Cumbres & Toltec
SCENIC RAILROAD

Lobato Trestle Bridge 339.78 Inspection and Rehabilitation Recommendations Report

August, 2010

HDR

PRELIMINARY
FOR INTERIM REVIEW ONLY. NOT FOR PERMITTING, BIDDING, OR CONSTRUCTION.
Prepared under the Direct Supervision of
JEFFERY W. TEIG, P.E. 16272
8/19/2010

SUMMARY

The purpose of this report is to provide an evaluation of the Lobato Trestle Bridge 339.78 for the Cumbres & Toltec Scenic Railroad. The bridge is located approximately 3 miles north of Chama, New Mexico and carries a single track on a tangent alignment over Wolf Creek. The bridge is approximately 310 feet in length, includes 1-40 foot and 5-54 foot steel open deck plate girder spans and is supported on steel trestle towers with an approximate 80-feet maximum height (See Figure 1). The as-built plans for the structure have a date of 1881 but the actual construction date of the bridge is unknown. The as-built plans do not indicate the type of material that the bridge is constructed.

On June 24, 2010 the timber ties of the open deck bridge caught fire. The fire destroyed the timber ties of spans 1 thru 5 and caused considerable damage to those spans. The bridge was inspected by Todd Riley, Shane Potts and Ann Griessmann utilizing assisted climbing techniques between the dates of 08/03/10 and 08/06/10. The bridge inspection was carried out according to the procedures outlined in the 2008 AREMA Bridge Inspection handbook. The main objective of the bridge inspection was to identify areas of damage to the bridge components caused by the fire, determine other deficiencies of accessible bridge components and provide field measurements of bridge components not addressed in the as-built drawings.

Our report provides a synopsis of the bridge conditions found during the inspection and the load rating results from our structural analysis of the superstructure spans, both of which will be utilized to provide repair recommendations. During the field inspection the General Manager Marvin Casias of the Cumbres & Toltec said that the trains coast over the bridge at a speed of 8 mph because the bridge sits in a sag vertical curve. HDR utilized this information and **did not** include the impact due to the hammer blow of the engine in the rating analysis. Impact due to the rocking effect of the engine, tender and eight (8) viewing cars was included in the load rating analysis. The bridge substructures have not yet been rated. The results of those ratings will be provided at a later date. The repair recommendations should help the Cumbres and Toltec Scenic Railroad determine the best action to preserve the structural integrity of this historic structure. Note that the built-up stone abutments and bent foundations were not inspected per the original scope of services.

The services under this contract include the professional opinion and judgment of HDR Engineering, Inc. based on the data and information reviewed. The conclusions and recommendations presented in this report are based on the information provided by the Cumbres and Toltec Scenic Railroad, our inspection of the bridge and two coupon samples mechanically extracted from the bridge. One sample included a 6-inch long piece of steel lattice removed from the bottom left side of Bent No. 5 and a sample roughly 5 ounces in weight and 2.5 inches in square area removed from the web of the left girder of span 6 at the third point. The coupon samples were sent to a metallurgical testing lab where test were performed to determine the chemical makeup. Yield and ultimate strength tests were also performed. A copy of those results is provided in appendix A.

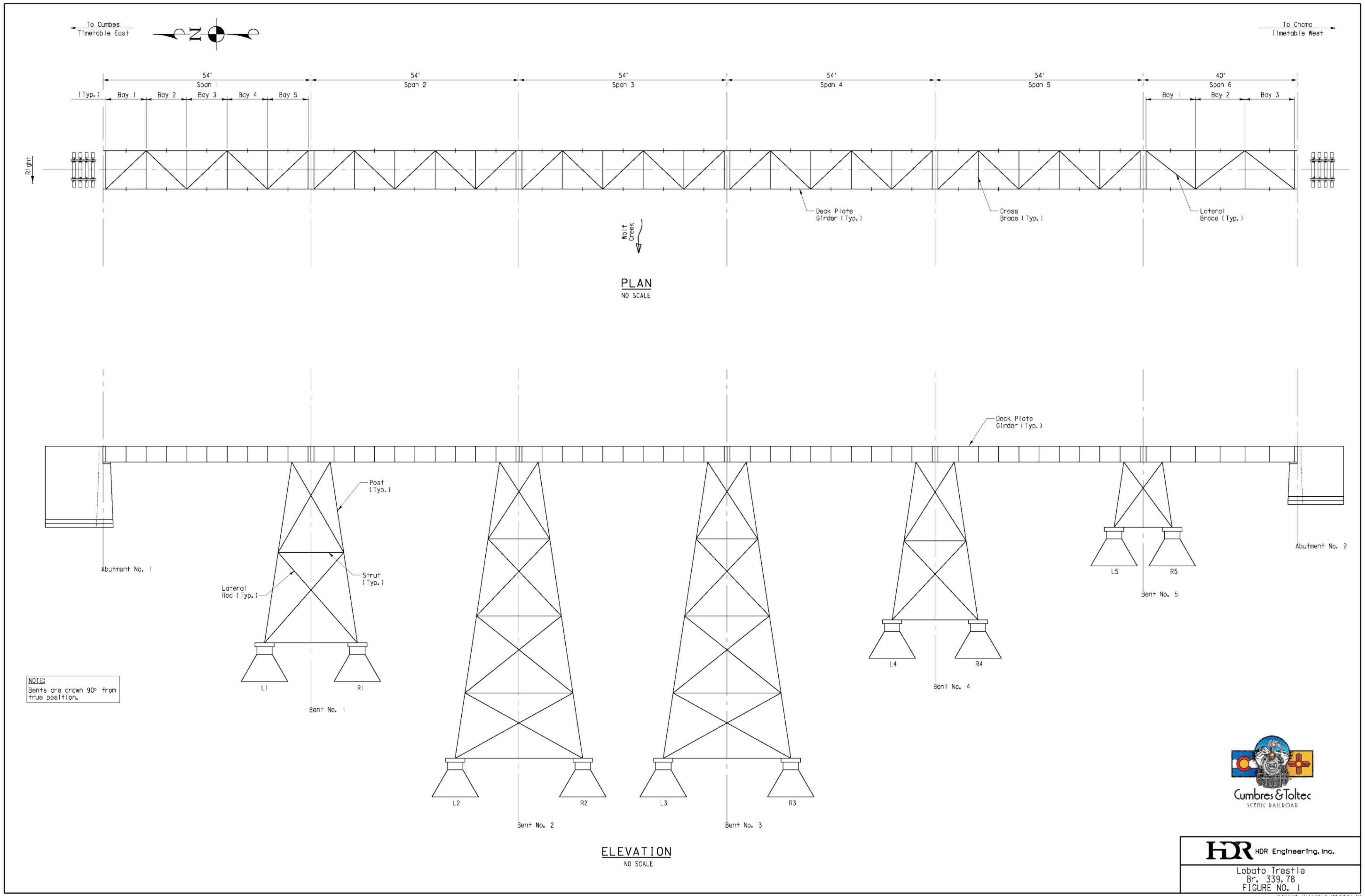
The following sections provide detail for the existing bridge, our inspection procedure, bridge condition summary, detailed inspection findings, rating results, and recommendations for repair. Included in the appendices is the following information:

1. Materials Testing Certification Form (Appendix A)
2. Photos of the bridge taken during the inspection between the dates of August 3 and August 6, 2010. (Appendix B)
3. Rating Calculations and results (Not Included in this submittal) (Appendix C)

North face (left Side) of bridge Looking Timetable West toward Chama

Bridge Element Numbering Methodology

Bents and spans are numbered sequentially in the direction of increasing milepost and left to right facing in the direction of increasing milepost. (See Figure No. 1)


To Cumbres
Timetable East
To Chama
Timetable West
54'
Span 1
54'
Span 2
54'
Span 3
54'
Span 4
54'
Span 5
40'
Span 6
(Typ.)
Bay 1
Bay 2
Bay 3
Bay 4
Bay 5
Right
Deck Plate
Girder (Typ.)
Cross
Brace (Typ.)
Lateral
Brace (Typ.)
Wolf
Creek
PLAN
NO SCALE
Post
(Typ.)
Strut
(Typ.)
Lateral
Rod (Typ.)
Abutment No. 1
Abutment No. 2
L1
R1
L2
R2
L3
R3
L4
R4
L5
R5
Bent No. 1
Bent No. 2
Bent No. 3
Bent No. 4
Bent No. 5
NOTE:
Bents are drawn 90° from
true position.
ELEVATION
NO SCALE
Cumbres & Toltec
SCENIC RAILROAD
HDR Engineering, Inc.
Lobato Trestle
Br. 339.78
FIGURE NO. 1

Bridge Condition Codes

In identifying current bridge member deficiencies the following condition codes will be utilized. They follow the current AREMA bridge inspection manual and are as follows.

P1- Requires immediate attention

P2- Poor condition, keep under observation until repaired.

P3- Fair condition should be monitored.

P4- Item noted, but of no concern.

Bridge Description

The bridge carries a single track on a tangent alignment in compass north/south path but considered east/west railroad directions. The valley cross section is approximately 100 feet deep (from top of tie to flow line) with steep slopes in front of the abutments. Wolf Creek passes at an approximate 90 degree angle to the bridge below span No. 3.

The bridge is approximately 310 feet in length and is comprised of 1-40 foot and 5-54 foot open deck plate steel girder spans. Each span is comprised of two riveted built-up girders with cross-bracing at 10'-6" intervals and laterally braced top flanges between cross braces. Girder bearings at the abutments includes 2, 1 ½-inch diameter anchor bolts per girder (one each side of the flange) located in a masonry plate with 4 ¼" long slotted holes. Girder bearings at the bents are combined bearings (1 bearing for each adjacent girder) bolted in the fixed condition on a single plate. A continuity plate is provided across the top of the adjacent girders and bolted to the top flange of each girder. (See photos 009- 010)

The 5 bridge bents are built-up towers comprised of riveted steel angles and steel plate cross lacing. Each bent has two posts; a transverse cross strut and transverse lateral rods at each level with the exception of the bottom levels. The shortest tower is roughly 17-feet in height and the tallest tower is roughly 77-feet in height. (See photos above) Each tower post provides a single combined bearing location for two girders of adjacent spans. The bearings at the base of each post are comprised of a single forged masonry plate with a single vertical anchor rod located at the center of the plate. A single transverse pin connects the bent post to the masonry plate via bent angles that are bolted to the masonry plate. (See photos 037 – 041)

Summary of Findings

In general, other than damage due to the fire the inspection revealed much of what you would expect to find for a bridge that is roughly 120 years old. Mild amounts of pack rust between abutting plates and cracked and pealing paint. No elongated eye bars, loose rivets or cracked gusset plates were discovered. The bent towers are in good condition. The bridge inspection also revealed that the bearings at both abutments 1 and 2 are tilted/bent in the railroad west direction (toward Chama) which leads us to believe that the entire bridge has shifted in that direction. (See photos 042 – 045)

Superstructure:

- Both girders of Span No. 1 now have a permanent inverted camber of approximately 7". Because of that reverse camber the girders are not resting on the bearings and the span is cantilevering 54-feet (its span length) from Bent No. 1. (See photos 028 – 031)
- The left girder of Span No. 2 has a 1/2" vertical buckle in the flange and a lateral buckle in the web. A majority of the lateral and top cross brace members are distorted and sagging.
- Both girders of Span No. 3 have vertical buckles in the top flanges and lateral buckles in the webs. A majority of the lateral and top cross brace members are distorted and sagging.
- Span Nos. 4 through 5 exhibit more of the same type of fire damage as that of Span Nos. 1 and 3. Both girders of span No. 4 are bent transversely out of plane and the webs of both girders are buckled.
- Span No. 6 was not damaged by the fire. A lateral crack approximately 4-inches in length on the bottom flange of the left girder was found near the end of the bottom cover plate. However, this crack is not believed due to an overstress. No other deficiencies were found on Span No. 6.

Substructure:

- Deficiencies were found at the left side masonry plates of bent Nos. 4 and 5. The masonry plate at bent no. 4 has a longitudinal split the full length and full depth of the plate. The masonry plate at bent no. 5 has longitudinal and transverse splits the full length and full depth of the plate. (See photos 032 – 041) No significant deficiencies were found during inspections of the bent posts, struts or lateral rods.
- Typical cleanup involving removing debris from around the masonry plates at the base of the bent post should be performed.

Table 1A – Detailed Deficiencies and Recommended Repairs

	RAILROAD BRIDGE INSPECTION FORM LOBATO TRESTLE	Bridge No.	339.78		
Cumbres & Toltec SCENIC RAILROAD		Location:	Chama, New Mexico		
		Inspected by:	TMR,SNP,AG	Date:	08/03 - 08/07, 2010

DETAIL COMMENTS

SPAN No.	COMMENTS SUPERSTRUCTURE	CONDITION RATING	PICTURE(S)	REPAIR RECOMMENDATIONS (CONDITION RATING)
to Chama - **SPAN 1** - to Antonito	ANCHORS BOLTS BROKEN AND GIRDER HAS LIFTED APPROXIMATELY 7" FROM MASONRY PLATE, LEFT AND RIGHT GIRDER	P1		REPLACE THE ENTIRE SPAN (P1)
	GIRDER OUT OF PLANE AROUND BAY #2, LEFT GIRDER	P1	1	
	1" SAG AND BOW IN TOP LATERAL BRACE, BAY #3	P1		
	MISSING BOLTS IN BEARING PLATE HOLES, PIER #2, LEFT AND RIGHT GIRDER	P1		
	1/2" GAP BETWEEN TOP OF GIRDERS, 0" GAP BETWEEN BOTTOM OF GIRDERS, PIER #1	P1		
	5" SAG AND IN TOP LATERAL BRACE, BAY #4	P1		
	GIRDER OUT OF PLANE AROUND BAY #4, RIGHT GIRDER	P1	2	
	MISSING BOLT IN TOP STRUT, CROSS FRAME #5, RIGHT GIRDER	P1		
	1/2" GAP BETWEEN SPAN 1 AND SPAN 2 AT TOP FLANGE, LEFT AND RIGHT GIRDER	P1		
to Chama - **SPAN 2** - to Antonito	1/2" BUCKLE IN TOP FLANGE, BAY #1, LEFT GIRDER	P1		REPLACE THE LEFT GIRDER (P1)
	1" SAG IN TOP LATERAL BRACE, BAY #1	P1		
	MISSING BOLT IN BOTTOM STRUT, CROSS FRAME #1, LEFT AND RIGHT GIRDER	P3		REPLACE TOP LATERAL BRACES, TOP CROSS BRACES, TOP GUSSET PLATES (P1)
	2" SAG IN TOP LATERAL BRACE, BAY #2	P1		
	CRACKED TOP LATERAL PLATE AT CROSS FRAME #2, RIGHT GIRDER	P1		
	2" SAG IN TOP LATERAL BRACE, BAY #3	P1		
	1" SAG IN TOP STRUT, CROSS FRAME #3	P1		
	MISSING BOLT IN BOTTOM STRUT, CROSS FRAME #3, LEFT AND RIGHT GIRDER	P3		
	GIRDER	P1		
	6" SAG IN TOP LATERAL BRACE, BAY #4	P1		REPLACE THE TOP FLANGE PLATES AND CONNECTING ANGLES FOR THE RIGHT GIRDER (P1)
	CRACK IN TOP FLANGE, BOW IN GIRDER AND WEB, BAY #4, LEFT GIRDER	P1	3 - 5	
	4" SAG IN TOP STRUT, CROSS FRAME #4	P1		
	1" SAG IN TOP LATERAL BRACE, BAY #5	P1		
	MISSING BOLTS IN BEARING PLATE HOLES, PIER #2, RIGHT GIRDER	P1	6	
to Chama - **SPAN 3** - to Antonito	KNIFE EDGE AT TOP STRUT, CROSS FRAME #0	P4		
	MISSING BOLTS IN BEARING PLATE HOLES, PIER #3, RIGHT GIRDER	P1	7	ADD NEW HIGH STRENGTH BOLTS
	TYPICAL GAP BETWEEN TOP OF GIRDERS, PIER #2, LEFT AND RIGHT GIRDER	P4		REPLACE TOP LATERAL BRACES, TOP CROSS BRACES AND CONENCTING GUSSET PLATES (P1)
	1" SAG IN TOP LATERAL BRACE, BAY #1	P1		
	BROKEN TOP LATERAL, CROSS FRAME #1, LEFT GIRDER	P1	8	
	CRACKED TOP LATERAL PLATE AT CROSS FRAME #1, RIGHT GIRDER	P1		
	MISSING RIVET IN TOP COVER PLATE, BAY #2, LEFT GIRDER	P2		REPLACE THE TOP FLANGE PLATES AND CONNECTING ANGLES FOR BOTH GIRDERS (P1)
	1" SAG IN TOP LATERAL BRACE, BAY #3	P1		
	1 1/2" SAG IN TOP STRUT, CROSS FRAME #3	P1		
	CRACKED TOP LATERAL PLATE AT CROSS FRAME #3, LEFT AND RIGHT GIRDER	P1		
	1" SAG IN TOP LATERAL BRACE, BAY #4	P1		
	GIRDER	P2		
	KNIFE EDGE AT TOP STRUT, CROSS FRAME #5, LEFT AND RIGHT GIRDER	P4	9	
	1 1/2" SAG AND 1/2" LATERAL BOW IN TOP STRUT, CROSS FRAME #5	P1		
	0.6" GAP BETWEEN TOP OF GIRDERS, 0" GAP BETWEEN BOTTOM OF GIRDERS, PIER #3	P4	10	
	PACK RUST BUILD UP OF APPROX. 1/8" BETWEEN COVER PLATES, BAY #5, LEFT GIRDER	P4		
	MISSING BOLT IN BOTTOM LATERAL, RIGHT GIRDER		11	

Table 1B – Detailed Deficiencies and Recommended Repairs (Continued)

RAILROAD BRIDGE INSPECTION FORM LOBATO TRESTLE	Bridge No.	339.78		
	Location:	Chama, New Mexico		
	Inspected by:	TMR,SNP,AG	Date:	08/03 - 08/07, 2010

DETAIL COMMENTS

SPAN No.	COMMENTS			
	SUPERSTRUCTURE	CONDITION RATING	PICTURE(S)	REPAIR RECOMMENDATIONS (CONDITION RATING)
to Chama - **SPAN 4** - to Antonito	MISSING BOLT IN BOTTOM STRUT AT BOTTOM FLANGE, CROSS FRAME #0	P3		REPLACE THE ENTIRE SPAN (P1)
	BUCKLING OF TOP FLANGE AND WEB, LEFT GIRDER	P1	12 - 15	
	BUCKLING OF TOP FLANGE AND WEB, RIGHT GIRDER	P1	16	
	NOTCH IN TOP FLANGE TO ACCOMMODATE BOLT AND WASHER AT CROSS FRAME #1, LEFT GIRDER	P1	17	
	1/2" SAG IN TOP LATERAL BRACE, BAY #2	P1		
	4" SAG AND LATERAL BOW IN TOP LATERAL BRACE, BAY #3	P1		
	BENT TOP LATERAL PLATE AT CROSS FRAME #3, LEFT GIRDER	P1		
	1" SAG IN TOP LATERAL BRACE, BAY #4	P1		
	GIRDER OUT OF PLANE AROUND BAY #4 AND #5, LEFT GIRDER	P1	18 - 20	
	CRACKED TOP LATERAL PLATE AT CROSS FRAME #4, RIGHT GIRDER	P1		
	2" SAG IN TOP LATERAL BRACE, BAY #5	P1		
	1 1/4" SAG AND 1/8" LATERAL BOW IN TOP STRUT, CROSS FRAME #5	P1		
	1/2" GAP BETWEEN TOP OF GIRDERS, 0" GAP BETWEEN BOTTOM OF GIRDERS, PIER #4	P4		
	MISSING BOLT IN BEARING PLATE HOLES, PIER #5, RIGHT GIRDER	P1		
to Chama - **SPAN 5** - to	1/2" SAG IN TOP LATERAL BRACE, BAY #1	P1		REPLACE TOP LATERAL BRACES, TOP CROSS BRACES AND CONENCTING GUSSET PLATES (P1)
	BENT TOP LATERAL PLATE AT CROSS FRAME #1, LEFT GIRDER	P1		
	1/2" SAG AND 1/4" LATERAL BOW IN TOP STRUT, CROSS FRAME #1	P1		
	CRACKED TOP LATERAL PLATE AT CROSS FRAME #2, RIGHT GIRDER	P1		REPLACE THE TOP FLANGE PLATES AND CONNECTING ANGLES FOR BOTH GIRDERS (P1)
	3/4" SAG IN TOP LATERAL BRACE, BAY #3	P1		
	3/8" SAG AND 1/4" LATERAL BOW IN TOP STRUT, CROSS FRAME #3	P1		
	PACK RUST IN BOTTOM FLANGE ANGLES, BAY #5	P3		
to Chama - **SPAN 6** - to Antonito	NO SIGNIFICANT FIRE DAMAGE TO SPAN	P4	21	
	MISSING BOLTS IN BEARING PLATE HOLES, PIER #5, LEFT AND RIGHT GIRDER	P1	22	ADD NEW HIGH STRENGTH BOLTS
	CRACKED BOTTOM FLANGE PLATE IN BAY #5, LEFT GIRDER	P3	23-26	MONITOR
	DELAMINATION IN BOTTOM FLANGE, BAY #5, LEFT GIRDER	P2	27-30	MONITOR
Abutment No. 1	FAILED ANCHOR BOLTS AT GIRDER BEARINGS	P1	28-31	REPLACE ANCHOR BOLTS
Bent No. 1	NO COTTER PIN AT LEVEL 2, RIGHT SIDE	P4		INSTALL NEW PIN
Bent No. 2	NO IDENTIFIED DEFICIENCIES IN BENT MEMBERS	P4		

Rating Results

Using the as-built plans, field measurements and section properties, a rating analysis was performed to determine the structural capacity of the spans. The rating analysis was performed in accordance with Chapter 15 Steel Structures of the 2010 version of the American Railway Engineering and Maintenance-of-Way Association (AREMA) manual for railway engineering. Table 2 summarizes the rating results for the superstructures from our analysis.

Per information provided by the Cumbres and Toltec Scenic Railroad two (2) trains per day, one in each direction, pass across the bridge at a maximum speed of 8 MPH. The train consists of a K36 or K37 coal fired steam engine locomotive, tender and eight (8) viewing cars with a maximum capacity of 44 passengers per car. Rating calculations for Normal and Maximum loads under pre-fire as-built conditions were completed.

The Normal ratings are for loads that can be carried by the structure for its expected service life at a standard speed. The intent of a “normal” rating is to limit the stresses in the structure to those which it would have typically been designed for and determine the Cooper’s equivalent load it could carry on a daily basis while providing a consistent factor of safety.

Maximum ratings are for loads that can be carried at infrequent intervals. The "maximum" rating provides a reduced factor of safety and, if more frequent maximum loads are allowed, a reduced structure life.

Table 2 – Rating Results in Equivalent Cooper Load – 8 mph

	NORMAL RATING		MAXIMUM	CONSIST COOPER
	STRENGTH	FATIGUE	RATING	E RATING
40-Foot Span - Flexure	34.1	20.1	54.0	E39.7
40-Foot Span - Shear	73.2	-	131.4	E37.7
54-Foot Span - Flexure	26.6	17.2	43.6	E37.3
54-Foot Span - Shear	57.8	-	57.8	E38.0

The rating analysis used a train speed of 8 mph on a tangent track with 0" of track offset. Currently the track is offset 2.5" but the assumption is that new track will be centered on the bridge. The ratings analysis was performed assuming simple spans with 10% fixity (top splice plate) at the bent bearings.

In flexure neither the 40-foot nor the 54-foot spans have the structural capacity to meet the normal rating demand for the current loading. The current demand is being controlled by the K36/K37 engine and tender and our conclusion is the spans have a low rating because the current engine and tender utilized are much heavier than the engine and tender in use at the time of bridge construction.

Estimate of Probable Construction Cost to Repair/Replace the Superstructure Spans

The estimated cost assumes that all repairs and replacements are provided in order to achieve the capacity for each span to carry the required Cooper E rating. Listed below is estimated cost to replace span Nos. 1 and 4 that were critically damaged during the fire (buckled and out of plane webs and top flanges); replace the left side girder of span No. 2; replace the top and bottom flange plates in span Nos. 2, 3 and 5 and replace all of the top lateral bracing, top cross brace members and all top gusset plates; replace the existing abutment bearings and replace the existing masonry plates at bent Nos. 4 and 5. The assumption is that the existing bents will have the capacity to carry current and future loadings and the new spans will be designed and detailed to carry current and future loadings. The new spans will be designed and detailed as simply supported structures.

- Replace Span Nos. 1 and 4 @ $175,000 x 2 = $ 350,000
- Repair/Rehab Span Nos. 2, 3 and 5 @ $150,000 = $ 450,000
- Rehab Span No. 6 @ 50,000 = $ 50,000
- Replace the abutment Bearings @ 2 x $10,000 = $ 20,000
- Replace Masonry Plates at Bent Nos. 4 and 5 = $ 30,000

Total = $ 900,000

Estimate of Probable Construction Cost to Replace the Superstructure Spans

The estimated cost assumes that all replacements are provided in order to achieve the required Cooper E rating capacity for each span. Listed below is estimated cost to replace the six (6) superstructure spans, replace the existing abutment bearings and replace the existing masonry plates at bent Nos. 4 and 5. The assumption is that the existing bents will have the capacity to carry current and future loadings and the new spans will be design and detailed to carry current and future loadings. The new spans will be design and detailed as simply supported structures.

- Replace Span Nos. 1 through 5 @ $175,000 x 5 = $ 875,000
- Replace Span No. 6 @ $50,000 = $ 50,000
- Replace the abutment Bearings @ 2 x $10,000 = $ 20,000
- Replace Masonry Plates at Bent Nos. 4 and 5 = $ 30,000

Total = $ 975,000

The estimated cost assumes that all replacements are provided in order to achieve the required Cooper E rating capacity for each span. The construction cost does not include cost for construction access roads or staging areas; contractor mobilization or demobilization, or environmental and construction permitting.

Note:

Any opinions of probable construction cost provided by the Engineer are made on the basis of information available to the Engineer and on the basis of the Engineer's experience and qualifications, and represents and represents judgment as an experienced and qualified professional engineer. However, since the Engineer has no control over the cost of labor, materials, equipment or services furnished by others, or over the contractor's methods of determining prices, or over competitive bidding or market conditions, the Engineer does not guarantee that proposals, bids or actual construction cost will not vary from opinions of probable construction cost prepared by the Engineer.

MATERIALS TESTING CERTIFICATION

METALS ENGINEERING & TESTING LABORATORIES
2040 W. Quail Ave., Phoenix, Arizona 85027 (602)272-4571 Fax (602)278-7438

Test Report(Corrected)

TO: HDR ENGINEERING INC.
8404 INDIAN HILLS DR.
OMAHA, NE 68114
ATTN: Page 1 of 1

DATE: August 13, 2010
YOUR P.O. NUMBER:
MATERIAL:
SPECIFICATION:

LAB NO. 080-203
P/N
SIZE

	BAR	SMALL	
Carbon	0.01	0.02	
Sulfur	0.010	0.020	
Phosphorus	0.11	0.19	
Silicon	0.22	0.17	
Chromium	0.01	0.01	*Material is Phosphorized mild steel
Nickel	0.01	0.03	
Manganese	0.03	0.03	
Copper	0.01	0.02	
Molybdenum	<0.01	<0.01	
Columbium	<0.01	<0.01	
Titanium	<0.01	<0.01	
Aluminum	0.02	0.01	
Vanadium	<0.01	<0.01	
Cobalt	0.01	0.02	
Tin	<0.01	0.01	
Tungsten	<0.01	<0.01	
Iron	Rem.	Rem.	

SAMPLE	SIZE	AREA	YIELD STRENGTH		TENSILE STRENGTH		ELONGATION		REDUCTION	
			Load	Lbs per inch^2	Load	Lbs per inch^2	2" Ga	%	Dim	%
BAR	.438/.503	.2203	6482	29,400	9941	45,100	.381	40		

MINIMUM REQUIREMENTS

YIELD STRENGTH DETERMINED BY: 0.2% OFFSET

Chemistry by OES / Units of Measurement = Percent

MEETS SPECIFICATION REQUIREMENTS

DOES NOT MEET SPECIFICATION REQUIREMENTS

X NOT APPLICABLE

RESPECTFULLY SUBMITTED,

MICHAEL GIBONEY, GENERAL MANAGER

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