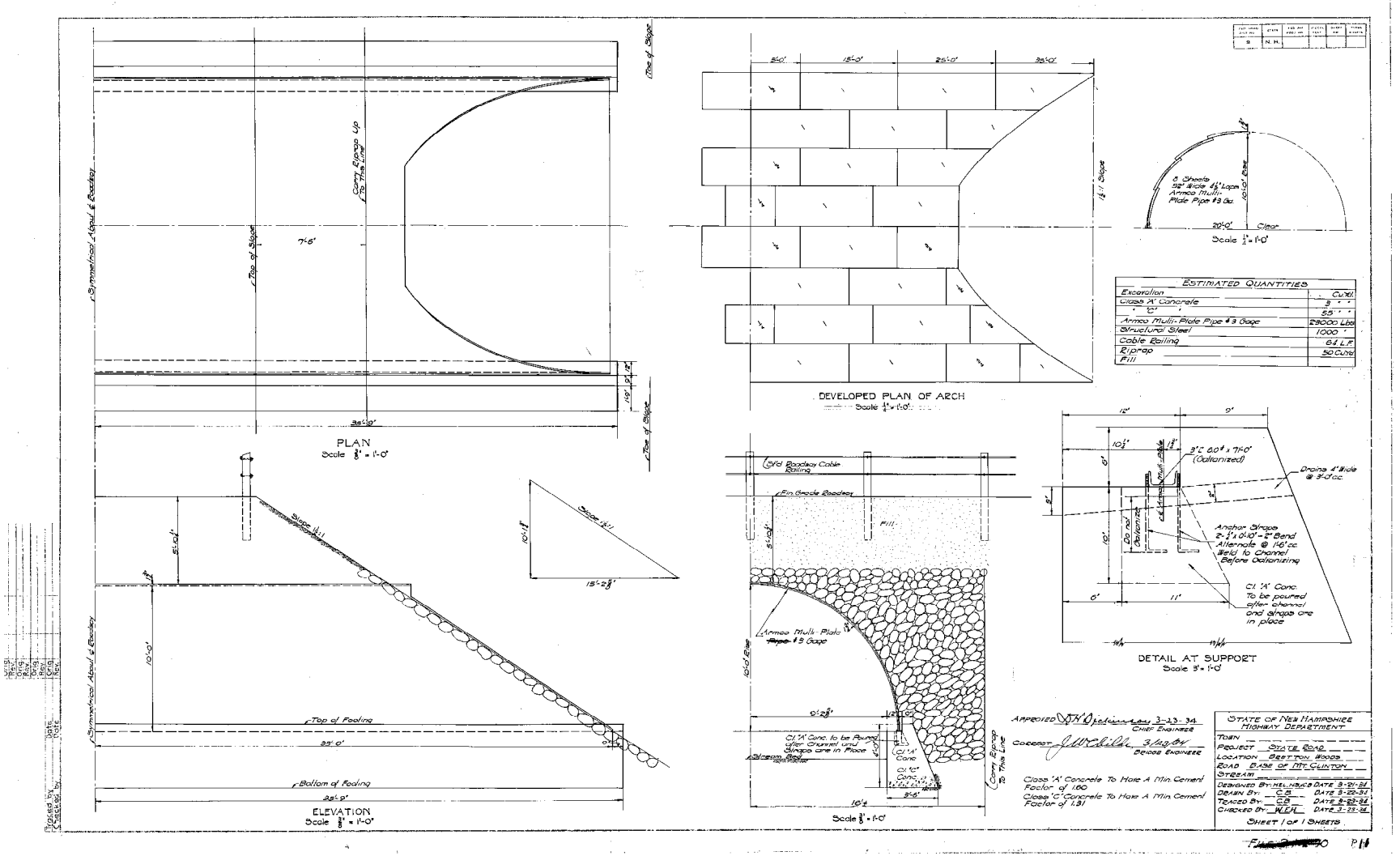
A-46) Bridge No. 106/076, Fremont, Scribner Road over Exeter River, 1941. NHDOT Bridge Design.



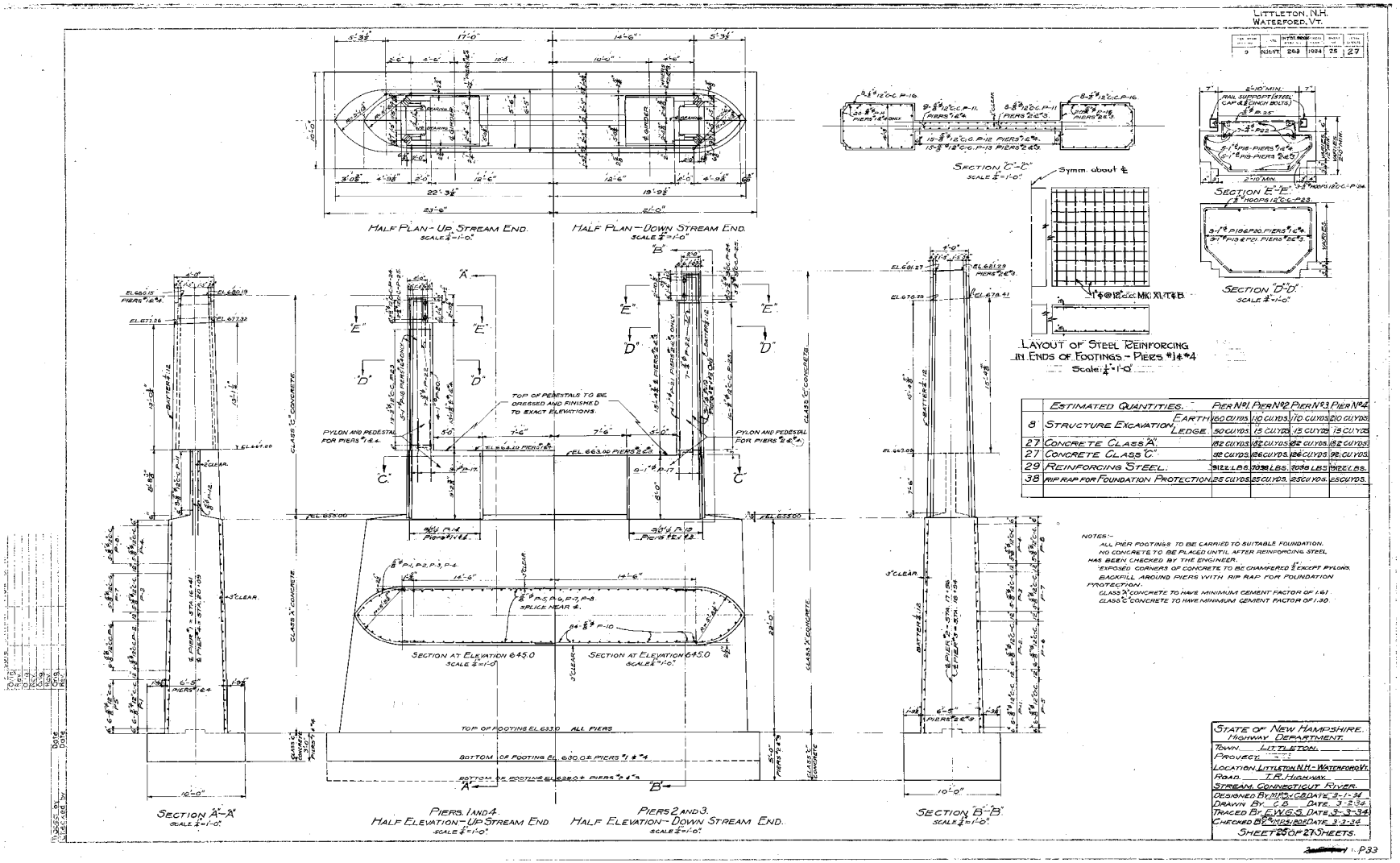
A-47) Bridge No. 106/076, Fremont, Scribner Road over Exeter River, 1941. NHDOT Bridge Design.



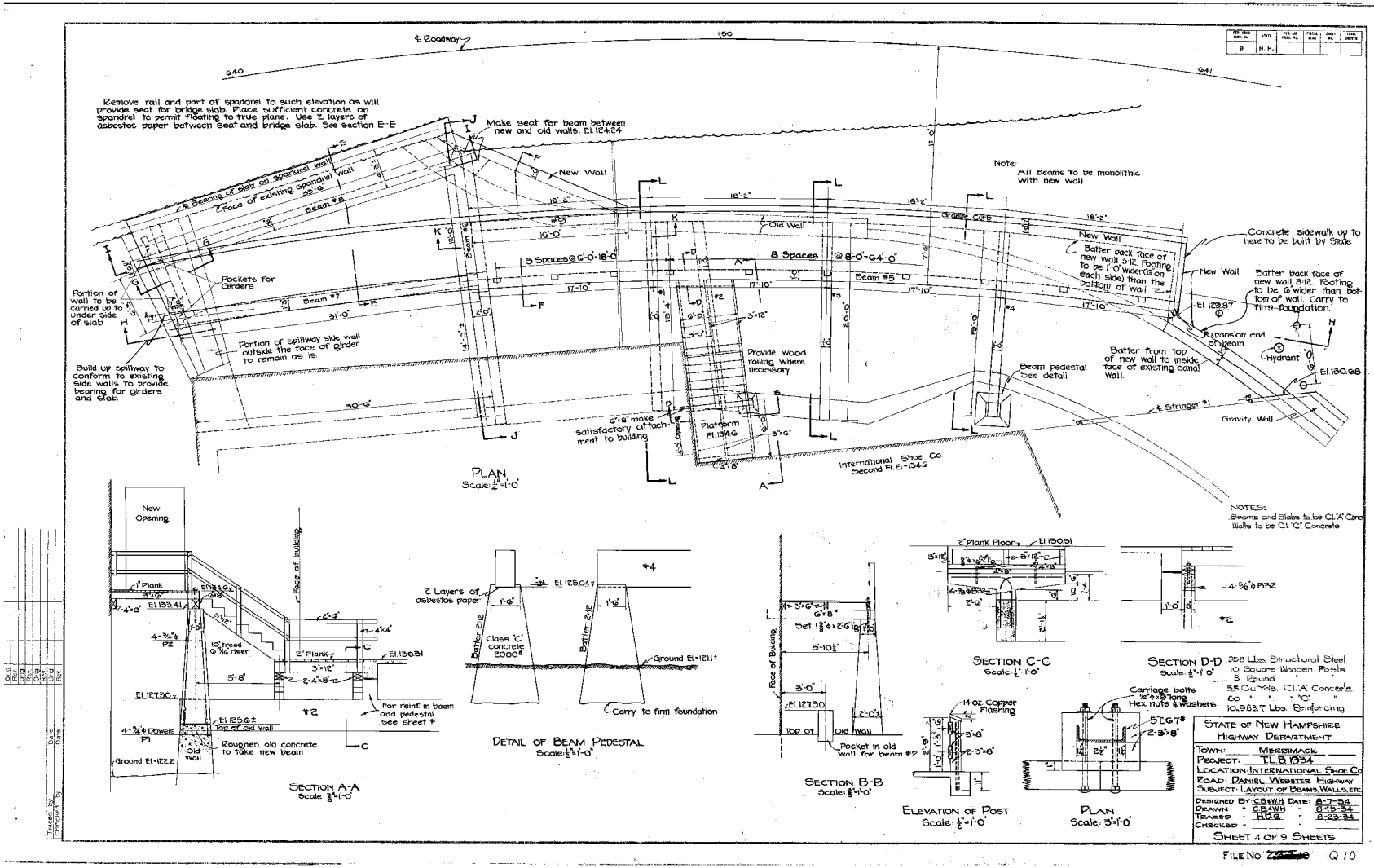
A-48) Bridge No. 070/032, Pittsburg, US Route 3 over Indian Stream, 1941 (replaced 1976). NHDOT Bridge Design.



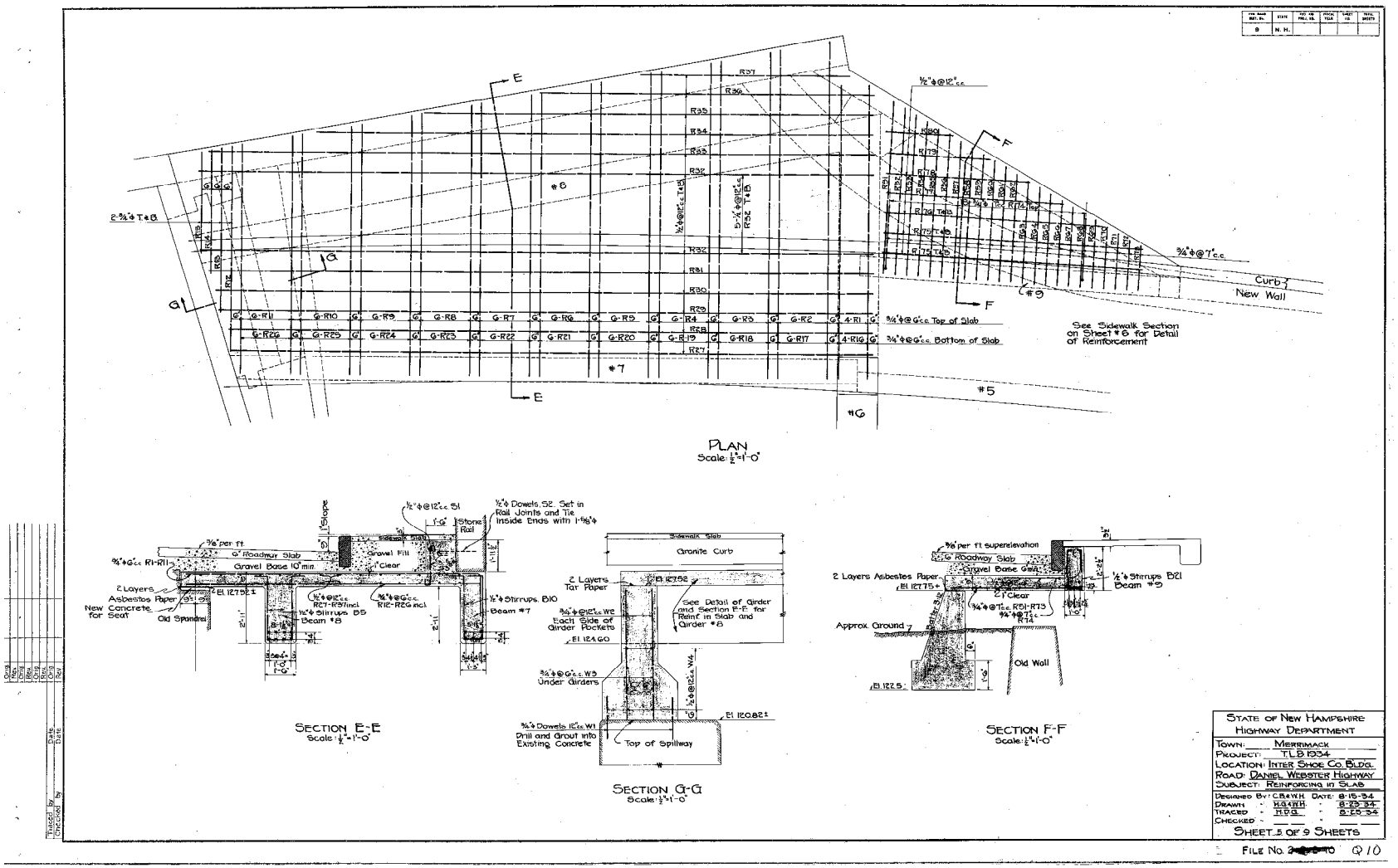
A-49) Bridge No. 090/179, Crawford's Purchase, Mt. Clinton Road over Sokokis Brook, 1934. NHDOT Bridge Design.



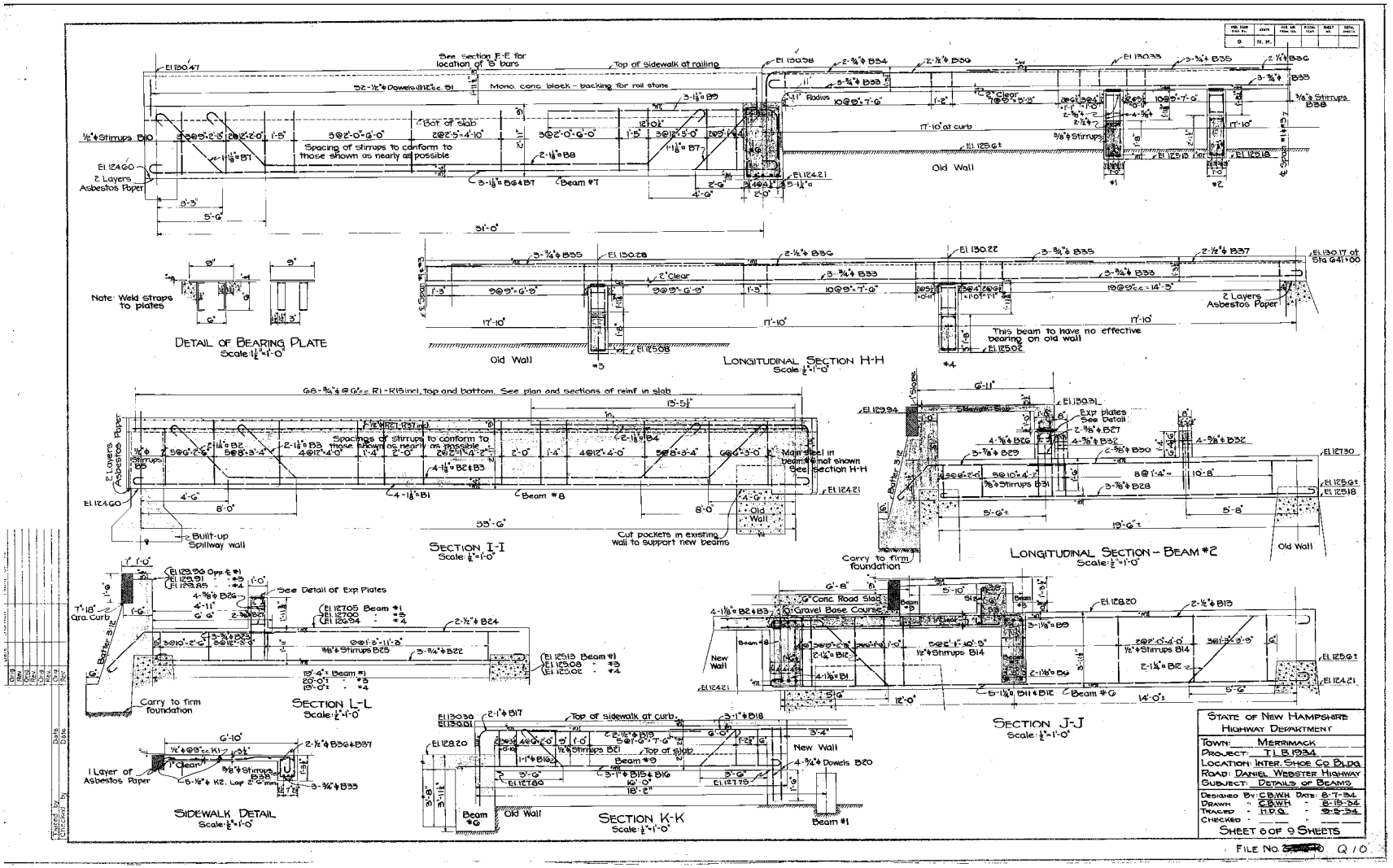
A-50) Bridge No. 109/134, Littleton, NH-Waterford, VT, NH Route 18 over Connecticut River, 1934, 25 of 27 sheets. Broker and Merritt P. Smith designed the piers of bridge designed by Richard D. Field. NHDOT Bridge Design.



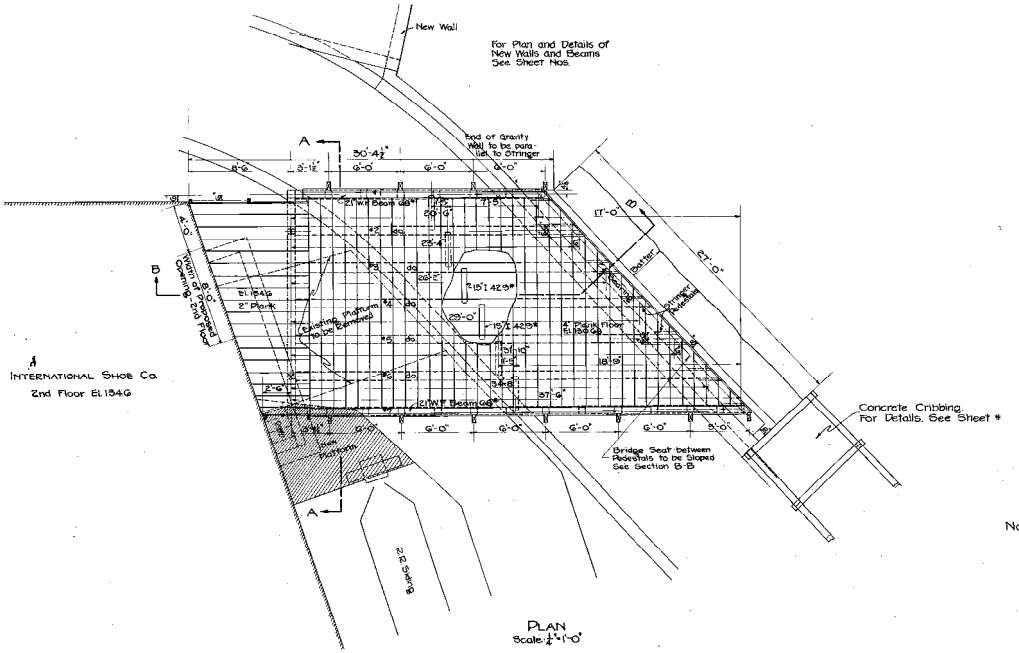
A-51) Bridge No. 116/120, Merrimack, US Route 3 over Souhegan River, Sheet 4 of 9, 1934. NHDOT Bridge Design.

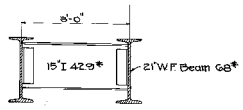


A-52) Bridge No. 116/120, Merrimack, US Route 3 over Souhegan River, Sheet 5 of 9, 1934. NHDOT Bridge Design.



A-53) Bridge No. 116/120, Merrimack, US Route 3 over Souhegan River, Sheet 6 of 9, 1934. NHDOT Bridge Design.





DETAIL OF DIAPHRAGM
Scale: 3/4"=1'-0"

Notes:-

Design Loading H-15. Specifications A.A.S.H.O. 1931 & N.H.H.D.
7/8"ϕ Dardelet Rivet-Bolts. Holes 15/16"ϕ.
Expansion Ends of Stringers to be Sheared.
Two Slotted Holes, 1 1/8" x 1 3/4" long, in Bottom Flanges of each Stringer at Expansion End.
15/16"ϕ Holes to be Punched in Top Flanges of Stringers for Nailing Strips.
Paint: 1 Shop Coat Red Lead and Oil.
1 Field " Approved Aluminum Paint.
Class 'C' Concrete to be Used. Minimum Cement Factor = 1.30
All Lumber on Truck Platform to be Creosoted.

STATE OF NEW HAMPSHIRE
HIGHWAY DEPARTMENT

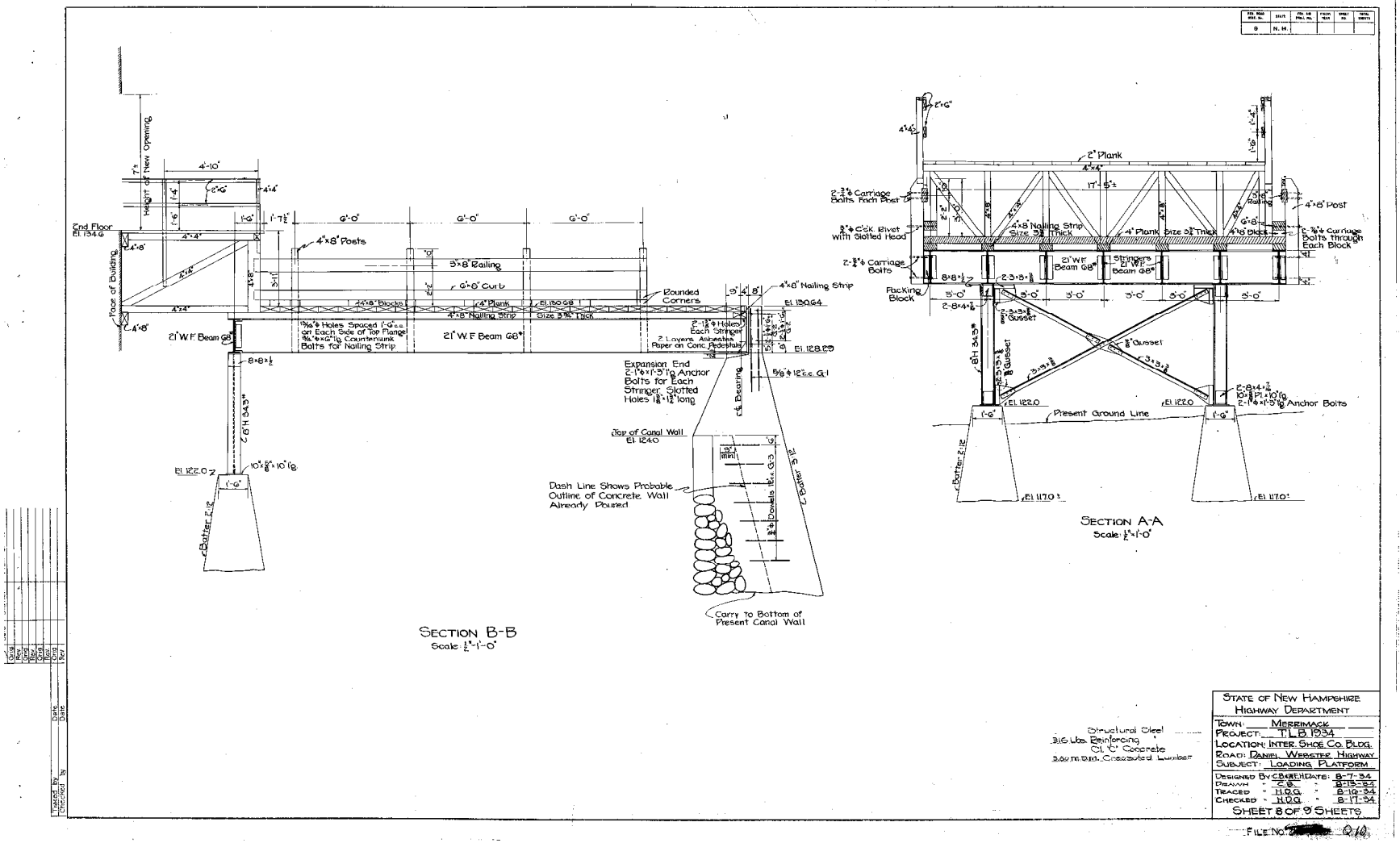
TOWN: MERRIMACK
PROJECT: T.L.B. 1934
LOCATION: INTER. SHOE CO. BLDG
ROAD: DANIEL WEBSTER HIGHWAY
SUBJECT: LOADING PLATFORM

DESIGNED BY: CBW/EH	DATE:	8-7-34
DRAWN " C.B.	"	8-9-34
TRACED " H.D.G.	"	8-15-34
CHECKED " H.D.G.	"	8-17-34

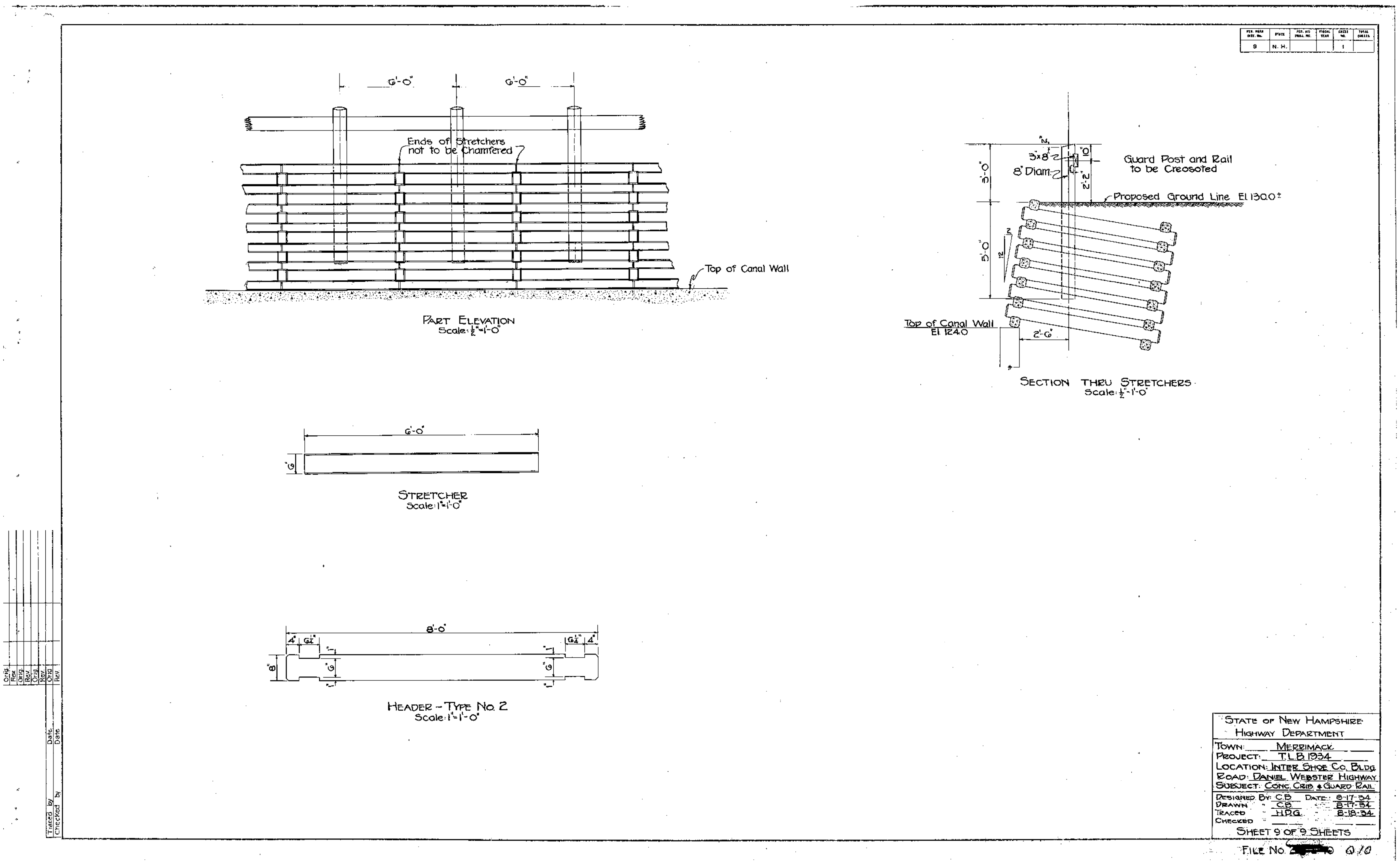
SHEET 7 OF 9 SHEETS.

FILE NO. [redacted] Q 10

A-54) Bridge No. 116/120, Merrimack, US Route 3 over Souhegan River, Sheet 7 of 9, 1934. NHDOT Bridge Design.



A-55) Bridge No. 116/120, Merrimack, US Route 3 over Souhegan River, Sheet 8 of 9, 1934. NHDOT Bridge Design.



A-56) Bridge No. 116/120, Merrimack, US Route 3 over Souhegan River, Sheet 9 of 9, 1934. NHDOT Bridge Design.