FINAL DESIGN STUDY REPORT

October 24, 2016

Revised January 9, 2017

Cairo Bridge
State Project S343-31-9.82 00
Federal Project STP-0031(037) D

Cairo, Ritchie County, West Virginia

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1.0 PROJECT DESCRIPTION & PURPOSE

This project involves the study, preparation, and submission of a Design Study Report for the Cairo Bridge which carries WV Route 31 over the North Fork Hughes River in Ritchie County and is located approximately 4 miles south of US Route 50.

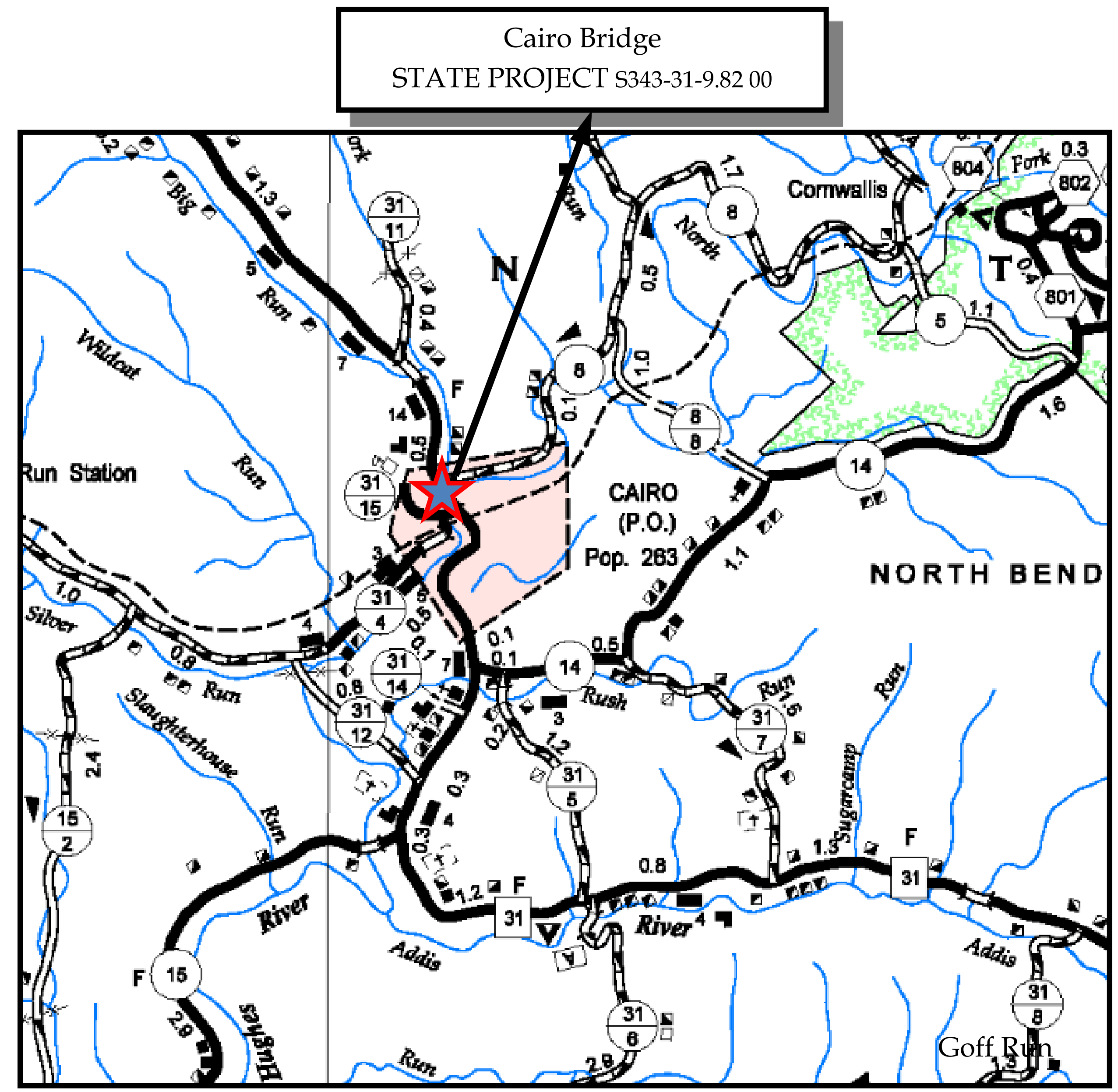
This structure, which is eligible for registration for the National Register of Historic Places, was built in 1925 and was rehabilitated in 1976 and 1989. Since that time, the bridge has experienced substantial deterioration and is currently silhouette posted 16 tons. A Routine Bridge Inspection Report prepared by the District 3 Bridge Department, dated August 7, 2015, rates the deck and superstructure in poor condition and in need of replacement.

The existing bridge has an 18′-5″ wide roadway and is limited to 15′-0″ vertical clearance (see cover photo). The current ADT of 750 vehicle per day on WV Route 31. The substandard width does render the bridge functionally obsolete for a two-lane, two-way bridge, and combined with load posting, restricts use by truck traffic. For this reason, the bridge is hindering substantial economic development in the oil and gas industry, and WVDOT predicts that the ADT and ADTT will both increase dramatically when this obstacle is removed.

The purpose of this Design Study Report is to compare various alternatives for replacement or rehabilitation of the existing bridge. Temporary traffic control during construction is a primary concern, as no reasonable detours appear to be available for vehicular or pedestrian traffic. The goal of the design study is to select an alternative that meets the following criteria:

- Minimizes impact to traffic during construction;
- Economically feasible to construct;
- Minimizes impact to the mussels in the stream;
- Maintains hydraulic performance of the stream;
- Addresses the historical significance;
- Accommodate pedestrians and bicycles;
- Creates a long-term, durable solution; and
- Provides acceptable level of aesthetics.

LOCATION MAP



2.0 PROJECT REQUIREMENTS

2.1 Existing Conditions

The existing bridge consists of a single-span truss supported on two wall-type abutments (Photos 1-6 in Appendix A). The bridge carries two lanes of traffic and one sidewalk with a clear roadway width of 18′-5″ and overall length of 180 feet. The profile grade is a constant -0.19 percent over the bridge transitioning to vertical curves on the approaches. The US Route 31 typical section on the south approach is downtown Main Street of Cairo. Main Street is composed of two lanes and one parking lane with an overall roadway width of 30 feet with a sidewalk on one side and curbs on both sides. The north approach roadway to the bridge is composed of two lanes for total roadway width of approximately 20′ with 2′ stone shoulders. The sidewalk ends at the south end of the bridge and pedestrians use the shoulder.

2.2 Design Criteria

The geometric design follows the guidelines established in the American Association of State Highway and Transportation Officials' (AASHTO) A Policy on Geometric Design of Highways and Streets, 6th Edition, 2011. The design will be in accordance to the Public Rights-of-Way Accessibility Guidelines (PROWAG) 2014. The study of the bridge structure will be based on Load and Resistance Factor Design (LRFD) in accordance with the AASHTO "LRFD Bridge Design Specifications, 2012" and latest interim revisions, and the WVDOT Bridge Design Manual, dated March 1, 2004, with any revisions.

For Build Alternatives 1A, 1B, 2A and 2B, the completed structure will provide two 11′-0″ lanes, two 4′-0″ shoulders, one 5′-7 3/8″ sidewalk, one 1′-0″ combo rail, and one 1′-2 ¾″ Type F Barrier. The roadway width will be 30′-0″ with a 37′-10 3/8″ out-to-out width. The 250′ horizontal curvature radius is an improvement over the existing 145′ radius. A 4% super-elevation will transition from the first curve to 2% held over the bridge and then back to a normal crown on Main Street. Detailed typical sections can be found in Appendix E.

Table 1
Design Criteria

Roadway	Classification	Design Speed	Maximum Grade
WV Route 31	Major Rural Collector	30 mph	10%

Design criteria tables are included in Appendix B. Design exceptions are required in order to match existing for Alternatives 1, 2, and 3.

2.3 Geotechnical Overview (Provided by WVDOT)

A geologist visited the area and performed limited research of readily available information. The search for previous subsurface information did not reveal any that was available. The field visit was conducted on September 25, 2015. Rocks ranging in size from pebbles to boulders were observed in the stream bed. The banks of the river were composed primarily of silty sand. It is anticipated that bedrock will be encountered close to the surface.

The Cairo Bridge is located along WV 31 at Cairo, WV. It crosses the North Fork of Hughes River on the northwest side of Cairo. The topography of this portion of the North Fork of Hughes River Valley ranges from flat bottom land to steep hillside. The relief near the project is about 470 feet from the floodplain to the hilltop. The valley floor is approximately 1,900 feet wide in this area.

Based on the West Virginia Geologic and Economic Survey (WVGES) web page, this project is located in the Appalachian Plateau Physiographic Province. The province is characterized by relatively flat lying rocks which have gentle folds of broad frequency and low amplitude that range in age from Ordovician (Pennsylvanian Period) to Dunkard (early Permian Period). These rocks were deeply eroded after the last stage of mountain building during the Appalachian Orogeny. Based on the WVGES Ritchie County geologic map, dated 1909, the only major fold within the project area influencing the bedrock orientation is the Burning Springs Anticline located approximately 33.8 miles west of the bridge. The strata has a regional strike of approximately N 5^{o} E and dips at less than 1^{o} to the east.

Strata exposed at the surface range from the Monongahela (late Pennsylvanian) to Dunkard (early Permian) aged rocks. Both the Monongahela Formation found in the floodplain and the Dunkard Formation found in the surrounding valley walls are composed primarily of non-marine cyclic sequences of sandstone, siltstone, shale, limestone and coal. Coal seams found in the vicinity of the project area include in descending stratigraphic order the Washington, Waynesburg, Uniontown, Sewickley, Redstone and Pittsburgh. Mapping found on the WVGES coal bed mapping website does not indicate mining in the area, nor any mineable seams. It is not anticipated that any coal seams will be encountered at this project location. Based on our review of the WVDEP Interactive Mapping and the WVGES Coal Bed Mapping web pages, there appears to be no active mining permits in the area.

The area below the northwest abutment of the existing bridge showed signs of instability. Scour of the alluvial/fill material placed during the construction of the bridge has created a scarp approximately 5 to 6 feet in height. It is recommended that 2:1 slopes be placed in front of the bridge and the embankment fills.

2.4 Environmental Overview (Provided by WVDOT)

It has not yet been determined if this project will be processed as an Expanded Categorical Exclusion or will have to be an Environmental Assessment for Environmental Section clearance of the National Environmental Policy Act (NEPA) and related requirements.

The following checklist represents the potential environmental concerns known at the time of completion of this design study report. As more information is obtained potential impacts or concerns may change.

Environmental Concerns	**YES**	**NO**	**Maybe**
Historic Resource Concerns	☒**Historic District. Bridge is a contributing resource.**	☐	☐
Archaeology Concerns	☐	☒ **Cleared**	☐
Wetland Concerns	☐	☒	☐
Residential/Business Concerns	☐	☐	☒
Mussel Survey Necessary	☒	☐	☐
Endangered Species	☒ **Will have to have a Biological assessment and then A biological Opinion from FWS**	☐	☐
Public Involvement	☒	☐	☐
Section 4 (f) Issues	☒	☐	☐
FHWA Approval of CE	☐	☐	☒

3.0 PROPOSED ALTERNATIVES

3.1 No Build Option

Due to the deteriorated condition of the bridge the No Build Alternative would result in eventual closure. The structure would continue to deteriorate until complete replacement was unavoidable. The No Build Alternative is not a viable option. Therefore, no further investigation was performed.

3.2 Description of Build Alternatives Considered

Various alternatives were reviewed during the development of this design study. Each alternative was carried forward to the point at which it was no longer feasible. Appendix A includes site photographs. Appendix C includes preliminary cost estimates. Appendix E includes plans, typical sections, and details of the alternatives.

The proposed alternatives include:

Alternative 1A: Single Span Replacement Bridge on Existing Alignment;
Alternative 1B: Three Span Replacement Bridge on Existing Alignment;
Alternative 2A: Single Span Replacement Bridge on Upstream Alignment;
Alternative 2B: Three Span Replacement Bridge on Upstream Alignment;
Alternative 3: Rehabilitate Bridge using Upstream Temporary Detour;
Alternative 4: Replacement Bridge on Downstream Alignment

Foundation protection will be placed around the abutments. The abutments will be backfilled with Class I aggregate and primary reinforcing fabric per the standards.

ALTERNATIVE 1A: SINGLE SPAN REPLACEMENT BRIDGE ON EXISTING ALIGNMENT

Build Alternative 1A proposes to replace the bridge on the existing alignment. The new single span structure will have 185′ span length consisting of curved steel plate girders with overall structure depth of 7′-2″. Semi-integral, wall-type abutments are supported on steel piles. The substructures are placed on radial lines with no skew.

A 130-foot long, two-span temporary bridge to the upstream side will be installed to maintain traffic. A temporary bent will be placed in the stream. The temporary bridge will include an 11′ lane and a 4′ sidewalk (but widened to 5′ on the approaches). Reverse curves will be needed on the approach which meet a 25-mph design speed. A temporary traffic single will be used to alternate vehicle across the bridge. The profile of the temporary detour bridge is set at an elevation to provide 2′ of freeboard over the 10 year storm. WVDOT has tabulated costs from previous projects and consulted with a contractor who thought the most economical temporary bridge will be a two span.

Alternative 1A has an estimated construction cost of $3,362,000. The 130 foot-long, temporary detour bridge was estimated at $85 per square foot for a total cost of $176,800.

ALTERNATIVE 1B: THREE SPAN REPLACEMENT BRIDGE ON EXISTING ALIGNMENT

Build Alternative 1B proposes to replace the bridge on the existing alignment. The three span structure will have spans of 68′-122′-68′ totaling 258′ in length. The steel rolled beams will be continuous over solid hammerhead shaped piers founded on drilled caissons. The integral abutments are supported on steel piles. The substructures are placed on radial lines with no skew.

The temporary bridge will utilized to maintain traffic as described in Alternative 1A.

Alternative 1B has an estimated construction cost of $3,112,000.

ALTERNATIVE 2A: SINGLE SPAN REPLACEMENT BRIDGE ON UPSTREAM ALIGNMENT

Build Alternative 2A proposes to replace the bridge on the upstream alignment. The new single span structure will have 185′ span length consisting of steel plate girders with overall structure depth of 7′-2″. Although slight curvature will exist on the Abutment 1 end, straight girder framing should be achievable with the use of variable overhangs. Likewise, Abutment 1 centerline is perpendicular to the forward tangent. Semi-integral, wall-type abutments are supported on steel piles.

Traffic will be maintained on the existing structure during construction of the proposed span.

Alternative 2A has an estimated construction cost of $2,839,000.

ALTERNATIVE 2B: THREE SPAN REPLACEMENT BRIDGE ON UPSTREAM ALIGNMENT

Build Alternative 2B proposes to replace the bridge on the upstream alignment. The three span structure will have spans of 68′-122′-68′ totaling 258′ in length. The steel rolled beams will be continuous over solid hammerhead shaped piers founded on drilled caissons. The integral abutments are supported on steel piles which will serve to counterweight uplift due to the shortened end spans. The substructures are placed on radial lines with no skew.

Traffic will be maintained on the existing structure during construction of the proposed spans.

Alternative 2B has an estimated construction cost of $2,805,000.

ALTERNATIVE 3: REHABILITATE BRIDGE USING UPSTREAM TEMPORARY DETOUR BRIDGE

Build Alternative 3 proposes to replace the stringers and the reinforced concrete deck and maintain the current configuration of two 9′-2½″ lanes. Various structural repairs would be made to the corroded steel members prior to abrasively cleaning and painting of the entire structure. The existing substructures and remaining portions of the existing superstructure would be rehabilitated and re-used. The chloride contaminated concrete of the substructure units would need to have the chlorides extracted. Visible existing and proposed concrete would be coated for protection.

To strengthen the bridge to an HS-25 design load, the stringers would need replaced and end floorbeams would be plated. The truss members, connections, and interior floorbeams appear to have adequate strength from the stress analysis performed by District 3 in October 2015. However, an updated analysis may be needed to account for any additional losses and to evaluate the loads of the new deck and sidewalk.

It is assumed the existing substructures are chloride contaminated. B&N has recently consulted with Vector Corrosion Technologies in regards to performing Electrochemical Chloride Extraction (ECE) on the existing concrete that will remain on a similar project. ECE is a treatment which a) extracts chloride ions from contaminated concrete and b) reinstates the passivity of steel reinforcement. Chloride extraction is carried out by temporarily applying an electric field between the reinforcement in the concrete and an externally mounted anode mesh. During the process chloride ions are transported out of the concrete. At the same time, electrolysis at the reinforcement surface produces a high pH environment. This process returns the steel reinforcement to a passive condition. According to Vector, ECE has been effectively performed in many states and project references can be provided.

Vector recommends to complete all patching and new concrete placement prior to starting the ECE process. Additional removal of concrete surfaces is not needed. The process will include continuous supply of water and electricity for approximately 60 days toward the end of the project. Vector provided an estimated cost of $56 to $64 per square foot. With additional costs for power and disposal, we have estimated $250,000 to perform ECE for this Alternative 3.

Over the lifespan of the bridge, the existing Abutment 1 has rotated toward the river. This suspected rotation has resulted in the expansion bearings at the abutment being backset causing zero clearance at both truss endposts, as per the 2014 inspection report. Horizontal cracks are present in the seat and backwall. The proposed stabilization repair at this location is to remove and replace the existing backwall with a reinforced concrete slab which attaches to the seat and extends beyond the back side of the abutment. The new concrete slab will also be anchored to bedrock via micropiles behind the abutment. This is a custom solution for a unique problem that will require careful planning and execution. The superstructure will be jacked up, temporarily supported, and the steel rocker bearings replaced with elastomeric expansion bearings.

The temporary bridge will utilized to maintain traffic as described in Alternative 1A.

Alternative 3 does not provide any additional lane width; therefore, this option provides less safety for two lane, two way traffic. This alternative would also result in significant, ongoing maintenance costs as compared to other alternatives since the original structure, built in 1925, would remain. The vertical and horizontal profiles require a design exception. The substandard width does render the bridge functionally obsolete for a two-lane, two-way bridge, and combined with load posting, restricts use by truck traffic. For this reason, the bridge is hindering substantial economic development in the oil and gas industry, and WVDOT predicts that the ADT and ADTT will both increase dramatically when this obstacle is removed. This alternative does not meet the purpose and need of the project.

Alternative 3 has an estimated construction cost of $3,146,000.

As a result of the recent inspection performed by WVDOH District 3, this alternative is no longer feasible (see report, memos, photographs, and sketches in Appendix F). Inspectors have detected significant destress in the deck, stringers, and lower chord of the truss. The low chord is bowed 3″ to the downstream which was not previously noted. Engineers from WVDOH and Burgess & Niple met at the bridge on November 29, 2016 to review the condition. The cause of the distress could be attributed to corrosion of the grid deck bars which is known to exert compressive stress on the bridge as the corrosion expands. In attempt to relieve this stress, the bridge deck was cut in two locations, but the effectiveness is still unknown. Another possible cause is the instability of the abutment could be increasing the compressive stress in the lower chord. Measurements made confirm that Abutment 1 is rotating and possibly Abutment 2 as well. This rotation could result as much as 6″ of movement at the cap level. As a precaution, District 3 is monitoring the position of the abutment and lower chords with surveying equipment on a periodic basis until improvements can be made. Rehabilitation of the bridge in this deformed condition of the lower chord is not practical or recommended.

ALTERNATIVE 4: REPLACEMENT BRIDGE ON DOWNSTREAM ALIGNMENT

Build Alternative 4 proposes to replace the bridge on the downstream alignment. Although traffic could be maintained on the existing structure during construction of the proposed spans, the bend in the river would make this alignment less desirable. The geometry would result in reverse curvature, more impacts below ordinary high water, and acquisition of existing residences. For these reasons, this alternative was eliminated early and not fully developed.

3.3 Utilities

Several utilities are located within the project area all around the existing bridge. Utilities verifications have been sent to various companies. The private gas companies are the only utility to not return verification as of the date of this report. In summary, the cost of the needed utility relocations outside of the existing right-of-way is insignificant across the alternatives.

The main overhead utility pole located near Abutment 2 on the downstream side supports utilities in all directions. This pole should be able to remain in place for alternatives, except Alternative 1B where it will conflict with the abutment excavation. The guy wire for this pole will need to be reconfigured for all alternatives. The pole is inside right-of-way, so the relocations should not affect the project costs. The overhead telephone paralleling the downstream upper chord will need to be relocated during demolition of the truss (Photo 25). The overhead fiber optic and telephone lines routed to the utility poles in the vicinity of the parking lot of Cairo United Methodist Church will need to be relocated at least temporarily during girder erection. Underground telephone on the southeast corner of the bridge will likely need relocated. The sanitary sewer lines and manholes on each approach should not need relocation. One gas line passes directly in front of Abutment 1 and will need relocated or abandoned (Photo 26). The gas line that parallels the downstream side of the bridge and is aerial in the stream will need to be relocated for Alternatives 1A and 1B (Photo 27). Several gas lines and markers exist downstream of the bridge near Abutment 1 which should not be affected (Photos 28-29). An underground gas line crossing Main Street (WV 31) at the south end of the bridge will need relocated for Alternative 2. A ¾" plastic underground water line crosses Main St. and the parking lot of Cairo United Methodist Church which should be able to remain.

Utility relocation costs will be provided by WVDOT and included with the final submission.

3.4 Major Drainage Requirements

No pipes 36" or larger are required for this project.

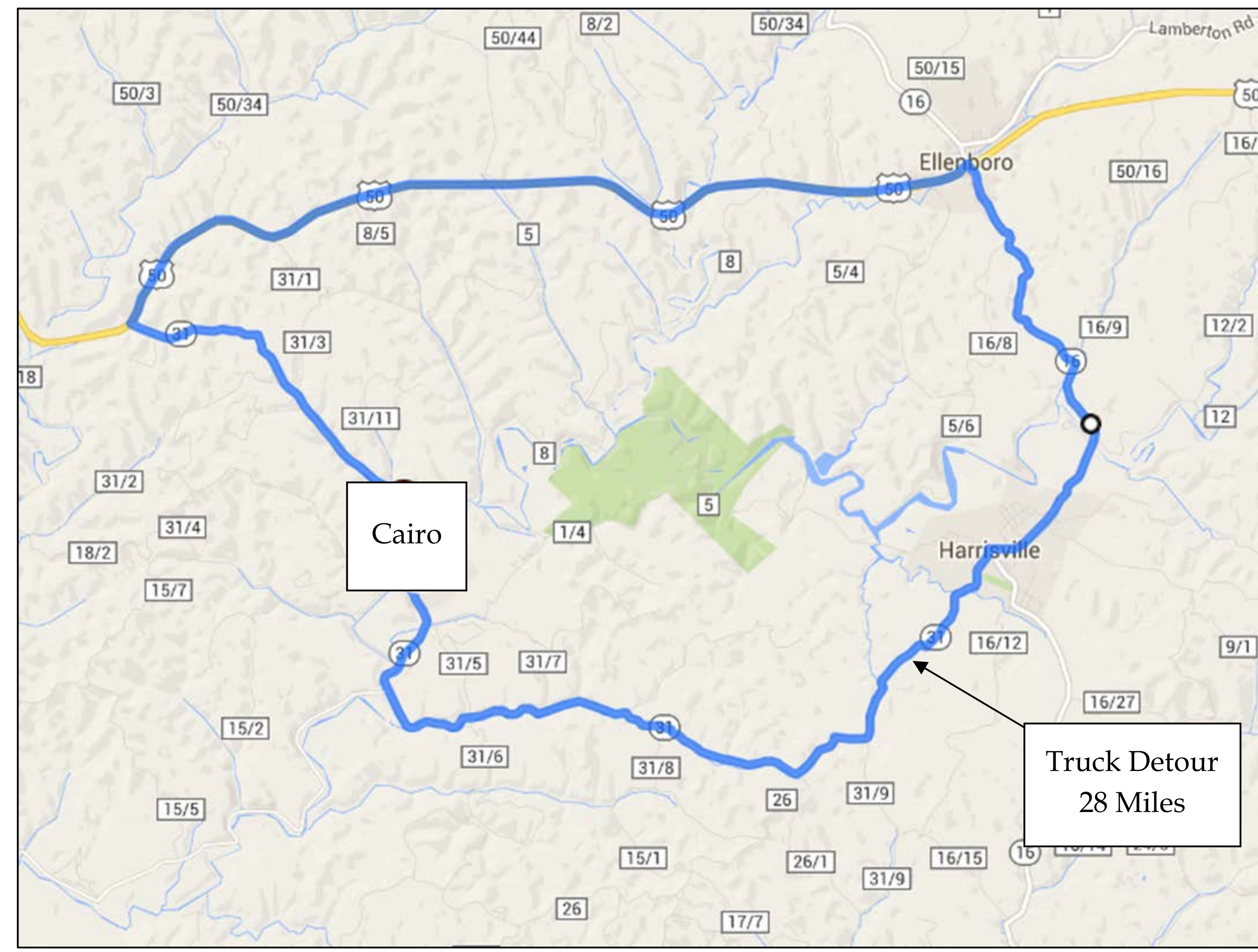
3.5 Constructability Issues

The girder will be spliced as needed to hold the field section to 100 feet which should be deliverable to the site. The piers and abutments are proposed out of the ordinary high water of the North Fork of the Hughes River, which should avoid the need for cofferdams and dewatering.

During Field Review Submission, we examined the feasibility of dismantling the existing structure and erecting the girders without impacting the stream. After review and discussion, on site of the complex demolition and erection plans provided in the Field Review Submission, WVDOT and B&N have concluded that the risk of proposing these unconventional methods is not warranted for this site. These risks which could still include inadvertent damage to the natural resource would be more than a responsible contractor would assume and would be reflected in a construction cost greater than has been presented in this Office Review Submission. Likewise, in-stream work will be required and a biological assessment for the mussels in the stream is being pursued.

Temporary rock causeways are proposed on each river bank with the center of the channel remaining open. This will allow crane and equipment to access each side for normal demolition and erection procedures. Alternative 2A may have less crane cost due to the erection of a single girder at a time with straight girders (instead of curved girder pairs like 1A).

Temporary shoring will be required on the south approach during the phased construction of Alternatives 2A and 2B abutment wingwalls where they conflict with existing structure which is still in service. Prior to the bridge construction, adequate time should be allowed for the relocation of various utilities. Pile driving may result in vibration felt in the adjacent residences and church structure.



Detour Map

3.6 Temporary Traffic Control

Schematic plans which apply for all alternatives are included in Appendix E.

It has been suggested that there is a 16-mile detour over County Route 5 and through North Bend State Park that most people would use if this bridge was out of service. However, the official 28-mile detour for truck traffic would be WV Route 31 to US Route 50 to Ellenboro and then on WV Route 16 through Harrisville and back to Cairo on WV Route 31 (see Detour Map). Likewise, no feasible detour is available for the duration of bridge construction. Accelerated bridge construction alternatives were not considered at this site due to the lower ADT.

3.7 Pedestrian Facilities

A 5′-0″ wide sidewalk will remain in service throughout construction in Alternatives 1A, 1B, 2A and 3 with one 5′-7 3/8″ sidewalk available on the completed structure. During construction of Alternative 1B, the sidewalk will need be closed to construct the abutment.

3.8 Bicycle Facilities

Cairo is a popular destination for bicyclists along the North Bend Rail Trail. Although dedicated bicycle lanes have not been included, the bicycles are accommodated within the proposed typical section per DD-813 by using wider 11-foot lanes and 4-foot shoulders. All the bridge barriers are topped with aluminum, bicycle-friendly railing that is 48″ tall due to the potential for a high drop off and significant bicycle traffic.

3.9 Proposed Right-of-Way

Proposed right-of-way takes will be required for the construction of the bridge. The parking lot area of the Cairo United Methodist Church will have minor takes in all the replacement alternatives (Photo 18). The contractor will have to maintain access to the Cairo United Methodist Church parking lot, residences, and businesses. However, the function of the parking lot should not be significantly affected. Given the historical nature of the church and congregational decisions that will need to occur, additional time will be required to coordinate and obtain this right-of-way. Only 5′ of right-of-way was taken outside the construction limits in attempt to limit the impact. Many of the alternatives require acquisition of a portions of empty lots on both the upstream and downstream sides of the bridge (Photos 11 & 12). An offset of 15′ was used outside of the construction limits on the empty lots. The upstream temporary detour will require temporary construction easement (TCE) from various properties. See Appendix E for the ownership index and property map. Notice the ownership of one parcel on the downstream side of the bridge is not apparent from the tax maps.

3.10 Hydraulic Performance

The Revised Preliminary Hydraulic Study of the alternatives is submitted under a separate cover and is summarized as follows:

As a result of the updated modeling, the base flood elevations of the existing conditions have increased by 0.27 feet at Section 84275 (14C).

The profile of the structure alternatives is set to provide approximately 2 feet of freeboard over the 25-year storm and minimal backwater for the 100 year storm. The existing structure low steel is well above the 100 year flood. All of the low steel will be designed to be above the 100-year flood. The temporary detour structure is designed to provide 2 feet of freeboard over the 10-year storm.

The proposed alternatives increase the 100-year water surface level up to 0.02 feet at the furthest upstream section (85694) and up to 0.05 feet just upstream of the existing bridge at section 84502. Since the existing FIS does not include the Regulatory Floodway, up to 1.0-foot of cumulative increase is permitted, including the effect of the proposed bridge. The temporary conditions has no impact on normal flows downstream of the bridge and minor impacts upstream. At the 100 year flow and above, the impacts upstream of the bridge due to the temporary conditions are generally still minor (0.51 feet and 0.20 feet at section 85694 for 100-yr and 500-yr profiles, respectively).

3.11 Bridge Aesthetics and Lighting

The location of bridge is visible from all sides to locals and tourists. Although the existing bridge has ornamental latticed steel railing along the sidewalk and latticed steel truss members (Photo 4), the aesthetics of the existing bridge are not enhanced. The south approach to the bridge (Main Street) has roadway lighting mounted to the utility pole. Lighting does not exist on the current bridge. Aesthetic treatment and lighting of the proposed alternatives is not anticipated at this time.

3.12 Other Considerations

The following should be considered during the next phase of the project:

- The tax maps for the project area are approximate and unclear. The deeds need to be plotted and further researched for more accurate property boundaries.

Table 2
Comparison of Alternatives

Number	Alternative	Bridge Width (feet)	Bridge Length (feet)	# of Spans & Span Lengths (ft)	Impact to Traffic During Construction	Re-use of Existing Historic Structure	Hydraulic Performance	Stress to Mussels in Stream	Utility Impacts	Right-of-Way Impacts	Right-of-Way Costs	Construction Costs
1A	Single Span Replacement Bridge on Existing Alignment	30	188	1 Spans @ 185	Moderate; Maintain traffic on temporary alignment.	None; All new construction	Best; Zero Backwater	Most; Causeway, temporary bridge pier, demo activities.	Low	Less Permanent Take Area	$110,000	$3,362,000
1B	Three Span Replacement Bridge on Existing Alignment	30	270	3 Spans @ 68, 122, 68	Moderate; Maintain traffic on temporary alignment.	None; All new construction	Good; 0.05′ Backwater	Most; Causeway, temporary bridge pier, demo activities	Higher (but not at cost to project)	Less Permanent Take Area	$108,000	$3,112,000
2A	Single Span Replacement Bridge on Upstream Alignment	30	188	1 Spans @ 185	Low; Maintain traffic on Existing.	None; All new construction	Better; 0.03′ Backwater, Less Backwater for Temporary	Moderate; Causeway and demo activities.	Low	Most Permanent Take Area	$113,000	$2,839,000
2B	Three Span Replacement Bridge on Upstream Alignment	30	270	3 Spans @ 68, 122, 68	Low; Maintain traffic on Existing.	None; All new construction	Better; 0.03′ Backwater, Least Backwater for Temporary	Moderate; Causeway and demo activities.	Low	More Permanent Take Area	$112,000	$2,805,000
3	Rehabilitate Bridge using Upstream Temporary Detour	18′-5″; Functionally Obsolete	185	1 Spans @ 180	Moderate; Maintain traffic on temporary alignment.	Re-use of trusses, floorbeams, railing, and abutments	Best; Zero Backwater	Least; No Construction Below OHW	None	Mostly just TCE	$91,000	$3,146,000
4	Replacement Bridge on Downstream Alignment	30; Poor Alignment with Reverse Curves	270	3 Spans @ 68, 122, 68	Low; Maintain traffic on Existing.	None; All new construction	Not Analyzed	Most; Causeway, temporary bridge pier, demo activities	Low	Most Significant, 1 Residence Displaced	Highest	Highest

4.0 CONCLUSIONS

The following conclusions may be inferred from this report:

- The No Build Alternative is not feasible.
- All of the alternatives are hydraulically acceptable.
- Alternative 3 would only provide a short-term structural solution and a sub-standard roadway width, require design exceptions, and would be 12% more costly. As a result of distress noted during the last inspection, this rehabilitation is not feasible.
- The three-span bridges of Alternatives 1B and 2B would be most feasible to erect.
- Replacing on the existing alignment in Alternatives 1A and 1B have less impact on the church parking area.
- The use of a temporary detour bridge will take the distressed existing bridge out of service earlier in the project schedule.
- The single-span bridge of Alternatives 1A and 2A have less substructures and bridge deck area to maintain in the future and provide the most open channel for flood debris.
- Replacing on the upstream alignments of Alternative 2A and 2B is the least cost and the least impact of traffic during construction.

Based on the conclusions of this design study report and review with WVDOT, we recommend proceeding with Alternative 1B: Three Span Replacement Bridge on Existing Alignment as the preferred alternative at this time. Concern over the existing bridge condition was the primary selection factor in this recommendation.