April 22, 2020

Mr. Keith A. Cota, PE
Chief Project Manager
New Hampshire Department of Transportation
7 Hazen Drive
P.O. Box 483
Concord, NH 03302

Re: Tsienneto Road over Tributary E, Exit 4A
Type, Span and Location Study
Fuss & O'Neill Reference No. 20190127.A10

Dear Mr. Cota:

Fuss & O'Neill is pleased to provide the following TSL Report for the construction of the Exit 4A Tsienneto Road Bridge over Tributary E. This report summarizes the layout and superstructure type, and evaluates the substructure types for the proposed bridge.

Executive Summary

- The bridge will replace the two existing undersized 30-inch and 36-inch diameter corrugated metal pipes.
- A simple-span prestressed precast concrete solid (or voided) slab bridge with a composite concrete overlay is recommended.
- Semi-Integral concrete abutments bearing on soil is recommended.

Existing Condition

The existing Tsienneto Road consists of two 11-foot lanes with a 3.25-foot shoulder on either side for a curb-to-curb width of 28.5 feet. The existing structure consists of a 30-inch diameter corrugated metal pipe (CMP) and a 36-inch diameter CMP skewed 30 degrees to the road. An additional 30-inch CMP begins in the driveway of the northeast abutter upstream and outlets at the same location of the other CMPs. This pipe will be removed in the vicinity of the bridge. The area upstream/north of the structure was delineated by the Town of Derry as a prime wetland; therefore, it is imperative a larger replacement structure does not result in a reduction of the water surface elevations within the wetland for normal flows. According to the Tsienneto Road over Tributary E Hydrologic and Hydraulic Report dated November 2019, the pipes are undersized and Tsienneto Road is overtopped for all storms greater than the 25-year event.

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Proposed Roadway Alignment and Profile

The proposed Tsienneto Road will be widened as part of the project to accommodate 5-foot shoulders for a curb-to-curb width of 32 feet as well as a 5.5-foot sidewalk on the north side. The sidewalk width will transition to 6-feet over the bridge. The centerline of the proposed structure will be on a horizontal tangent, however, due to the 30-degree skew of the proposed replacement structure, the northwest corner of the bridge will be within the horizontal approach curve. Due to the location of the structure in relation to the horizontal approach curve, the cross slope along the length of bridge will be along the superelevation runoff transition.

The existing roadway embankment is only 6 to 7 feet above the thalweg of Tributary E, which limits the possible structure replacement types to those with shallow structure depths. As part of the proposed roadway improvements and to maximize the available clearance for a replacement structure, the Tsienneto Road profile will be raised 2 feet, and the vertical profile at the project location will be on a tangent. Although an additional increase in the roadway profile would be beneficial for the hydraulic design, the amount of the raise is limited by the intersection of Tsienneto Road and Chester Road (Route 102), which is located several hundred feet to the east and is at the project limits.

Proposed Bridge Layout

Adjacent to the upstream invert of the existing crossing is a gravel drive that provides access to the abutter's property. Due to the limited frontage of this property along the road that is further reduced by the extensive wetlands present on the property, relocating this drive is not feasible. Therefore, the bridge will be located far enough away from the drive to provide sufficient room to accommodate a wingwall and to properly terminate the guardrail that will need to wrap around the edge of the drive. The location of the bridge is further limited by the horizontal alignment of the proposed road. To ensure the bridge is not located partially on a horizontal curve resulting in complicated geometry, the bridge will be located far enough to the east to ensure the entire centerline of the bridge is located on the tangent of the road.

Based on the above factors, the bridge will be placed just past the tangent point, which will also provide enough space past the drive to accommodate guardrail along the edge of the adjacent drive and a flared wingwall on the proposed structure. The gravel drive itself will be paved to the limit of work past the end of the guardrail terminal.

A 40-foot clear-span was initially estimated for the hydraulic analysis, which assumes 1.2 times bankfull width plus 2 feet with a delineated bankfull width of 32 feet. However, the NHDES Stream Crossing Requirements state that the clear-span should be equal to the bankfull width times a factor based on the "low" side of the entrenchment ratio as specified by "The Key to the Rosgen Classification of Natural Rivers" (Rosgen) chart. The stream survey, conducted after the hydraulic analysis was completed, determined an entrenchment ratio of 5.91 and a revised bankfull width of 18.3. Based on the Rosgen chart and an entrenchment ratio of 5.91, a factor of 2.2 should be used, which results in a clear-span of 40 feet. As the resulting clear-span did not change from what was originally estimated, the results of the hydraulic report are accurate and do not need to be updated. The hydraulic analysis indicates that a 40-foot clear-span structure passes the design 50-year event without overtopping based on an assumed structure depth of 3 feet. However, a scour analysis has not been performed and will be required.

As the crossing occurs within a FEMA detailed study area that includes a floodway delineation, a Letter of Map Revision (LOMR) application will be required at the completion of construction and hydraulic analyses of existing and proposed conditions will be required. As-built survey will be required to complete the application.

The proposed structure is recommended to be skewed 30 degrees to the road to align with Tributary E as closely as possible. A clear-span of 40 feet (perpendicular to the stream) results in a 50-foot span along the alignment from centerline-of-bearing to centerline-of-bearing.

To ensure no reduction in the wetland water surface elevations for normal flows, a weir structure will be utilized at the outlet of the replacement bridge, and the 293.3-foot elevation of the weir crest was set based on the hydraulic analysis to maintain existing upstream water surface elevations up to and including the 2-year event. Upstream water surface elevations will decrease as compared to existing for storm events greater than the 2-year event. A low flow channel will be built into the weir structure to accommodate fish passage.

<u>Bridge Superstructure</u>

A span length of 50 feet eliminates buried structures as a replacement option, therefore the replacement structure will be a bridge.

T4 bridge rail with a 6-foot sidewalk will be provided on the north side of the bridge, and T3 bridge rail will be provided on the south side. As noted previously, the bridge will be located on a horizontal and vertical tangent with cross slopes along the length of bridge on a superelevation runoff transition.

Based on the hydraulic analysis, the controlling low chord elevation to accommodate the minimum 1-foot of freeboard for the 50-year design event is 295 feet. This results in a maximum structure depth of approximately 3 feet. Given this fairly shallow structure depth, two bridge superstructure options were ultimately considered suitable for the project requirements; precast, prestressed concrete solid (or voided) slabs with a composite cast-in-place concrete overlay and rolled steel girders with a composite cast-in-place concrete deck. A precast, prestressed concrete NEXT beam bridge was eliminated as an option as the required depth of the NEXT beam for this span would be too deep to accommodate the required 1-foot of freeboard. The concrete solid slab and steel options are discussed below.

Option 1 – Rolled Steel Girders

Two 11-foot travel lanes and a 5-foot shoulder will be provided in the eastbound and westbound directions. The out-to-out bridge width of this option is 41.5 feet. After accounting for the cross-slope, pavement, deck, and haunch; the 3-foot structure depth results in an allowable beam depth of approximately 18.4 inches. The preliminary girder layout assumed a small 6-foot girder spacing to minimize the required beam depth. This spacing results in a total of 7 beams with 2.5-foot overhangs. The shallowest beam that meets the live load deflection criteria of L/1000 for the proposed layout is a W14x311. However, this beam is not economical and the steel cost for this option will be high for the relative size of the bridge. A more economical W18x211 rolled beam was then selected as the next shallowest beam to meet the live load deflection criteria. However, the actual beam depth of this section is 20.7 inches, which results in a 2.3 inch reduction of the required 1-foot of freeboard; therefore, it is not recommended. In order to meet the 1-foot freeboard requirement, the W14x311 beam or similar size plate girder, will be required for the steel superstructure option.

For the 10-year event, the low chord of the structure is less than 2 feet from the water, therefore, weathering steel is not recommended. Due to the length of the proposed beams and the lack of larger kettle lengths locally, double dipping would be required to galvanize the beam, or the beam would need to be sent out of the region. A splice could be utilized to shorten the beam length, but is not ideal. Double dipping would roughly double the cost of galvanizing per pound of steel, and shipping the beams out of the region to dip them would also be expensive. Due to the high cost of galvanizing, metalizing is recommended.

Since the size of the rolled beam needed to meet both the deflection and freeboard requirements is uneconomical, this option is not recommended.

Option 2 – Precast, Prestressed Concrete Solid (or Voided) Slabs

As precast, prestressed concrete slab units come in specific whole number widths, the bridge out-to-out width of this option had to be increased to 42 feet. One 11-foot travel lane and a 5.5-foot shoulder will be provided in the eastbound direction and one 11-foot travel lane and a 5-foot shoulder will be provided in the westbound direction. The additional 6 inches in bridge width was added to the east shoulder. The structure will consist of a combination of 3- and 4-foot wide by 21-inch deep precast, prestressed solid (or voided) slab units with a 6-inch composite cast-in-place concrete overlay. This option will give a structure depth of 29.5 inches, which is below the maximum allowable 36 inches (3 feet).

Due to the varying cross slopes, it is recommended the slabs be set level transversely and the cross-slope will be made up by varying the thickness of the concrete overlay. Concrete is also preferred as compared to steel when in close proximity to surface water.

This option is recommended as it meets the freeboard requirement, is more cost effective than the steel beam option, and is more durable than steel in close proximity to water.

Geotechnical

Four borings were taken near the proposed abutment locations. The borings furthest from the stream on either side have approximate bedrock elevations of 288.5 feet (B01) and 285.3 feet (B06). The bedrock for these borings are listed as slightly to moderately weathered and moderately to extremely fractured. The rock quality designation for the cores sampled were 54% (B01) and 61% (B06). The two borings closest to the stream and approximate abutment location have approximate bedrock elevations of 277.3 feet (B03) and 276.8 feet (B05). In both B03 and B05, the soil above the approximate bedrock consists of dense sand and gravel with high blow counts per foot.

Abutment Type

Several abutment types have been evaluated for the recommended bridge layout; integral/semi-integral, cantilever on piles, and cantilever on spread footings. The evaluated abutment types are discussed below.

Cantilever Abutment on Piles

This option consists of a cantilever abutment supported on piles driven into bedrock. An expansion joint should be located at Abutment A because it has the higher finished grade elevation. The joint should also be located behind the backwall to protect the bearings and beam seat from future leaking.

According to the NHDOT Bridge Design Manual section 6.2.2.B, the bottom of a footing founded on piles should be 4 feet below finished grade. The proposed minimum finished grade in front of both abutments is 290.4 feet which leaves a bottom of footing elevation of approximately 286 feet. This would result in a maximum depth to bedrock of 9.2 feet from the bottom of footing, and it is possible that the bedrock would be above or just below one or both of the abutment footings. It is therefore not cost effective to mobilize pile driving for such short piles, so this option is not recommended.

Cantilever Abutment on Spread Footings

This option consists of a cantilever abutment on soil or rock and will have the same geometry as the cantilever abutment on piles option.

According to the NHDOT Bridge Design Manual section 6.2.2.B, the bottom of a footing founded on soil should be 5 feet below grade. This results in a bottom of footing elevation of approximately 285 feet. The competency of the existing soil for bearing should be confirmed by a geotechnical engineer. If the soil is found to be competent, the footing could be founded directly on the existing soil. If it is not considered competent, the existing soil could be excavated to bedrock and replaced with either structural fill or a tremie seal/subfooting depending on the actual bedrock elevations once the subgrade has been revealed. Additionally, the competency of the bedrock for bearing will need to be evaluated by a geotechnical engineer.

The cost to do this work would be less than driving short piles, therefore spread footings are recommended. However, it should be noted that a scour analysis has not yet been performed and may dictate the bottom of footing elevations and/or subgrade materials below the footings.

Integral/Semi-Integral Abutments

According to the NHDOT Bridge Design Manual sec. 6.4.2.B, integral abutments with skews greater than or equal to 20 degrees cannot be designed utilizing the simplified method documented in the VTrans Integral Abutment Bridge Design Guidelines. Although a more advanced method could be utilized to design integral abutments at a 30 degree skew, it is not a feasible option due to the short pile lengths. However, semi-integral abutments on spread footings could be utilized and would be preferable to a cantilever abutment because it moves the joint off the bridge. The spread footings for this option are required to satisfy the same requirements as the cantilever abutments on spread footings discussed above. A semi-integral abutment will conform to the current NHDOT bridge design manual details, which have been included at the end of this report.

Maintenance of Traffic

Phased construction will be utilized to construct the replacement structure. Three phases will be required to complete the work. During phase 1 and phase 2 construction, eastbound traffic will be detoured via Bypass 28 and Route 102 and westbound traffic will be maintained on Tsienneto Road over the bridge utilizing phased construction. See the traffic control memo (attached) for the traffic analyses. Phase 3 construction will maintain two lanes of traffic on the bridge while constructing the sidewalk. In order to maintain two lanes of traffic throughout construction (one lane in each direction), a structure width of 59 feet would be required or the horizontal alignment would have to be shifted. Since the wetland upstream is delineated as prime and there are delineated wetlands downstream as well, over-widening the structure or shifting the alignment would require significant additional impact to these wetlands and therefore is not recommended.

For the first phase of construction, one lane of traffic will remain on the existing south portion of the roadway while the northern portion of the proposed structure is built. One westbound lane and shoulders will be constructed. The sidewalk will not be built during the first phase because extra room will be needed to accommodate phase two traffic. Excavation support will be required to support the existing roadway while excavating for the proposed abutment footings.

While driving the sheeting to support the existing roadway during the first phase, stream flow must be maintained through the construction area. Due to the proximity of the existing pipes to the proposed Abutment A, the pipe closest to the abutment could be removed with the other pipe being maintained during construction. However, this would reduce the existing hydraulic opening which is already significantly undersized. In addition, the condition of this pipe is unknown and the removal of the pipe adjacent to it could compromise its integrity and prevent its use. Alternatively, a new temporary pipe could be installed through the existing roadway embankment to maintain stream flow during construction. This work will require multiple days of one-way alternating traffic or a temporary closure to excavate and install the pipe. Alternatively, jacking the pipe through the embankment could be done, but would likely not be cost effective. Pumping the water and utilizing a temporary pipe bypassed just beneath the roadway surface to the east of Abutment B could also be an option.

To support phase 1 backfilling of the abutments, excavation support attached to each of the new abutments is required to support the new road while phase 2 excavation operations commence to construct the rest of each abutment. During phase two, traffic will be shifted onto the newly constructed westbound lane while the eastbound lane, shoulder, and railing are constructed. For the third phase of construction, two lanes of traffic will be accommodated by shifting both lanes to the east of the newly constructed bridge so that the sidewalk and railing can be constructed. Temporary one-lane alternating traffic may be required utilizing flaggers during daytime hours for some construction activities such as reinforcement delivery or concrete placement.

Cost Estimate

A preliminary cost estimate, for the bridge only, has been prepared for both superstructure options using the slope intercept method. For the precast, prestressed solid slabs option, the base bridge items were calculated using a square foot cost of $245. For the steel structure option, the base bridge item square foot cost was originally $210. Since an uneconomical beam is needed to accommodate the low chord elevation, the base bridge item square foot cost was raised to $255 to account for the additional steel weight that is required for the uneconomical section as compared to a more economical steel beam section that would have been utilized had structure depth not been a controlling factor. These prices were based on recently bid, similar type, projects.

50-Foot Span Steel Structure

Base Bridge Items:	$	870,000
Cofferdams:	$	180,000
Weir Construction:	$	70,000
Culvert Removal:	$	20,000
Mobilization (10%):	$	120,000
Engineering & Permitting (10%):	$	130,000
Construction Engineering (15%):	$	190,000
GRAND TOTAL	$	1,580,000

50-Foot Span Precast, Prestressed Solid Slabs Structure

Base Bridge Items:	$ 850,000
Cofferdams:	$ 180,000
Weir Construction:	$ 70,000
Culvert Removal:	$ 20,000
Mobilization (10%):	$ 120,000
Engineering & Permitting (10%):	$ 130,000
Construction Engineering (15%):	$ 190,000
GRAND TOTAL	$ 1,560,000

Recommendations

The recommended bridge type is a 50-foot simple-span precast, prestressed concrete solid slab bridge with a composite concrete overlay supported on semi-integral abutments on spread footings. This option meets both the NHDOT hydraulic requirements and the NHDES Stream Crossing Guidelines, is the more economical option, and is more durable than steel in close proximity to the water.

Please contact me if you have questions, comments, or require any additional information.

Sincerely,

Jaime French

Jaime French, PE
Bridge Team Lead | Project Manager

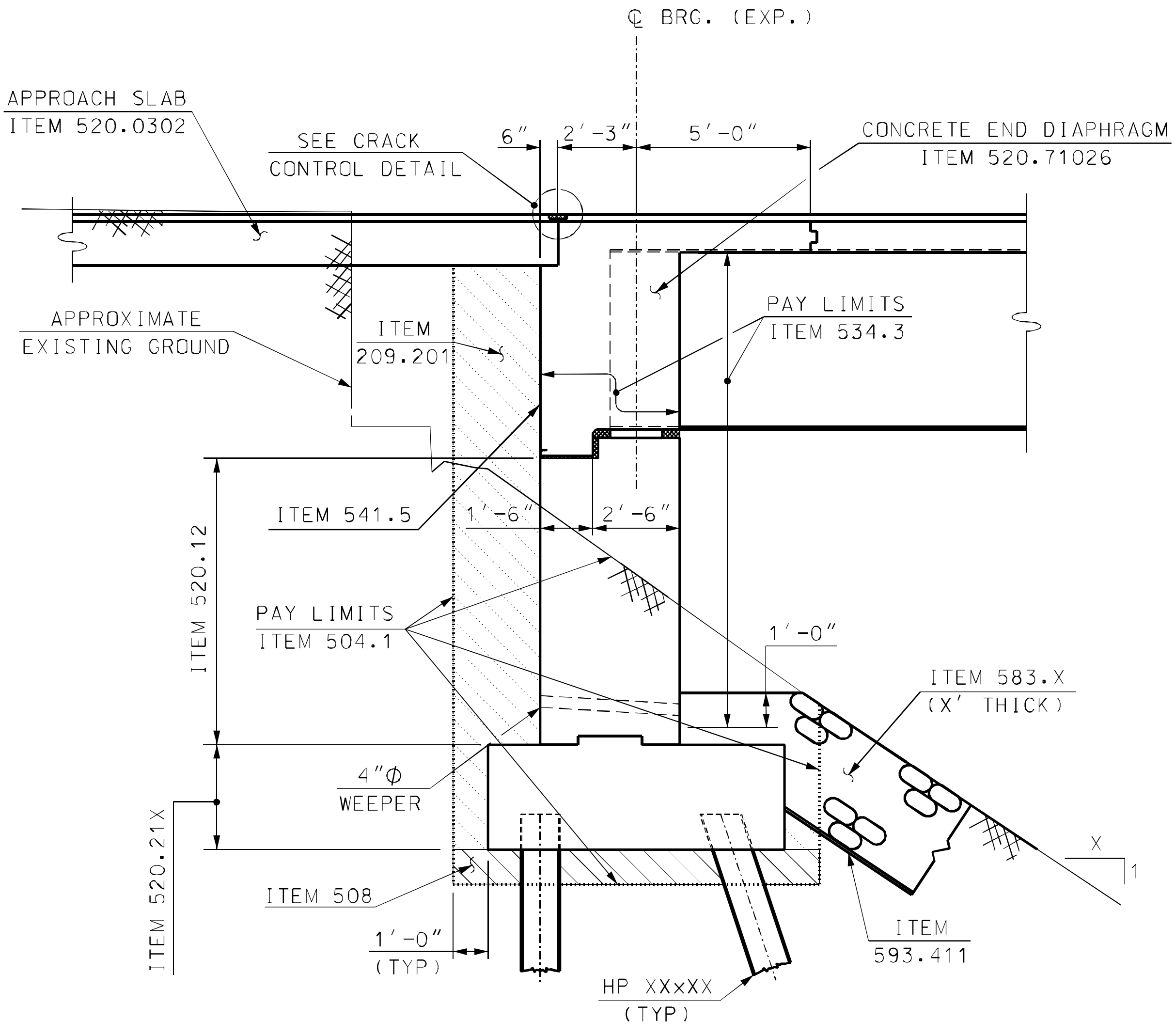
Enclosures

NEW HAMPSHIRE DEPARTMENT OF TRANSPORTATION

BUREAU OF BRIDGE DESIGN

DESCRIPTION: SUBSTRUCTURE DETAILS - TYP. SEMI-INTEGRAL ABUTMENT SECTION

DATE REVISED: 2/8/2016



TYPICAL SEMI-INTEGRAL ABUTMENT SECTION

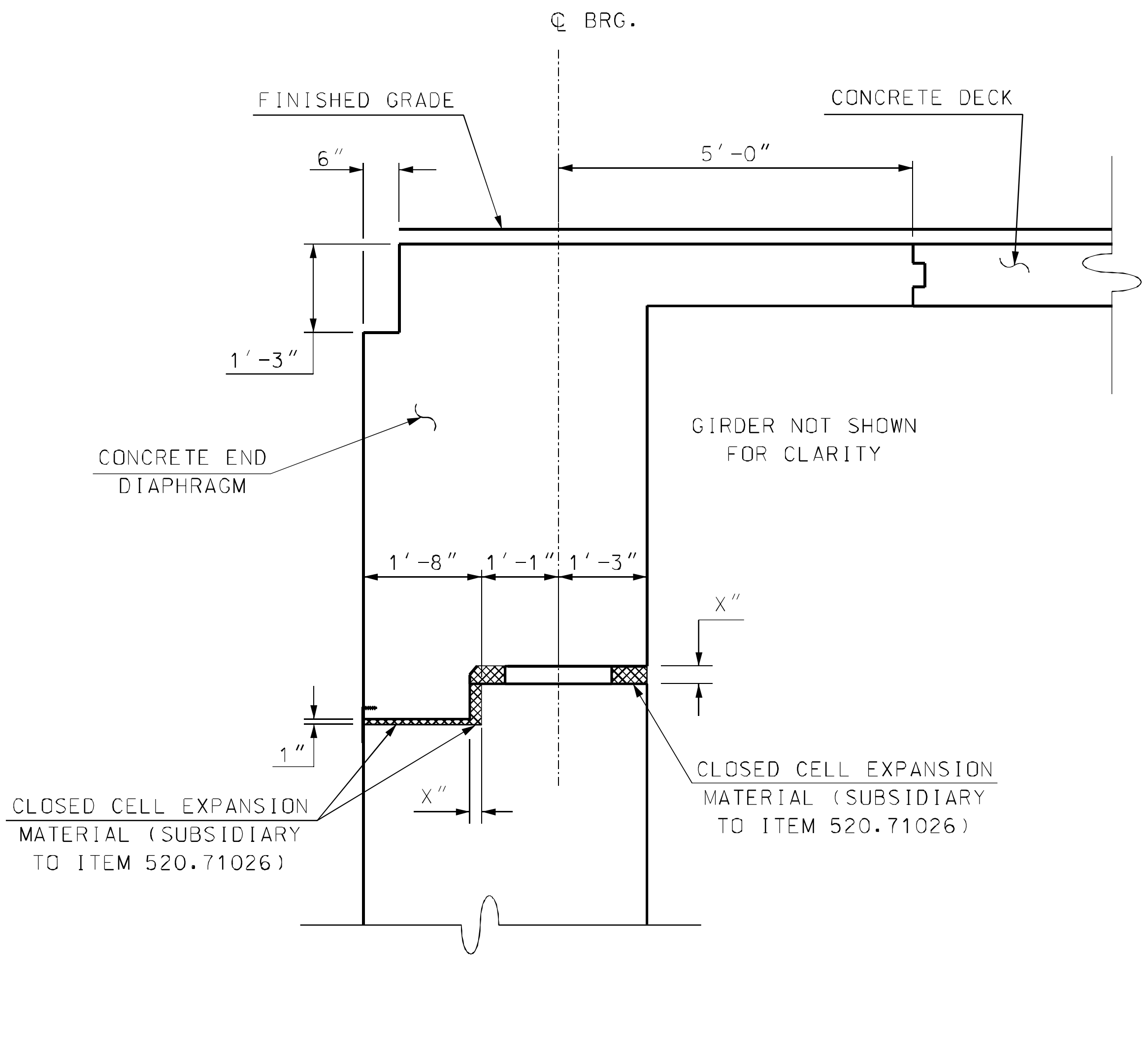
MODIFY TO FIT PROJECT

NEW HAMPSHIRE DEPARTMENT OF TRANSPORTATION

New Hampshire DOT Department of Transportation

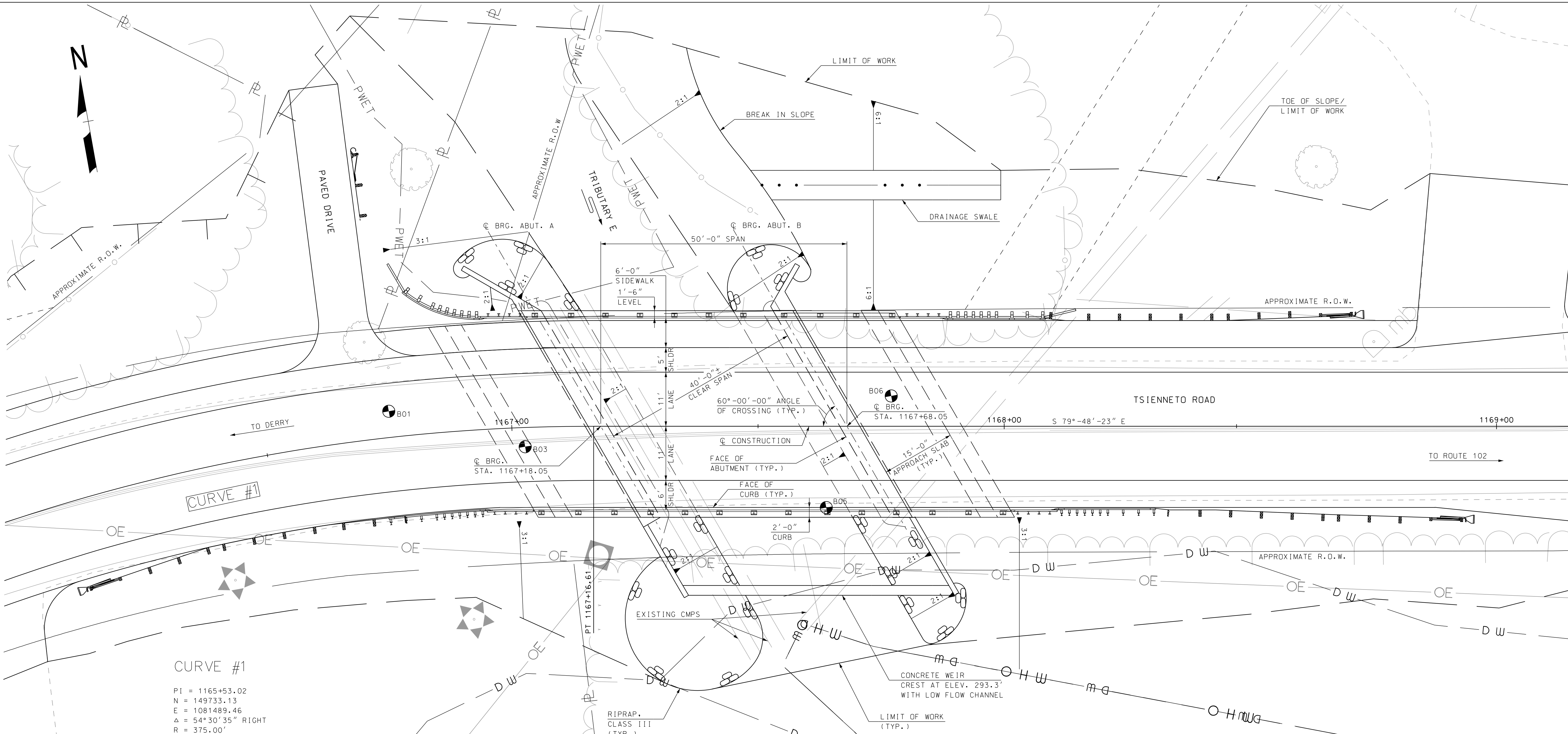
BUREAU OF BRIDGE DESIGN

DESCRIPTION: SUBSTRUCTURE DETAILS - TYPICAL SEMI-INTEGRAL DIAPHRAGM SECTION	DATE REVISED: 2/8/2016



TYPICAL SEMI-INTEGRAL DIAPHRAGM SECTION

MODIFY TO FIT PROJECT

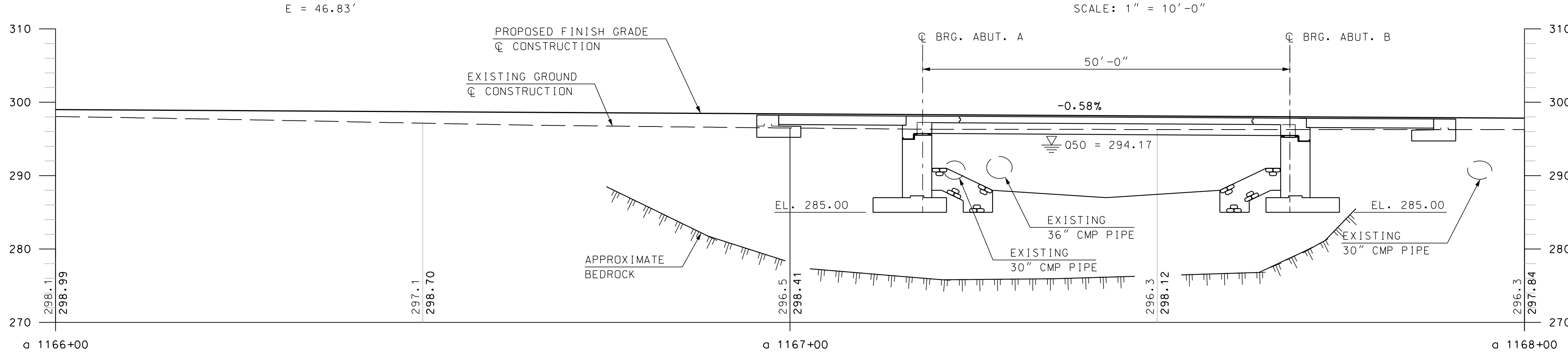


GENERAL PLAN

SCALE: 1" = 10'-0"

CURVE #1

PI = 1165+53.02
N = 149733.13
E = 1081489.46
Δ = 54°30'35" RIGHT
R = 375.00'
T = 193.18'
L = 356.77
E = 46.83'



PROFILE

SCALE: 1" = 10'-0"

FUSS & O'NEILL

SUBDIRECTORY	.DGN LOCATOR	SHEET SCALE
XX	13065PreGen	AS NOTED

STATE OF NEW HAMPSHIRE
DEPARTMENT OF TRANSPORTATION * BUREAU OF BRIDGE DESIGN

TOWN DERRY AND LONDONDERRY — BRIDGE NO. 085\140 — STATE PROJECT 13065

LOCATION TSIENNETO ROAD OVER TRIBUTARY E

GENERAL PLAN AND PROFILE

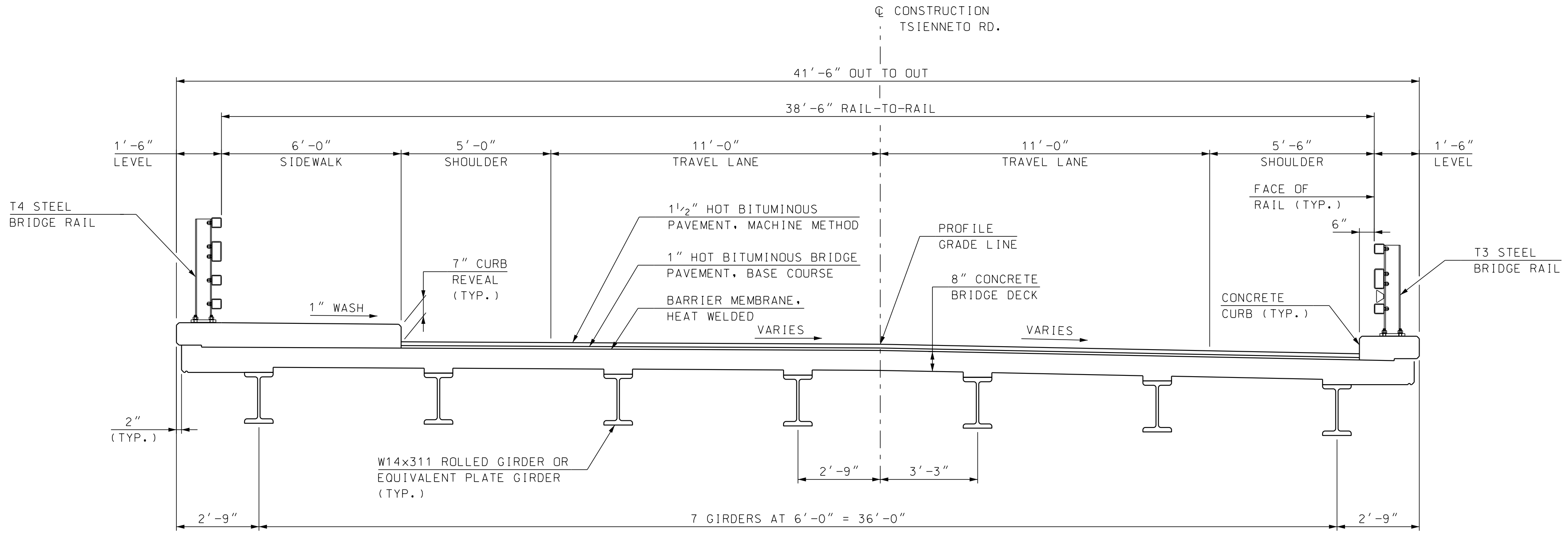
BRIDGE SHEET 1 OF 3

REVISIONS AFTER PROPOSAL

	BY	DATE		BY	DATE
DESIGNED	KAC	9/19	CHECKED	SRB	9/19
DRAWN	MWS	9/19	CHECKED	KAC	9/19
QUANTITIES			CHECKED		

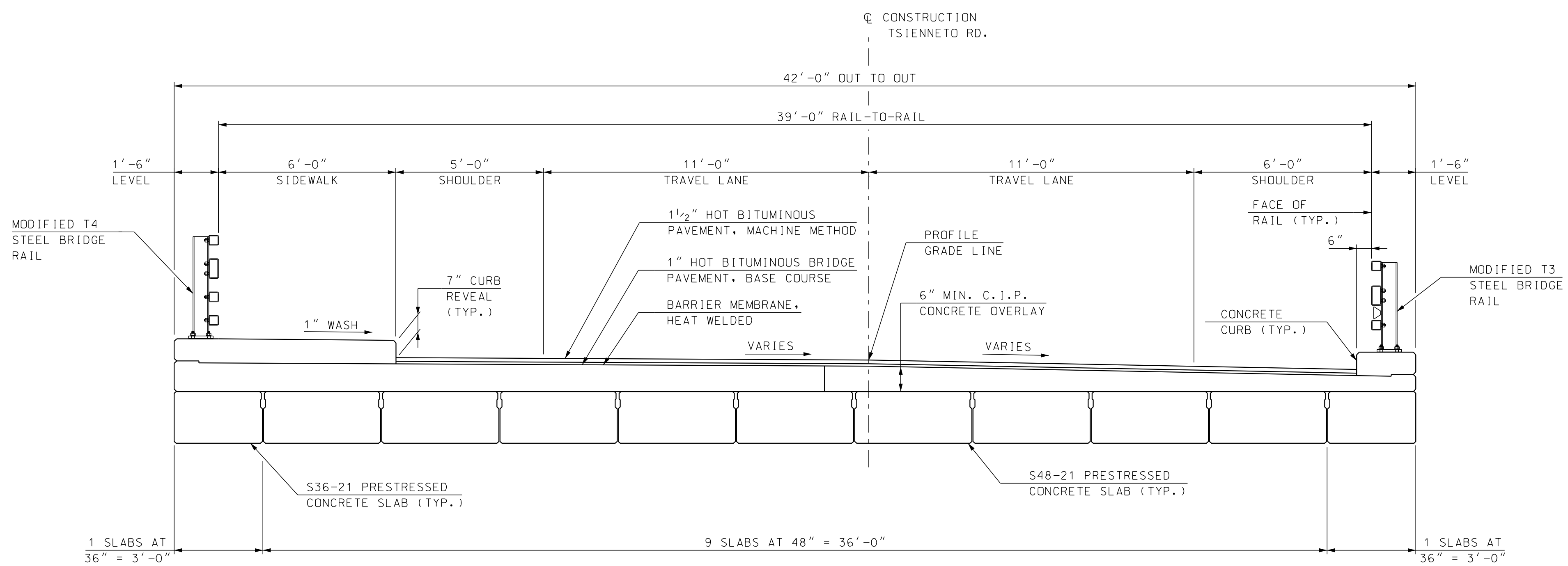
FILE NUMBER

ISSUE DATE	FEDERAL PROJECT NO.	SHEET NO.	TOTAL SHEETS
REV. DATE	------------	1	3



TYPICAL DECK SECTION - STEEL BEAM OPTION

SCALE: ⅜" = 1'-0"



TYPICAL DECK SECTION - SOLID SLAB OPTION

SCALE: ⅜" = 1'-0"

FUSS & O'NEILL

SUBDIRECTORY	.DGN LOCATOR	SHEET SCALE
XX	13065DectSection	AS NOTED

STATE OF NEW HAMPSHIRE

DEPARTMENT OF TRANSPORTATION * BUREAU OF BRIDGE DESIGN

TOWN DERRY AND LONDONDERRY BRIDGE NO. 085\140 STATE PROJECT 13065

LOCATION TSIENNETO ROAD OVER TRIBUTARY E

TYPICAL DECK SECTION

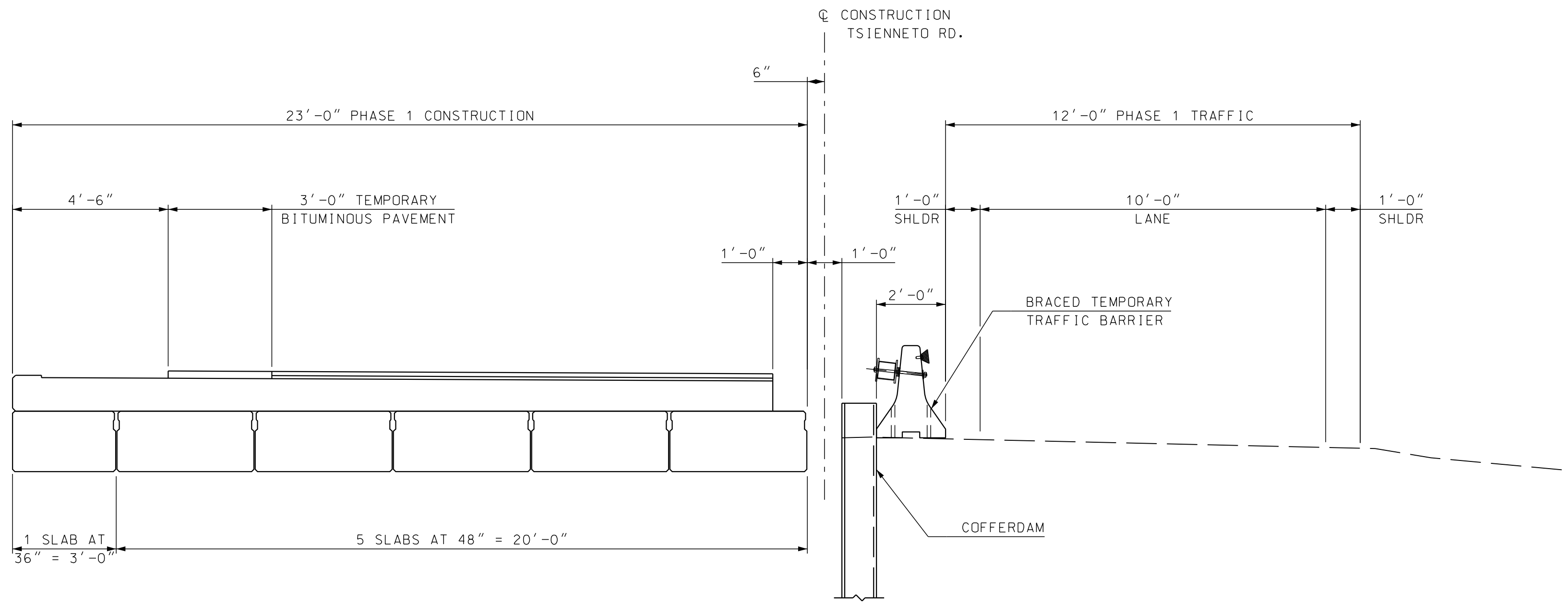
BRIDGE SHEET 2 OF 3

FILE NUMBER

REVISIONS AFTER PROPOSAL

	BY	DATE		BY	DATE
DESIGNED	KAC	1/20	CHECKED	SRB	1/20
DRAWN	MWS	1/20	CHECKED	KAC	1/20
QUANTITIES			CHECKED		

ISSUE DATE	FEDERAL PROJECT NO.	SHEET NO.	TOTAL SHEETS
REV. DATE	------------	2	3

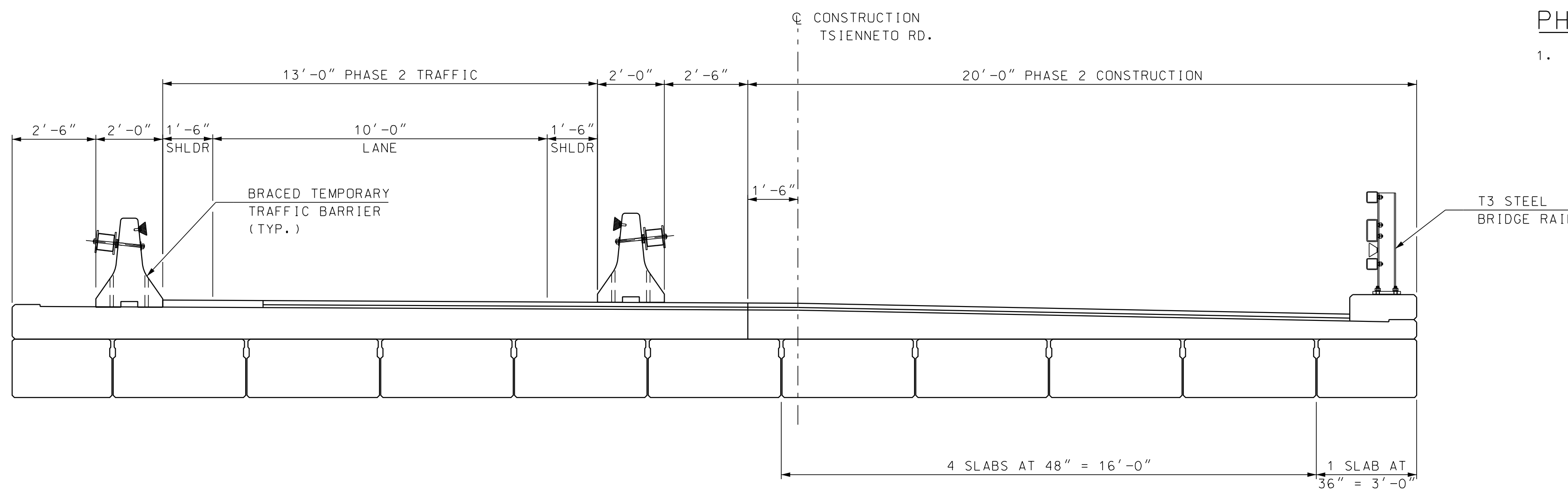


PHASE 1 CONSTRUCTION

SCALE: $^3/_8$" = 1'-0"

PHASE 1 NOTES:

1. CONSTRUCT WESTBOUND LANE OF PROPOSED STRUCTURE (THE WESTBOUND SIDEWALK AND BARRIER WILL BE CONSTRUCTED IN PHASE 3).

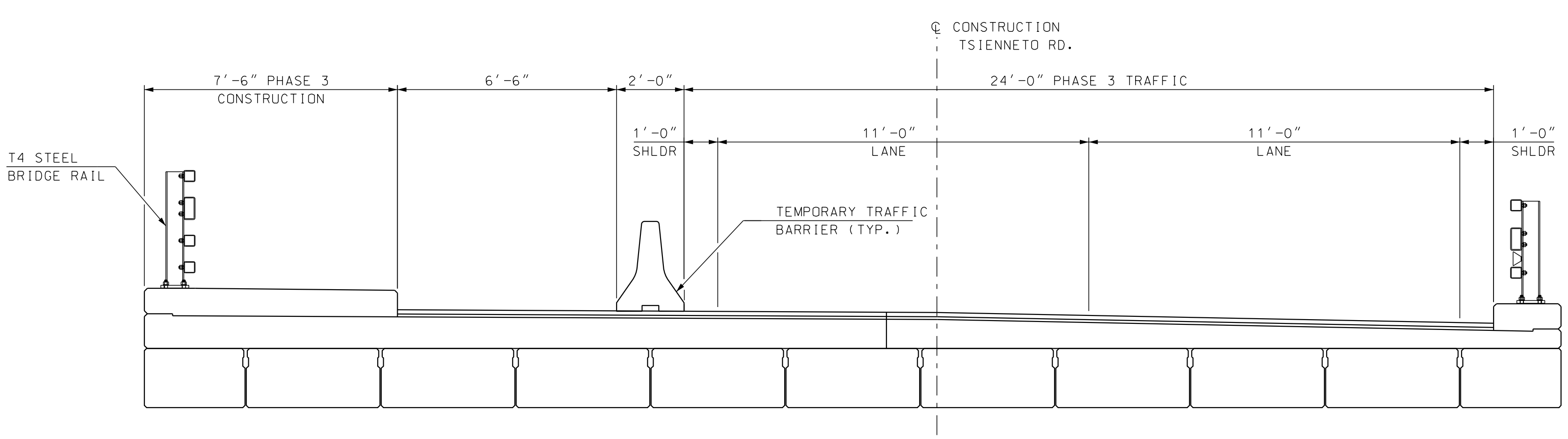


PHASE 2 CONSTRUCTION

SCALE: $^3/_8$" = 1'-0"

PHASE 2 NOTES:

1. MOVE TRAFFIC ONTO WESTBOUND LANE AND CONSTRUCT EASTBOUND LANE AND BARRIER.



PHASE 3 CONSTRUCTION

SCALE: $^3/_8$" = 1'-0"

PHASE 3 NOTES:

1. MOVE TRAFFIC ONTO EASTERN SIDE OF BRIDGE AND CONSTRUCT SIDEWALK AND BARRIER ON WESTBOUND SIDE OF THE STRUCTURE.

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STATE OF NEW HAMPSHIRE
DEPARTMENT OF TRANSPORTATION * BUREAU OF BRIDGE DESIGN

TOWN	DERRY AND LONDONDERRY		BRIDGE NO.	085\140	STATE PROJECT	13065		
LOCATION	TSIENNETO ROAD OVER TRIBUTARY E							
STAGED CONSTRUCTION PHASING								BRIDGE SHEET 3 OF 3
REVISIONS AFTER PROPOSAL		BY	DATE		BY	DATE		FILE NUMBER
DESIGNED		ETC	1/20	CHECKED	SRB	1/20		
DRAWN		MWS	1/20	CHECKED	ETC	1/20		
QUANTITIES				CHECKED				
ISSUE DATE		FEDERAL PROJECT NO.			SHEET NO.		TOTAL SHEETS	
REV. DATE		------------			3		3	

SUBDIRECTORY	.DGN LOCATOR	SHEET SCALE
XX	13065Phase	AS NOTED