Kansas Citys, Missouri and Kansas
Flood Risk Management Feasibility Study

Engineering Appendix to the Final Feasibility Report

Chapter A-9

KANSAS RIVER

BRIDGES

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INTRODUCTION

There are a number of bridges over the Kansas River between the Kansas City Levees (Armourdale, CID-Kansas, and Argentine) that currently have low beam below the top of existing levee. A couple of these structures were modified in the 60's to be raised in a flood event and one or two were permanently raised. The KC Terminal Railroad bridge can no longer be raised because the raise mechanism was not maintained by the owner. As noted in the tables included in this report, the depth underwater varies for each of the bridges over the Kansas River and that depth increases from existing to future with project conditions. Increasing superstructure depth underwater increases load due to flow on the structure. The superstructures, substructures and foundations for the Kansas River bridges were most likely not originally designed for stream flow lateral loads that occur during a 500-year event. Impacts to the bridges as a result of the future with project levee raise as compared to existing conditions is assessed in this report by doing a qualitative assessment of the failure modes and probability of failures are then assigned to the critical structures. A detailed structural analysis of each bridge was not completed due to the excessive cost of doing so. Some background information on decisions and assumptions made follow in this report. The attached tables provide specific background to the assessments and corresponding structural failure rating.

HNTB performed a bridge reconnaissance and provided the COE with a letter of opinion in November 2008. During the reconnaissance, a significant amount of bridge data was collected and a list of potential failure modes was developed. The 5 failure modes in the HNTB letter of opinion are used in this qualitative assessment of the bridges. The HNTB letter is included as an attachment to this report.

FAILURE MODES

STRUCTURAL FAILURE

Two structural failure modes were identified in the HNTB letter of opinion and have been modified slightly here to account for the fact that overstress is not a failure mode. Overstress is considered to be unacceptable damage, but not necessarily bridge failure.

1. Superstructure Failure (Bearing and anchor bolt failure) - The analysis will evaluate the bearings and anchor bolts for failure that result from the uplift and lateral hydraulic forces on the superstructure.
2. Substructure Failure (Pier section shear and bending) - The analysis will evaluate the pier section for shear and bending failure that result from the lateral forces.

GEOTECHNICAL FAILURE

Three geotechnical failure modes were identified in the HNTB letter of opinion and have been modified slightly here to account for the fact that overstress is not a failure mode. Overstress is considered to be unacceptable damage, but not necessarily bridge failure.

1. Substructure Failure (Overturning)- The analysis will evaluate the substructure for exceeding ultimate overturning resistance that results from lateral hydraulic forces.
2. Substructure Failure (Sliding) - The analysis will evaluate the substructure for exceeding ultimate sliding resistance that results from lateral forces.
3. Foundation Failure - The analysis will evaluate the substructure foundation for failure that results from the lateral forces. Tension or pile capacity of the timber piles as well as bearing capacity of the piers on rock are to be evaluated as part of the foundation failure assessment.

Although scour was not listed as a specific failure mode, scour does impact the probability of the 3 geotechnical failure modes. Existing conditions scour ratings were available from the bridge underwater inspection reports and are as indicated in the attached tables. It was assumed that the future scour rating will be reduced by 1 for future with project assuming that scour will get worse with increased velocities. It is assumed that the future scour rating is not impacted by general river degradation. It is assumed river degradation will happen over a long period of time and repairs or modifications will have been made over the life of the structure and will not be directly impacted by the Kansas City levee future with project condition.

BRIDGE FAILURE ASSUMPTIONS AND IMPACTS TO LEVEE FAILURE

There are 4 bridges that could fall on and damage floodwalls in an event of the bridge superstructure failure. Of the 4, only 2 of these bridges are under water for the N500+3 water surface elevations. The Kansas Avenue East Bridge and the I-670 Bridge are the only two bridges that should be considered as possibly causing levee failure as a direct result of bridge failure. The bridges were assumed not to have superstructure spans over flood protection if:

- If the superstructure is over a floodwall and the portion of the superstructure over the floodwall would not be under water in an event
- If the superstructure is over earthen levee, because it was assumed that if the structure were to fall on the earthen levee it will not fail the levee.
- If piers on overbanks are in the levee footprint, because it is assumed the overbank piers would not see enough force to pullout and fail the earthen levee.
- If ends of the bridge are stoplog gaps, because it is assumed that superstructure failure will not fail the gap.

The Superstructure failure mode by failure of bearing anchor bolts is assumed not to impact the bridge abutment structural integrity and it is assumed that the abutment or gap at this location will not fail if the superstructure fails. The substructure failure (structural and geotechnical) is assumed to occur at the river piers because these piers are typically the most prone to scour and damage during a flood.

There is a high probability of one bridge that has failed causing another bridge downstream to fail as well. The first failed bridge would cause a dam effect upstream of the second bridge. This would increase the pressure on the second bridge causing failure to be more likely than if the first bridge had not failed.

Ultimately, there is a higher risk of hydraulic overtopping for all but the 2 bridges listed above. For the 2 bridges listed above it is possible that structural failure could directly cause levee failure. It is assumed with the exception of these 2 bridges, the other bridge failures would cause a higher risk of levee failure as a result of a failed bridge causing a dam and resulting in a higher water surface elevation but still lower than the proposed raise. See the ED-HH MFR attachment to this section.

EXISTING AND FUTURE WITHOUT PROJECT

There are currently 11 bridges below existing TOL. Of those 11, 7 bridges are greater than 3 ft below existing TOL. This includes all bridges currently spanning the river, active or abandoned. Table 1 lists the data associated with the existing conditions and future without project conditions. This table gives an indication of the level of risk and reasoning for that assessment for each of the failure modes. Each failure mode is then categorized by color to indicate level of risk from a graphical standpoint.

- Green = low risk
- Yellow = moderate risk
- Red = high risk

FUTURE WITH PROJECT

There are 5 bridges with low chord above the N500 water surface elevation but below the N500+3 top of levee. There are 7 bridges with low chord below the N500 water surface elevation. Table 2 lists the data associated with the future with project conditions. This table gives an indication of the level of risk and reasoning for that assessment for each of the failure modes. Each failure mode is then categorized by color to indicate level of risk from a graphical standpoint.

- Green = low risk
- Yellow = moderate risk
- Red = high risk

Although it is assumed that removal of abandoned bridges at future with project could address issues with these bridges, they are still included in the risk assessment to identify if it should be considered a problem bridge.

FAILURE MODE ASSESSMENT

A major factor in determining the level of risk for each of the failure modes is the superstructure and substructure type. Structure type considerations made when assigning a failure mode risk assessment:

- A continuous span superstructure is less likely than a simple span structure to result in failure.
- A continuous span superstructure is also less likely to result in collapse due to scour of the bridge piers.
- A truss structure is likely to be able to convey some water thru the superstructure
- A solid shaft pier is very unlikely to fail in shear or bending, due to volume of concrete and reinforcing in the structure
- A substructure on piles or drilled shafts in rock is less likely to fail than a substructure on spread footing on rock. There is some likelihood that the spread footing founding material could be negatively impacted by scour despite the fact that it is rock.

Another major consideration given is with respect to how much of the length of the superstructure is under water at the indicated water surface elevation. If the structure is a haunched structure the amount of water actually on the superstructure is likely to be for only a short length of the bridge because the beam or truss varies in depth. The grade of the bridge also has impacts on the length of the superstructure under water. The bridge plans were reviewed to determine superstructure types and elevations to determine the approximate length of the bridge under water. Those with haunched superstructures or with minimal lengths of the bridge underwater were noted in Tables 1 and 2.

FAILURE MODE RATING

Values from 1 to 9 were assigned for red to green failure mode designations respectively, see Table 3 and Table 4 for table of values. These values are also dependent on the water height above low steel. A weighted average for the two structural failure modes is calculated and a weighted average for the three geotechnical failure modes is calculated. The weighted average for the geotechnical failure modes is then adjusted with respect to the scour rating. Then a total weighted average is calculated and results in the total rating value for that bridge. The bridges with the lowest total rating value are the highest risk structures.

The scour adjustment rating was loosely based on the probability of failure tables in the HAZUS MR4 technical manual. A scour rating of 6 and above is considered to have no impact on the failure mode analysis. A scour rating of 4 or 5 indicate some distress and has been identified, but no significant impact to the failure modes. A scour rating of 3 and below are considered to greatly impact the geotechnical failure modes.

EXISTING CONDITIONS

The bridges with low chord below the existing top of levee (TOL) O&M designated water surface elevation with any yellow or red failure mode in Table 1 were translated to Table 3. Table 3

calculates a failure mode rating considering the likelihood of each of the different type of failure modes. For each bridge failure mode a value is assigned in Table 3 according to the colors and descriptions from Table 1.

The Kansas City Terminal Railroad bridge is under the most water for future conditions. No probability of structural failure was calculated for existing conditions.

FUTURE CONDITIONS

The bridges with low chord below the N500+3 water surface elevation with any yellow or red failure mode in Table 2 were translated to Table 4. Table 4 calculates a failure mode rating considering the likelihood of each of the different type of failure modes. For each bridge failure mode a value is assigned in Table 4 according to the colors and descriptions from Table 2.

The Kansas City Terminal Railroad bridge is under the most water for future conditions. This bridge was investigated for the probability of structural failure because it appeared to be the worst case bridge. The structural analysis reviewed the uplift and stream forces on the bridge versus the resisting dead load. The bridge dead load was approximated from the bridge drawings. The dead load was listed on the drawings and this was the dead load used in the analysis. The dead load was significant enough to exceed the forces due to uplift and forces due to uplift and stream forces combined. Therefore the structural reliability was assigned a value of 99.8% and the rest of the bridges on the river, which have less water on them, are assumed to be at a reliability of 99.8% as well. Consideration was given to the fact that other structure's dead load may not exceed the uplift and stream forces. The other bridges that are high risk are all trusses and are likely to perform similarly due to large dead load compared to minimal uplift pressures due to minimal water displacement. Note the probability of failure was not investigated for the geotechnical or scour failure modes. These are assumed not to control based on the geotechnical and scour weighted ratings typically being greater than the structural failure weighted rating, indicating the likely failure mode is structural.

SUMMARY

In summary, the probabilistic analysis performed in this report indicates a very low probability of failure of a Kansas River bridge (0.2%). The Kansas Avenue East Bridge is the only bridge that could directly result in levee failure should the bridge fail by falling on a structural component of the existing flood protection system (floodwall). This analysis is a very broad look at the potential failure modes and likelihood of failure. More detailed analysis, though costly, would better indicate probability of failures for these bridges.

ATTACHMENTS

TABLE 1 – EXISTING AND FUTURE WITHOUT PROJECT CONDITIONS - PROBABILISTIC APPROACH TO BRIDGE FAILURE

EXISTING CONDITIONS AND FUTURE WITHOUT PROJECT CONDITIONS - PROBABILISTIC APPROACH TO BRIDGE FAILURE

#	Bridge ID	RM	Owner	Low Chord over Channel (NGVD29)	surveyed low chord over channel (NGVD29)	CID Existing TOL O&M (NGVD29)	ARMOURDALE Existing TOL O&M (NGVD29)	ARGENTINE Existing TOL O&M (NGVD29)	Dist low chord is below Existing TOL O&M	superstructure spans over flood protection (Y/N)	Existing gap (Y/N)	investigate	superstructure type type	superstructure type simple span or continuous span	n500 channel velocities at the investigation locations (fps)	5 failure modes Bearing or anchor bolt failure due to tension	5 failure modes Pier section failure due to shear or bending	5 failure modes Substructure overturning	5 failure modes Substructure sliding	5 failure modes Foundation failure due to tension or bearing in piles or bearing of footings	Substructure type River Piers	Substructure type Overbank Piers	Scour notes	Scour Rating Existing scour rating	Risk - Scour Rating Risk of bridge failure without project	Risk - Scour Rating Risk of bridge failure with project	Risk - Scour Rating Risk if bridge fails then levee fails	NOTES
1	**MO Pac RR #1**	**0.26**	**Union Pacific RR**	759.0	758.1	760.9	---	---	2.8	N	N	1 river pier and 1 pier in 4th span	4 span truss	simple	12	medium risk - simple span bridge, but only 2.8ft under water. Structure is a truss bridge with significant Dead wt compared to ht of water	low risk - solid shaft pier	low risk for overbank piers (piles on rock); low risk for river piers minimal water on superstructure	low risk for overbank piers (piles on rock); low risk for river piers minimal water on superstructure	low risk due to minimal water on superstructure	concrete bearing on rock	concrete on timber piles driven to rock	timber piles exposed during low water; general channel degradation noted					
2	I-70 WB	0.28	KDOT	784.6		760.9	758.5	---	-23.7	Y	N				10									5	LOW NOT UNDER WATER	LOW NOT UNDER WATER	LOW NOT UNDER WATER	
3	I-70 EB	0.3	KDOT	767.0		760.9	758.5	---	-6.1	Y	N				10									7	LOW NOT UNDER WATER	LOW NOT UNDER WATER	LOW NOT UNDER WATER	
4	James St	0.5		761.8		760.7	758.5	---	-1.1	N	N				10									5	LOW NOT UNDER WATER	LOW NOT UNDER WATER	LOW NOT UNDER WATER	
5	**KC Southern**	**0.81**	**KC Southern RR**	759.4	758.6	762.1	760.7	---	3.5	N	N	1 river pier and bearings	3-span truss	simple	13	medium risk - simple span bridge, 3.5ft under water. Structure is a truss bridge with significant Dead wt compared to ht of water	low risk - solid shaft pier	low risk piles on rock	low risk piles on rock	low risk for piles on rock	concrete on timber piles driven to rock							Abandoned Bridge
6	Central Ave	1.11	UG	760.6	760.2	762.1	761.7	---	1.9	N	N	1 river pier and bearings	truss	simple	13	low risk - simple span truss bridge 1.9ft (6%of structure ht) under water-(fixed bearings at one end of each simple span)	low risk - solid shaft pier	low risk - minimal water on superstructure	low risk - minimal water on superstructure	low risk - minimal water on superstructure	concrete bearing on rock	concrete footing bearing on piles	top and sides of footings are exposed 2-4ft, however solid footings are 23ft thick according to drawings	5				
7	I-670	1.4		763.6		762.1	762.3	---	-1.5	Y	N		steel plate girder	continuous	13						concrete on drilled shafts socketed into shale			5 for EB and 8 for WB				
8	**MO Pac RR #72**	**1.62**	**Union Pacific RR**	758.9		762.5	762.5	---	3.6	N	N/Y	1 river pier and bearings	4-span truss	simple	13	medium risk - simple span truss bridge 3.6ft under water-no brg details available (fixed at one end)	low risk - appear to be solid shaft pier	low risk piles on rock	low risk piles on rock	low risk for piles on rock	concrete on timber piles driven to rock		timber piles exposed during low water; general channel degradation noted; possible scour evidence at Bent 4					
9	**UP RR #3**	**1.64**	**Union Pacific RR**	753.9		762.5	762.5	---	8.6	N	Y	1 river pier and bearings	4-span truss	simple	13	medium to high risk - simple span truss bridge 8.6ft (30% of ht of structure) under water-no brg details available (fixed at one end)	low risk - solid shaft pier	low risk piles on rock	low risk piles on rock	low risk for piles on rock	concrete on timber piles driven to rock		general channel degradation noted					Bridge Raised 8' in 1993 Flood, Low Chord Reported in Down Position
10	**CRIP RR**	**2.1**	**City of Kansas City, MO**	762.8	763.1	764.8	763.6	---	1.7	N	Y	1 river pier on rock and 1 river pier on piles	3-span truss	simple	13	low risk - simple span truss bridge 1.7ft (5%of structure ht) under water-no brg details available (fixed at one end)	low risk - appear to be solid shaft pier	low risk for overbank piers (piles on rock); low risk for river piers, minimal water on superstructure	low risk for river piers, minimal water on superstructure	low risk for river piers, minimal water on superstructure	concrete bearing on rock	concrete on timber piles	general channel degradation noted, based on exposed wooden forms					Raised to Current Position, Gap Permanently Closed, and Abandoned
11	**KS Ave East**	**2.17**	**UG**	760.8		765	764.3	---	4.2	Y	N	west river pier and bearings	3-span truss	continuous	13	medium risk - continuous truss bridge 4.2ft (12%of ht of struture) under water-no brg details availabe	low risk - solid shaft pier	low risk for river piers	low risk for shafts on rock	low risk for shafts on rock	concrete shafts on rock		no evidence of scour at piers	5				
12	**KC Terminal**	**2.53**	**KC Terminal RR**	755.9		765.9	765.5	---	10.0	N	Y	1 river pier and bearings	3-span truss	simple	12	medium risk - simple span double deck truss bridge 10ft (17% of ht of structure) under water-no brg details available (fixed at one end)	low risk - solid shaft pier	moderate risk for river piers	moderate	moderate	concrete bearing on rock		exposed caisson at the bottom					End Spans Raised 10' in 1993, but currently not operable, Low Chord Reported in Down Position

TABLE 1

EXISTING CONDITIONS AND FUTURE WITHOUT PROJECT CONDITIONS - PROBABILISTIC APPROACH TO BRIDGE FAILURE

#	Bridge ID	RM	Owner	Low Chord over Channel (NGVD29)	surveyed low chord over channel (NGVD29)	CID Existing TOL O&M (NGVD29)	ARMOURDALE Existing TOL O&M (NGVD29)	ARGENTINE Existing TOL O&M (NGVD29)	Dist low chord is below Existing TOL O&M	superstructure spans over flood protection (Y/N)	Existing gap (Y/N)	investigate	superstructure type: type	superstructure type: simple span or continuous span	n500 channel velocities at the investigation locations (fps)	5 failure modes: Bearing or anchor bolt failure due to tension	5 failure modes: Pier section failure due to shear or bending	5 failure modes: Substructure overturning	5 failure modes: Substructure sliding	5 failure modes: Foundation failure due to tension or bearing in piles or bearing of footings	Substructure type: River Piers	Substructure type: Overbank Piers	Scour notes	Scour Rating: Existing scour rating	Risk - Scour Rating: Risk of bridge failure without project	Risk - Scour Rating: Risk of bridge failure with project	Risk - Scour Rating: Risk if bridge fails then levee fails	NOTES
13	**7th St NB**	**3.42**	**KDOT**	756.0	758.4	---	768.2	---	9.8	N	N	east river pier and bearings	3-span truss	continuous	10	low risk - continuous 3 span truss bridge 9.8ft under water at lowest point (haunched)-no brg details availabe (3.3 million pounds of steel/rebar on qty sheet)	low risk - solid shaft pier	low risk piles on rock	low risk piles on rock	low risk for piles on rock	concrete on timber piles driven to rock		past scour - repaired by driving sheet pile around E river pier and concrete filled; general channel degradation noted; exposed sheet pile	7				
14	7th St SB	3.43	KDOT	787.0		---	768.2	---	-18.8	N	N			continuous	10									7	LOW NOT UNDER WATER	LOW NOT UNDER WATER	LOW NOT UNDER WATER	
15	12th St	4.28		767.7	767.5		769.5	---	2.0	N	N		steel plate girder	continuous	10	low risk most of superstructure is out of the water (only a small portion of N span under water)	low risk most of superstructure is out of the water	low risk most of superstructure is out of the water	low risk most of superstructure is out of the water	low risk most of superstructure is out of the water	on drilled shafts in rock	spread ftg on piles	new piers ~1998	8	LOW			
16	**18th St**	**4.96**	**KDOT**	764.3	765.0		771	771	6.0	N	N	east river pier and bearings	3-span truss	continuous	9	medium to low risk-1082ft continuous 3spans, 6ft under water (abt 28%of ht of structure) - continous span makes less likely to fail- no brg details available	low risk - solid shaft pier	low risk piles on rock	low risk piles on rock	low risk for piles on rock	concrete on timber piles driven to rock		no evidence of scour at piers	8				
17	KS Ave West	5.82		773.7	774.8		773.2	773.4	-1.4	N	N		steel plate girder	continuous	7						concrete ftg on steel piles			8				
18	I-635 NB	7.34	KDOT	781.3			---	774.4	-6.9	N	N				8						2piers - concrete ftg on steel piles and 2 piears concrete spread footing abt 6ft into rock			8	LOW NOT UNDER WATER	LOW NOT UNDER WATER	LOW NOT UNDER WATER	
19	I-635 SB	7.35	KDOT	781.5			---	774.4	-7.1	N	N				8						2piers - concrete ftg on steel piles and 2 piears concrete spread footing abt 6ft into rock			8	LOW NOT UNDER WATER	LOW NOT UNDER WATER	LOW NOT UNDER WATER	
20	Turner Bridge (K-132 Hwy)	9.5	KDOT	778.9	779.3		---	776.8	-2.5	N	N		steel plate girder	continuous	7						concrete drilled shafts in rock							

abandoned
bold bridges reviewed by HNTB in 2008 bridge recon study
very low risk - superstructure not under water

Bridges With Low Chord Below TOL > 3ft
Bridges With Low Chord Below TOL < 3ft

TABLE 1

TABLE 2 - FUTURE WITH PROJECT - PROBABILISTIC APPROACH TO BRIDGE FAILURE

FUTURE WITH PROJECT - PROBABILISTIC APPROACH TO BRIDGE FAILURE

#	Bridge ID	RM	Owner	Low Chord over Channel (NGVD29)	surveyed low chord over channel (NGVD29)	CID: Existing TOL O&M (NGVD29)	CID: Proposed N500+3 TOL (NGVD29)	ARMOURDALE: Existing TOL O&M (NGVD29)	ARMOURDALE: Proposed N500+3 TOL (NGVD29)	ARGENTINE: Existing TOL O&M (NGVD29)	ARGENTINE: Proposed N500+3 TOL (NGVD29)	N500 WSE (NGVD29)	Dist low chord is below N500+3 TOL	superstructure spans over flood protection (Y/N)	Existing gap (Y/N)	Proposed Gap (Y/N)	investigate	superstructure type: type	superstructure type: simple span or continuous span	n500 channel velocities at the investigation locations (fps)	5 failure modes: Bearing or anchor bolt failure due to tension	5 failure modes: Pier section failure due to shear or bending	5 failure modes: Substructure overturning	5 failure modes: Substructure sliding	5 failure modes: Foundation failure due to tension or bearing in piles or bearing of footings	Substructure type: River Piers	Substructure type: Overbank Piers	Scour notes	Scour Rating: Existing scour rating	Scour Rating: Future conditions scour rating	Risk - Scour Rating: Risk of bridge failure without project	Risk - Scour Rating: Risk of bridge failure with project	Risk - Scour Rating: Risk if bridge fails then levee fails	POF due to scour FOR 500YR EVENT(in percent)	NOTES
1	**MO Pac RR #1**	**0.26**	**Union Pacific RR**	759.0	758.1	760.9	760.9	---	---	---	---	756.9	2.8	N	N	N	1 river pier and 1 pier in 4th span	4 span truss	simple	12	medium risk - simple span bridge, but only 2.8ft under water. Structure is a truss bridge with significant Dead wt compared to ht of water	low risk - solid shaft pier	low risk for overbank piers (piles on rock); moderate risk for river piers	low risk for overbank piers (piles on rock); moderate risk for river piers	moderate	concrete bearing on rock	concrete on timber piles driven to rock	timber piles exposed during low water; general channel degradation noted							
2	I-70 WB	0.28	KDOT	784.6		760.9	760.9	758.5	761.1	---	---	757.8	-23.7	Y	N	N				10									5	4	LOW NOT UNDER WATER	LOW NOT UNDER WATER	LOW NOT UNDER WATER	0	
3	I-70 EB	0.3	KDOT	767.0		760.9	760.9	758.5	761.2	---	---	757.9	-6.1	Y	N	N				10									7	6	LOW NOT UNDER WATER	LOW NOT UNDER WATER	LOW NOT UNDER WATER	0	
4	James St	0.5		761.8		760.7	761.7	758.5	761.6	---	---	758.6	-0.2	N	N	N				10									5	4	LOW NOT UNDER WATER	LOW NOT UNDER WATER	LOW NOT UNDER WATER	0	
5	**KC Southern**	**0.81**	**KC Southern RR**	759.4	758.6	762.1	762.1	760.7	762.1	---	---	759.0	3.5	N	N	N	1 river pier and bearings	3-span truss	simple	13	medium risk - simple span bridge, 3.5ft under water. Structure is a truss bridge with significant Dead wt compared to ht of water	low risk - solid shaft pier	low risk piles on rock	low risk piles on rock	low risk for piles on rock	concrete on timber piles driven to rock									Abandoned Bridge
6	Central Ave	1.11	UG	760.6	760.2	762.1	763.7	761.7	763.5	---	---	760.0	3.3	N	N	Y	1 river pier and bearings	truss	simple	13	medium risk - simple span bridge, 3.3ft under water (10% of superstructure height). Structure is a truss bridge with significant Dead wt compared to ht of water	low risk - solid shaft pier	low risk for overbank piers (piles); low risk for river piers	low risk for overbank piers (piles); low risk for river piers	moderate risk for overbank piers	concrete bearing on rock	concrete footing bearing on piles	top and sides of footings are exposed 2-4ft, however solid footings are 23ft thick according to drawings	5	4				0	
7	I-670	1.4	KDOT	763.6		762.1	764.9	762.3	765	---	---	761.7	1.3	Y	N	N		steel plate girder	continuous	13	low risk- continuous, haunched span bridge, only 1.3ft under water only at low haunch near 1 pier- continous span makes less likely to fail due to uplift - no brg details available	low risk - solid shaft pier	low risk for shafts socketed into rock	low risk for shafts socketed into rock	low risk for shafts on rock	concrete on drilled shafts socketed into shale			5 for EB and 8 for WB	4				0	
8	**MO Pac RR #72**	**1.62**	**Union Pacific RR**	758.9		762.5	765.5	762.5	765.4	---	---	762.2	6.5	N	N/Y	Y/Y	1 river pier and bearings	4-span truss	simple	13	medium risk - simple span truss bridge 6.5ft under water-no brg details available (fixed at one end)	low risk - appear to be solid shaft pier	low risk piles on rock	low risk piles on rock	low risk for piles on rock	concrete on timber piles driven to rock		timber piles exposed during low water; general channel degradation noted; possible scour evidence at Bent 4							
9	**UP RR #3**	**1.64**	**Union Pacific RR**	753.9		762.5	765.6	762.5	765.5	---	---	762.5	11.6	N	Y	Y	1 river pier and bearings	4-span truss	simple	13	medium to high risk - simple span truss bridge 11.6ft (40% of ht of structure) under water-no brg details available (fixed at one end)	low risk - solid shaft pier	low risk piles on rock	low risk piles on rock	low risk for piles on rock	concrete on timber piles driven to rock		general channel degradation noted							Bridge Raised 8' in 1993 Flood, Low Chord Reported in Down Position
10	**CRIP RR**	**2.1**	**City of Kansas City, MO**	762.8	763.1	764.8	767.7	763.6	767.7	---	---	764.3	4.6	N	Y	N	1 river pier on rock and 1 river pier on piles	3-span truss	simple	13	medium risk - simple span truss bridge 4.6ft (15%of structure ht) under water-no brg details available (fixed at one end)	low risk - appear to be solid shaft pier	low risk for overbank piers (piles on rock); moderate risk for river piers	moderate	moderate	concrete bearing on rock	concrete on timber piles	general channel degradation noted, based on exposed wooden forms							Raised to Current Position, Gap Permanently Closed, and Abandoned
11	**KS Ave East**	**2.17**	**UG**	760.8		765	768	764.3	768	---	---	764.9	7.2	Y	N	N	west river pier and bearings	3-span truss	continuous	13	medium risk - continuous truss bridge 7.2ft (21%of ht of struture) under water-no brg details availabe	low risk - solid shaft pier	low risk for river piers	low risk for shafts on rock	low risk for shafts on rock	concrete shafts on rock		no evidence of scour at piers	5	4				0	
12	**KC Terminal**	**2.53**	**KC Terminal RR**	755.9		765.9	769.7	765.5	769.7	---	---	766.7	13.8	N	Y	Y	1 river pier and bearings	3-span truss	simple	12	medium to high risk - simple span double deck truss bridge 13.8ft (23% of ht of structure) under water-no brg details available (fixed at one end)	low risk - solid shaft pier	moderate risk for river piers	moderate	moderate	concrete bearing on rock		exposed caisson at the bottom		4					End Spans Raised 10' in 1993, but currently not operable, Low Chord Reported in Down Position
13	**7th St NB**	**3.42**	**KDOT**	756.0	758.4	---	---	768.2	772.8	---	---	769.8	14.4	N	N	N	east river pier and bearings	3-span truss	continuous	10	low risk - continuous 3 span truss bridge 14.4ft under water at lowest point (haunched)-no brg details availabe (3.3 million pounds of steel/rebar on qty sheet)	low risk - solid shaft pier	low risk piles on rock	low risk piles on rock	low risk for piles on rock	concrete on timber piles driven to rock		past scour - repaired by driving sheet pile around E river pier and concrete filled; general channel degradation noted; exposed sheet pile	7	6				0	

TABLE 2

FUTURE WITH PROJECT - PROBABILISTIC APPROACH TO BRIDGE FAILURE

#	Bridge ID	RM	Owner	Low Chord over Channel (NGVD29)	surveyed low chord over channel (NGVD29)	CID Existing TOL O&M (NGVD29)	CID Proposed N500+3 TOL (NGVD29)	ARMOURDALE Existing TOL O&M (NGVD29)	ARMOURDALE Proposed N500+3 TOL (NGVD29)	ARGENTINE Existing TOL O&M (NGVD29)	ARGENTINE Proposed N500+3 TOL (NGVD29)	N500 WSE (NGVD29)	Dist low chord is below N500+3 TOL	superstructure spans over flood protection (Y/N)	Existing gap (Y/N)	Proposed Gap (Y/N)	investigate	superstructure type: type	superstructure type: simple span or continuous span	n500 channel velocities at the investigation locations (fps)	5 failure modes: Bearing or anchor bolt failure due to tension	5 failure modes: Pier section failure due to shear or bending	5 failure modes: Substructure overturning	5 failure modes: Substructure sliding	5 failure modes: Foundation failure due to tension or bearing in piles or bearing of footings	Substructure type: River Piers	Substructure type: Overbank Piers	Scour notes	Scour Rating: Existing scour rating	Scour Rating: Future conditions scour rating	Risk - Scour Rating: Risk of bridge failure without project	Risk - Scour Rating: Risk of bridge failure with project	Risk - Scour Rating: Risk if bridge fails then levee fails	POF due to scour FOR 500YR EVENT(in percent)	NOTES
14	7th St SB	3.43	KDOT	787.0		---	---	768.2	772.8	---	---	769.8	-14.2	N	N	N			continuous	10									7	6	LOW NOT UNDER WATER	LOW NOT UNDER WATER	LOW NOT UNDER WATER	0	
15	12th St	4.28		767.7	767.5			769.5	774.3	---	---	771.3	6.8	N	N	Y		steel plate girde	continuous	10	low risk most of superstructure is out of the water (only 40ft of N span under water)	low risk most of superstructure is out of the water	low risk most of superstructure is out of the water	low risk most of superstructure is out of the water	low risk most of superstructure is out of the water	on drilled shafts in rock	spread ftg on piles	new piers ~1998	8	7	LOW			0	
16	**18th St**	**4.96**	**KDOT**	764.3	765.0			771	775.9	771	775.9	772.9	10.9	N	N	N	east river pier and bearings	3-span truss	continuous	9	medium to low risk- 1082ft continuous 3spans, 10.9ft under water (abt 50%of ht of structure) - continous span makes less likely to fail due to uplift - no brg details available	low risk - solid shaft pier	low risk piles on rock	low risk piles on rock	low risk for piles on rock	concrete on timber piles driven to rock		no evidence of scour at piers	8	7				0	
17	KS Ave West	5.82		773.7	774.8			773.2	777.4	773.4	777.4	774.4	2.6	N	N	N		steel plate girde	continuous	7	low risk- 1426ft continuous 5 spans, only 2.6ft under water - haunched girders and continous span makes less likely to fail due to uplift - no brg details available	low risk - solid shaft pier	low risk piles on rock	low risk piles on rock	low risk for piles on rock	concrete ftg on steel piles			8	7				0	
18	I-635 NB	7.34	KDOT	781.3				---	---	774.4	778.3	775.3	-3.0	N	N	N				8						2piers - concrete ftg on steel piles and 2 piears concrete spread footing abt 6ft into rock			8	7	LOW NOT UNDER WATER	LOW NOT UNDER WATER	LOW NOT UNDER WATER	0	
19	I-635 SB	7.35	KDOT	781.5				---	---	774.4	778.4	775.4	-3.1	N	N	N				8						2piers - concrete ftg on steel piles and 2 piears concrete spread footing abt 6ft into rock			8	7	LOW NOT UNDER WATER	LOW NOT UNDER WATER	LOW NOT UNDER WATER	0	
20	Turner Bridge (K-132 Hwy)	9.5	KDOT	778.9	779.3			---	---	776.8	781.1	778.1	1.8	N	N	N		steel plate girde	continuous	7	low risk - 440ft continuous span only 1.8ft (26% of ht of girders) of water on girders, no brg details available	low risk, superstructure only underwater 1.8ft and piers have webwall between shafts	low risk, piers on shafts into rock	low risk, piers on shafts into rock	low risk for shafts on rock	concrete drilled shafts in rock									

4

abandoned

bold bridges reviewed by HNTB in 2008 bridge recon study

very low risk - superstructure not under water

Bridges With Low Chord Below n500 Water Surface Elevation

Bridges With Low Chord Above n500 Water Surface Elevation but Below n500+3 TOL

TABLE 2

TABLE 3 - KANSAS RIVER BRIDGE EXISTING CONDITIONS

PROBABILISTIC FAILURE RATING

KANSAS RIVER BRIDGE EXISTING CONDITIONS PROBABILISTIC FAILURE RATING

Failure Mode	Water Height Above Low Steel	
	1	2
	2	3
	4	5
	5	6
	7	8
	8	9

SCOUR RATING	SCOUR RATING multiplier
8	1
7	1
6	1
5	0.95
4	0.9
3	0.7
2	0.6
1	0.4

Bridge	Dist low chord is below existing TOL O&M	Bridge Type	FAILURE MODES: SUPERSTRUCTURE: Bearing or Anchor Bolt	SUBSTRUCTURE: STRUCTURAL FAILURE: Pier Failure	GEOTECHNICAL FAILURE: Overturning	GEOTECHNICAL FAILURE: Sliding	GEOTECHNICAL FAILURE: Foundation	FUTURE CONDITIONS Scour Rating	STRUCTURAL FAILURE Rating: Raw Average	STRUCTURAL FAILURE Rating: Weighted Average	GEOTECHNICAL FAILURE Rating: Raw Average	GEOTECHNICAL FAILURE Rating: Weighted Average	SCOUR ADJUSTED GEOTECHNICAL FAILURE Weighted Rating	Total Rating: Raw Average	Total Rating: Weighted Average	POF of structural failure	levee failure as direct result of bridge failure
KC Terminal	10	Simple	4	7	4	4	4	5	5.50	2.35	4.00	1.80	1.71	4.75	2.03	0.20%	0
UP RR#3	8.6	Simple	1	7	7	7	7	5	4.00	0.85	7.00	3.15	2.99	5.50	1.92	0.20%	0
CRIP RR*	1.7	Simple	4	7	4	4	4	5	5.50	2.35	4.00	1.80	1.71	4.75	2.03	0.20%	0
KC Southern*	3.5	Simple	4	7	7	7	7	5	5.50	2.35	7.00	3.15	2.99	6.25	2.67	0.20%	0
MO Pac RR#72	3.6	Simple	4	7	7	7	7	5	5.50	2.35	7.00	3.15	2.99	6.25	2.67	0.20%	0
MO Pac RR#1	2.8	Simple	5	8	5	8	5	5	6.50	2.90	6.00	2.70	2.57	6.25	2.73	0.20%	0
KS Ave East**	4.2	Continuous	5	7	7	7	7	4	6.00	2.85	7.00	3.15	2.84	6.50	2.84	0.20%	1
Central Ave	1.9	Simple	5	8	8	8	6	4	6.50	2.90	7.33	3.30	2.97	6.92	2.94	0.20%	0
18th St	6	Continuous	5	7	7	7	7	7	6.00	2.85	7.00	3.15	3.15	6.50	3.00	0.20%	0
Weighting Percentage			50%	5%	15%	15%	15%			50%			50%				

Notes:
Unshaded values in structural rating table for simple, shaded values for continuous.
Red values in Scour Rating column are assumed.
*Abandoned Bridges
**Structural failure could directly cause levee failure on CID-KS side only

TABLE 3

TABLE 4 - KANSAS RIVER BRIDGE FUTURE WITH PROJECT PROBABILISTIC FAILURE RATING

KANSAS RIVER BRIDGE FUTURE WITH PROJECT PROBABILISTIC FAILURE RATING

Failure Mode	Water Height Above Low Steel	
	1	2
	2	3
	4	5
	5	6
	7	8
	8	9

SCOUR RATING	SCOUR RATING multiplier
8	1
7	1
6	1
5	0.95
4	0.9
3	0.7
2	0.6
1	0.4

Bridge	Dist low chord is below N500+3 TOL	Bridge Type	FAILURE MODES: SUPERSTRUCTURE: Bearing or Anchor Bolt	SUBSTRUCTURE: STRUCTURAL FAILURE: Pier Failure	GEOTECHNICAL FAILURE: Overturning	GEOTECHNICAL FAILURE: Sliding	GEOTECHNICAL FAILURE: Foundation	FUTURE CONDITIONS Scour Rating	STRUCTURAL FAILURE Rating: Raw Average	STRUCTURAL FAILURE Rating: Weighted Average	GEOTECHNICAL FAILURE Rating: Raw Average	GEOTECHNICAL FAILURE Rating: Weighted Average	SCOUR ADJUSTED GEOTECHNICAL FAILURE Weighted Rating	Total Rating: Raw Average	Total Rating: Weighted Average	POF of structural failure	levee failure as direct result of bridge failure
KC Terminal	13.8	Simple	1	7	4	4	4	5	4.00	0.85	4.00	1.80	1.71	4.00	1.28	0.20%	0
UP RR#3	11.6	Simple	1	7	7	7	7	5	4.00	0.85	7.00	3.15	2.99	5.50	1.92	0.20%	0
CRIP RR*	4.6	Simple	4	7	4	4	4	5	5.50	2.35	4.00	1.80	1.71	4.75	2.03	0.20%	0
KC Southern*	3.5	Simple	4	7	7	7	7	5	5.50	2.35	7.00	3.15	2.99	6.25	2.67	0.20%	0
MO Pac RR#72	6.5	Simple	4	7	7	7	7	5	5.50	2.35	7.00	3.15	2.99	6.25	2.67	0.20%	0
MO Pac RR#1	2.8	Simple	5	8	5	8	5	5	6.50	2.90	6.00	2.70	2.57	6.25	2.73	0.20%	0
KS Ave East**	7.2	Continuous	5	7	7	7	7	4	6.00	2.85	7.00	3.15	2.84	6.50	2.84	0.20%	1
Central Ave	3.3	Simple	5	8	8	8	6	4	6.50	2.90	7.33	3.30	2.97	6.92	2.94	0.20%	0
18th St	10.9	Continuous	5	7	7	7	7	7	6.00	2.85	7.00	3.15	3.15	6.50	3.00	0.20%	0
Weighting Percentage			50%	5%	15%	15%	15%			50%			50%				

Notes:
Unshaded values in structural rating table for simple, shaded values for continuous
Red values in Scour Rating column are assumed.
*Abandoned Bridges
**Structural failure could directly cause levee failure on CID-KS side only

TABLE 4

KC TERMINAL RR BRIDGE STRUCTURAL FAILURE HAND CALCULATIONS

U.S. ARMY CORPS OF ENGINEERS - KANSAS CITY DISTRICT

Comp. By KSM Date 11/4/11 Project KC Levees feasibility study Sheet ____ of ____

Chkd. By ____ Date ____ Subject Kansas River bridges Sheet ____ of ____

Future w/ Project probabilistic failure rating

- take worst case bridge (amount of superstructure under water)

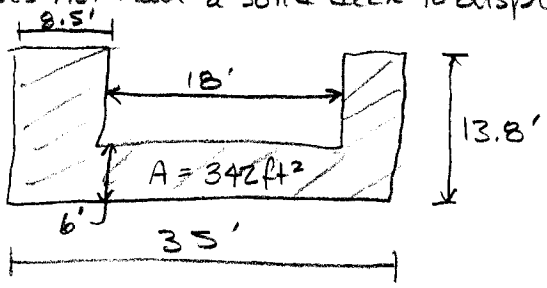
KC Terminal Bridge

on RR drawing DL w/ both floors ballasted = 25,500#/lin ft (25.5 k/ft)

Check uplift

13.8' underwater

Assume the following area contributing to uplift since the bridge does not have a solid deck to displace the water:

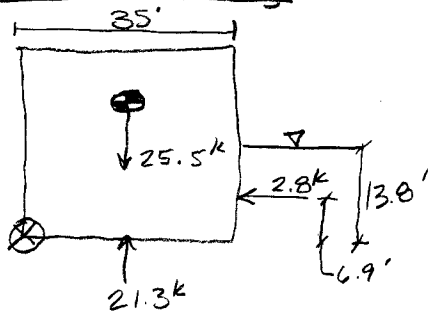


buoyant uplift = $342 ft^2 \times 62.4 \frac{\#}{ft^3} = 21.3 \, k/ft$

$\frac{25.5^k}{21.3^k} = 1.2$ Factor of Safety

1.2 > 1.1 required FS for extreme load case

Check overturning



Streamforces:

V = 12 fps K = 1.4 for drift

$P = KV^2 = 1.4 \times 12^2 = 202 psf = 0.2 ksf$

$F = 13.8 ft \times 0.2 ksf = 2.8 k/lin ft$

Resist ↻ $M_{\otimes} = 25.5^k \times \frac{35'}{2} = 446 k \cdot ft$

Overt. ↺ $M_{\otimes} = 21.3^k \times \frac{35'}{2} + 2.8^k \times 6.9' = 392 k \cdot ft$

$\frac{446}{392} = 1.14 > 1.1$ for extreme event

OK Reliability = 99.8%

MRK FORM 222

(g) Ice Pressure

In the absence of more precise data, the following shall be used as minimum design criteria:

1) Ice pressure is 150 psi.

2) Ice thickness is 1'-0".

3) Location of force on pier shall be midway between the ordinary high water elevation and the elevation at Q100.

Ice loads would normally not be considered except on larger rivers such as the Kansas or Missouri Rivers. The need to include ice pressure in the design of a structure should be made at the field check.

(h) Drift

Piers located in streams which are susceptible to transporting large amounts of drift and debris shall be designed to withstand the corresponding increase in stream pressure due to drift accumulation on the pier. The amount of drift build-up is a matter of judgment, but as a guide, the size of the drift may be approximated as follows: (Ref. 1993 AASHTO Interims)

(1) The drift width may be assumed as 10% of each span length contributory to the pier, but no less than 10 feet nor greater than 45 ft.

(2) The vertical depth could extend from the flow line to the computed high water elevation.

An estimate of the amount of drift to be expected should be discussed at Field Check.

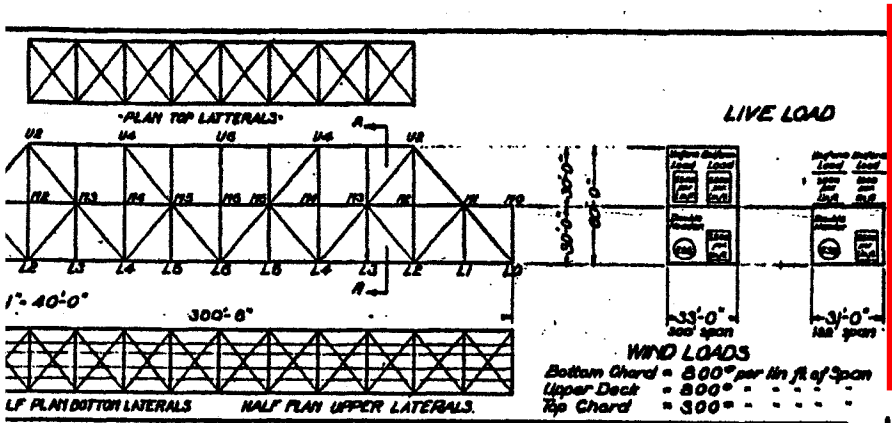
The stream flow pressure can be calculated by $P = KV^2$ (AASHTO Art. 3.18.1) with K = 1.4 for drift lodged against a pier.

Blockage of the flow area by drift build-up can increase the stream velocity and thus increase the scour depths through the bridge opening.

(i) Scour

Scour is not a load per se, however by changing the conditions of the channel its effects need to be considered in the design of the substructure. The bridge should

rminal 2.47



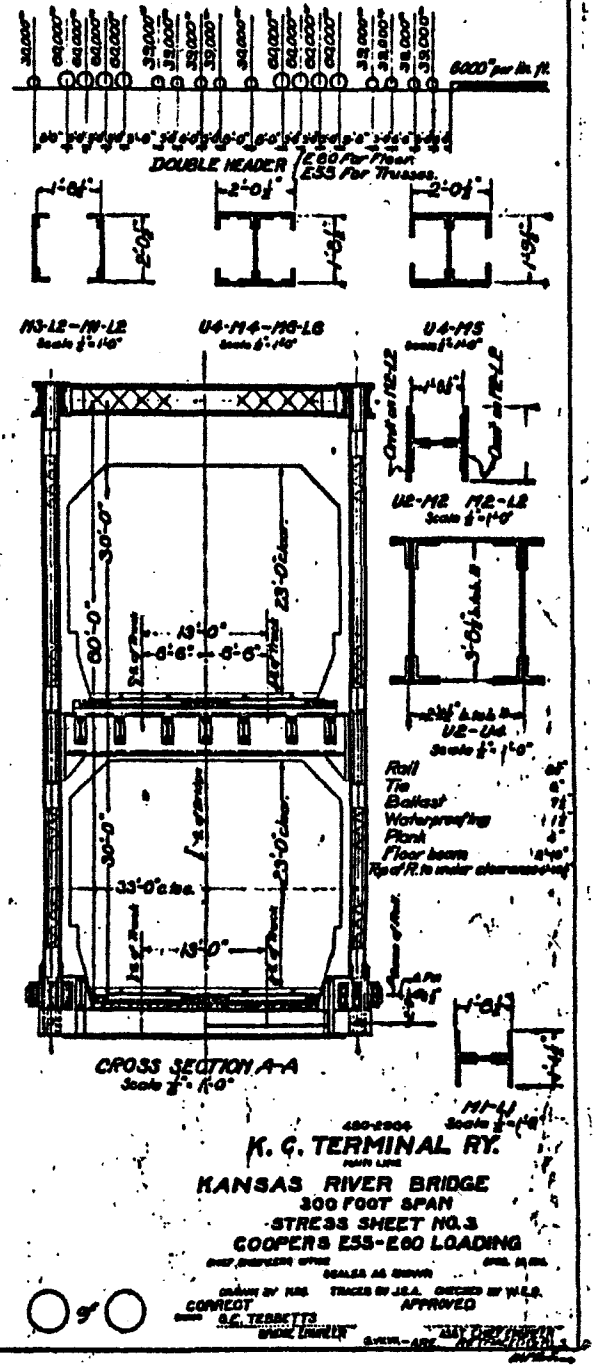
Case A. { Upper floor - Open. Lower " - Ballasted
Case B - Both floors ballasted
300' Span - High carbon steel for Top Chords and End Posts
Nickel steel for eye bars and pins.
Remainder - Structural steel.
132' Span - Structural Steel

ASSUMED LOADING
Dead Loads

	Case "A"	Case "B"
Lower Floor Track	4000# per lin. ft of Span	4000# per lin. ft. of Span.
Upper " "	3200# - - - - -	3200# - - - - -
Lower " Steel	3350# - - - - -	3350# - - - - -
Upper " "	2900# - - - - -	3200# - - - - -
Laterals	650# - - - - -	650# - - - - -
Trusses	6400# - - - - -	6700# - - - - -
Total	20500# - - - - -	23500# - - - - -

Members for Cases A & B - 300 ft. Span.

ula for t Stress		Unit Stress		Area Req'd		Area Used		Material Used	Make up of Sections.
	E80.	E55.	E80.	E55.	E80.	E55.	E80.		
00	32500	26000	32500	106#	106#	108.5		Nickel Steel.	4 Bars 14" x 1 13/16"
	do	do	do	112.5#	112#	112#			4 Bars 14" x 2"
	do	do	do	160#	161.5#	162.8#		Nickel Steel.	6 Bars 14" x 1 13/16"
	do	do	do	172#	171.0#	173.3#			6 Bars 14" x 2 1/16"
	23000-112½ Plus. 21800	17500#	21900	224#	225#	224.3#		High Carbon Steel	1 Web PL 48" x 3/8" 4 Angles 4" x 4" x 3/8" 2 Webs 48" x 3/8"
	do	do	do	242#	238#	242.2#			1 Web PL 48" x 3/8" 4 Angles 4" x 4" x 3/8" 2 Webs 48" x 3/8"
	do	do	do	251#	251#	250#		do	Same as U2-U4 and add 2 Pls 20" x 3/8"
	do	do	do	270#	269#	274.7#			Same as U2-U4 and add 2 Pls 20" x 3/8"
	do	17500	21900	246#	247#	250#		do	Same as U4-U6.
	do	do	do	263#	261#	274#			Same as U4-U6.
	do	do	do	221.5#	223#	224.3#		do	Same as U2-U4.
	do	do	do	238#	236#	242.2#			Same as U2-U4.
0	32500	26000	32500	97#	98#	98#		Nickel Steel	4 Bars 14" x 1 3/8"
	do	do	do	103#	104#	105#			4 Bars 14" x 1 3/8"
	do	do	do	87.5#	90#	91#		do	4 Bars 14" x 1 3/8"
	do	do	do	93#	94#	93.5#			4 Bars 14" x 1 13/16"
0	20000	16000	20000	85#	94#	91.5#		Structural Steel	8 Ls 4" x 4" x 3/8" 4 Pls 24" x 3/8" 1 Pl 24" x 3/8"
				87#	95.6#	"			"
0	20000	16000	20000	83#	93#	91.5#		do	" "
				83.6#	94#	"			"
0	20000	16000	20000	83.0#	86#	87.4#		do	4 Ls 6" x 6" x 3/8" 2 Pls 24" x 3/8" 1 Web 20" x 3/8" 2 Pls 24" x 3/8"
				85.0#	91#	87.4#		do	do do
0	20000	16000	20000	66.0#	68#	67.4#		do	4 Ls 6" x 6" x 3/8" 2 Pls 24" x 3/8" 1 Web 20" x 3/8"
				69.0#	71#	70.0#			Ls do 2 Pls 24" x 3/8" Web do
0½	20000-90½	12600	15680	86#	94.5#	98.0#		do	4 Ls 4" x 4" x 3/8" 4 Ls 3" x 3" x 3/8" 4 Webs 24" x 3/8" 1 Pl 20" x 3/8"
				89#	98.5#	98.0#			do do
0½	20000-90½	12500	15600	96#	104#	99#		do	4 Ls 4" x 4" x 3/8" 4 Ls 3" x 3" x 3/8" 2 Webs 24" x 3/8" 1 Pl 20" x 3/8"
				101#	105#	106#			do
								do	4 Ls 3½" x 3½" x 3/8" 4 Ls 3" x 3" x 3/8" 2 Webs 24" x 3/8" 1 Web 20" x 3/8"
0½	20000-90½	12200	15140	42.5#	43#	56.6#		do	4 Ls 3½" x 3½" x 3/8" 4 Ls 3" x 3" x 3/8" 2 Webs 24" x 3/8" 1 Web 20" x 3/8"
				45.8#	45.7#	58.5#			"
				36#	38#			do	Ls " 2 Webs 18" x 3/8" "
				38#	39#				
0	20000	16000	20000	33.2#	33.2#	35.4#		do	2 Ls 3" x 3" x 3/8" 1 Pl 20" x 3/8"
				33.3#	33.3#	35.4#			
0½	20000-90½	12300	15100	46.2#	46#	48.94#		do	4 Ls 4" x 4" x 3/8" 2 Pls 24" x 3/8"
				48.2#	47.6#	48.94#			
						19.8#		do	2 Ls 15" x 33#



ED-HH MFR

CENWK-ED-HH 24 February 2012 (Draft)

MEMORANDUM FOR Record

SUBJECT: Effects of Bridge Failure on Water Surface Elevations (KC Levees)

This hydraulic evaluation included quantifying the effects of a bridge failure on the 0.2% and 1.0% (500 and 100 year) water surface elevations on the Kansas River. There are several bridges over the Kansas River between the Kansas City Levees that could be impacted by flood waters.

The choice of which bridge to assume could fail during a 0.2% and 1.0% flood event was primarily based on the "Failure Modes" evaluation conducted by the structural group. The failure modes report indentified several bridges that would be overtopped by floodwaters during an extreme storm event. In addition, the report includes a table that provides probabilistic approach to potential bridge failure. Within the table the bridges within the reach of interest are given ratings based on the failure modes evaluated. This evaluation reveled that the bridge with the highest probability of failure during a 0.2% storm event was the KC Terminal Railroad Bridge (See Figure 1).

Figure 1 – KC Terminal Railroad Bridge Location

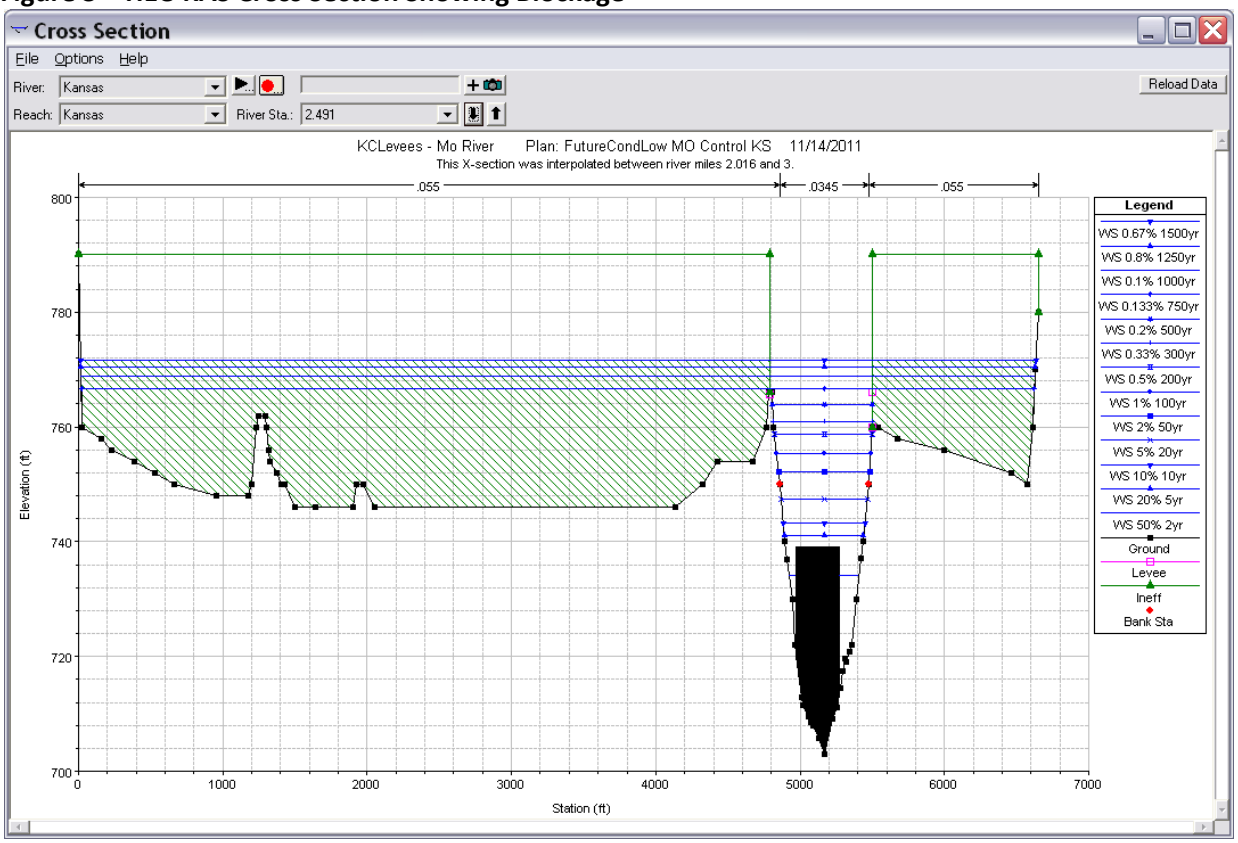
Bridge Failure Modeling Approach

The evaluation of a potential bridge failure included modifying the proposed conditions HEC-RAS model to reflect the loss of one span from the KC Terminal Bridge. Based on photos from the 1951 Flood, the truss bridges that failed appeared to only lose the center span, while the other spans remained intact or failed in place. As such the assumption for the KC Terminal Bridge is that a failure could occur on the center span while the other two spans remain intact. A photo of the KC Terminal Bridge is shown in Figure 2.

Figure 1 – KC Terminal Railroad Bridge Photo

As noted above, the modeling approach assumes that only the center span of the KC Terminal Bridge will fail during a 0.2% flood event. For this effort it is assumed that center span failure would result in blockage of the Kansas River. In order to model the “blockage” a failed bridge would cause, a blocked obstruction was added to the cross section down stream of the bridge location (See Figure 3).

Figure 3 – HEC-RAS Cross Section Showing Blockage



Two blockage scenarios were evaluated. The first assumes that the failed center span would come to rest immediately at the bridge location, i.e. it would not be carried downstream. The second scenario assumes that the bridge would be carried/pushed downstream and trapped at the next river crossing, Kansas Avenue. To account for the open space between the bridge webbing, the height of the blocked obstruction was set to 36 feet, which is approximately one-half the height of the intact bridge structure. This height also accounts for some bridge deformation. It should also be noted that the center span of the bridge was removed from the "bridge cross section" within the HEC-RAS model to account for it not being there.

Results

The blocked obstruction resulted in an increase in water surface elevations upstream of the bridge failure. The worst case condition was a failure that remained near the bridge location. The hydraulic model indicated that for a 0.2% (500-year) event, water surface profiles would be increased by approximately 2.2 feet above non-failure conditions. The model indicates that the increase would be carried upstream and reduces to 0.7 feet above non-failure conditions 12 miles upstream of the failure location (end of the modeled reach). Comparison tables for both the 0.2% and 1.0% events are provided below.

Table 1 – 0.2% (500-year) Storm

River Station	Non-Fail Elevation	Bridge failure Elevation	Difference
14.62	782.29	782.96	0.67
14.25	782.15	782.82	0.67
13.65	781.96	782.64	0.68
13.3	781.68	782.39	0.71
12.94	781.43	782.16	0.73
12.4	781.22	781.95	0.73
11.85	780.84	781.61	0.77
11.35	780.29	781.09	0.80
10.9	779.85	780.69	0.84
10.6	779.00	779.9	0.90
10.4	778.80	779.72	0.92
9.82	778.59	779.52	0.93
9.505	778.03	778.98	0.95
9.49	777.99	778.93	0.94
9.04	777.30	778.3	1.00
8.42	776.74	777.79	1.05
7.65	775.64	776.78	1.14
7.364	775.30	776.45	1.15
7.35962	775.29	776.45	1.16
7.35087	775.26	776.42	1.16
7.34212	775.25	776.41	1.16
7.33337	775.22	776.39	1.17
7.329	775.21	776.38	1.17
6.88	774.97	776.17	1.20
5.967	774.46	775.7	1.24
5.831	774.49	775.73	1.24
5.811	774.46	775.7	1.24
5.52	773.96	775.23	1.27
5.506	773.92	775.19	1.27
4.97	773.40	774.72	1.32
4.949	773.17	774.49	1.32
4.48	771.78	773.22	1.44
4.284	771.42	772.9	1.48
4.276	771.23	772.69	1.46
3.96	770.71	772.23	1.52
3.427	769.75	771.39	1.64
3.405	769.43	771.06	1.63
3.05	768.54	770.26	1.72
2.536	766.64	768.59	1.95
2.5305	KC Terminal Bridge		
2.525	766.10	768.28	2.18

Table 2 – 1.0% (100-year) Storm

River Station	Non-Fail Elevation	Bridge failure Elevation	Difference
14.62	773.97	774.61	0.64
14.25	773.80	774.45	0.65
13.65	773.57	774.23	0.66
13.3	773.23	773.93	0.70
12.94	772.94	773.66	0.72
12.4	772.69	773.42	0.73
11.85	772.31	773.08	0.77
11.35	771.69	772.47	0.78
10.9	771.23	772.06	0.83
10.6	770.39	771.28	0.89
10.4	770.10	771	0.90
9.82	769.80	770.75	0.95
9.505	769.43	770.39	0.96
9.49	769.40	770.36	0.96
9.04	768.64	769.68	1.04
8.42	768.01	769.11	1.10
7.65	766.97	768.17	1.20
7.364	766.61	767.84	1.23
7.35962	766.60	767.84	1.24
7.35087	766.57	767.81	1.24
7.34212	766.56	767.8	1.24
7.33337	766.53	767.78	1.25
7.329	766.52	767.77	1.25
6.88	766.25	767.53	1.28
5.967	765.75	767.08	1.33
5.831	765.74	767.08	1.34
5.811	765.72	767.07	1.35
5.52	765.30	766.68	1.38
5.506	765.27	766.65	1.38
4.97	764.78	766.21	1.43
4.949	764.66	766.1	1.44
4.48	763.47	765.03	1.56
4.284	763.10	764.71	1.61
4.276	763.01	764.63	1.62
3.96	762.56	764.23	1.67
3.427	761.61	763.43	1.82
3.405	761.45	763.28	1.83
3.05	760.64	762.61	1.97
2.536	758.99	761.23	2.24
2.5305	KC Terminal Bridge		
2.525	758.75	761.08	2.33

Anthony Hall P.E.
Hydraulic Engineer

HNTB 2008 BRIDGE RECONNAISSANCE - LETTER OF OPINION

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Date
11/7/08

To
Lamar McKissack, COE

From
Dave Renetzky, HNTB

PROJECT CORRESPONDENCE

Subject
Kansas City Levees Phase 2
Bridge Reconnaissance – HNTB Task 3a
Letter of Opinion

Introduction

The bridge analysis task of the Kansas City Levees Phase 2 Study to determine potential impacts to existing bridges, railroad crossings, gaps, and closures on the lower Kansas River has many aspects to it. The Kansas River units of the feasibility study include Argentine, Central Industrial District (CID), and Armourdale. Task 3 of the HNTB Scope of Work dated 13 August 2008 provides an overview of technical requirements to complete the effort, including field data collection, stakeholder coordination, and detailed analysis and documentation. It was decided that breaking the task into two parts, Task 3a and Task 3b, would accomplish initial goals while bringing insight into the effort necessary to complete the overall task. Task 3a was considered bridge reconnaissance, while Task 3b will be performance of the analyses.

The general purpose of the bridge reconnaissance was to:

- Research and understand the bridge configurations
- Observe structural conditions of the bridges
- Observe site conditions with respect to scour, geotechnical aspects, and closure gaps
- Relate low steel elevations to the proposed water surface elevations
- Form an approach to the lateral load analysis
- Provide an opinion of base and option tasks in the scope

Nine bridges were identified by the Corps to include in the reconnaissance effort. Dave Renetzky (HNTB), Chuck Steffensmeier (HNTB), Kevin Kuhl (HNTB), Alma Baratta (HNTB), Bill McFarland (COE), Eddie Fernandez (COE), and Ernie Quinto (Kaw Valley Drainage District) visited the following bridges on 14 October 2008:

- Missouri Pacific #1
- Missouri Pacific #72
- Union Pacific #3
- Kansas City Terminal

On 15 October 2008, Dave Renetzky (HNTB), Chuck Steffensmeier (HNTB), Tom Westerman (HNTB), Alma Baratta (HNTB), Bill McFarland (COE), and Ernie Quinto (KVDD) visited the remaining bridges:

- Kansas Avenue East
- 7th Street Northbound
- 18th Street

- Chicago Rock Island & Pacific
- Kansas City Southern

Site visit notes and reports are included in the appendix to this document, along with numerous photos from each bridge on CD. Each bridge was documented with a structural observation sheet, a stream stability analysis sheet, and a geotechnical site visit report.

Structural Analysis Overview

The superstructures, substructures and foundations for the bridges contained in this study were most likely not originally designed for stream flow lateral loads that occur during a 500-year flood event. The substructures for all of the bridge river piers are either concrete piers that bear directly on rock or concrete piers that are supported by timber piles that have been driven to rock. The five failure modes that are shown on the next page and explained below should be evaluated for each bridge for the stream flow lateral load that result from the 500-year and 500-year + 3' flood event. The analysis of all five failure modes will determine if modifications are needed to decrease risk of failure for the bridge.

It is recommended that the railroad bridge substructures be evaluated with the load combinations, which include stream flow, from chapter 8 of the 1995 edition of the AREMA manual for Railway Engineering. The highway bridge substructures should be evaluated for the load combinations, which include stream flow, from the 2002 17th edition of the AASHTO Standard Specifications for Highway Bridges. All of the bridges will be evaluated by either the Load Factor or Service Load design method.

Another part of the recommended study is scour analysis to be performed on the bridge piers. The results of the scour analysis should be included in the structural evaluation of the river pier foundations for both storm events.

The five potential failure modes of the bridges include:

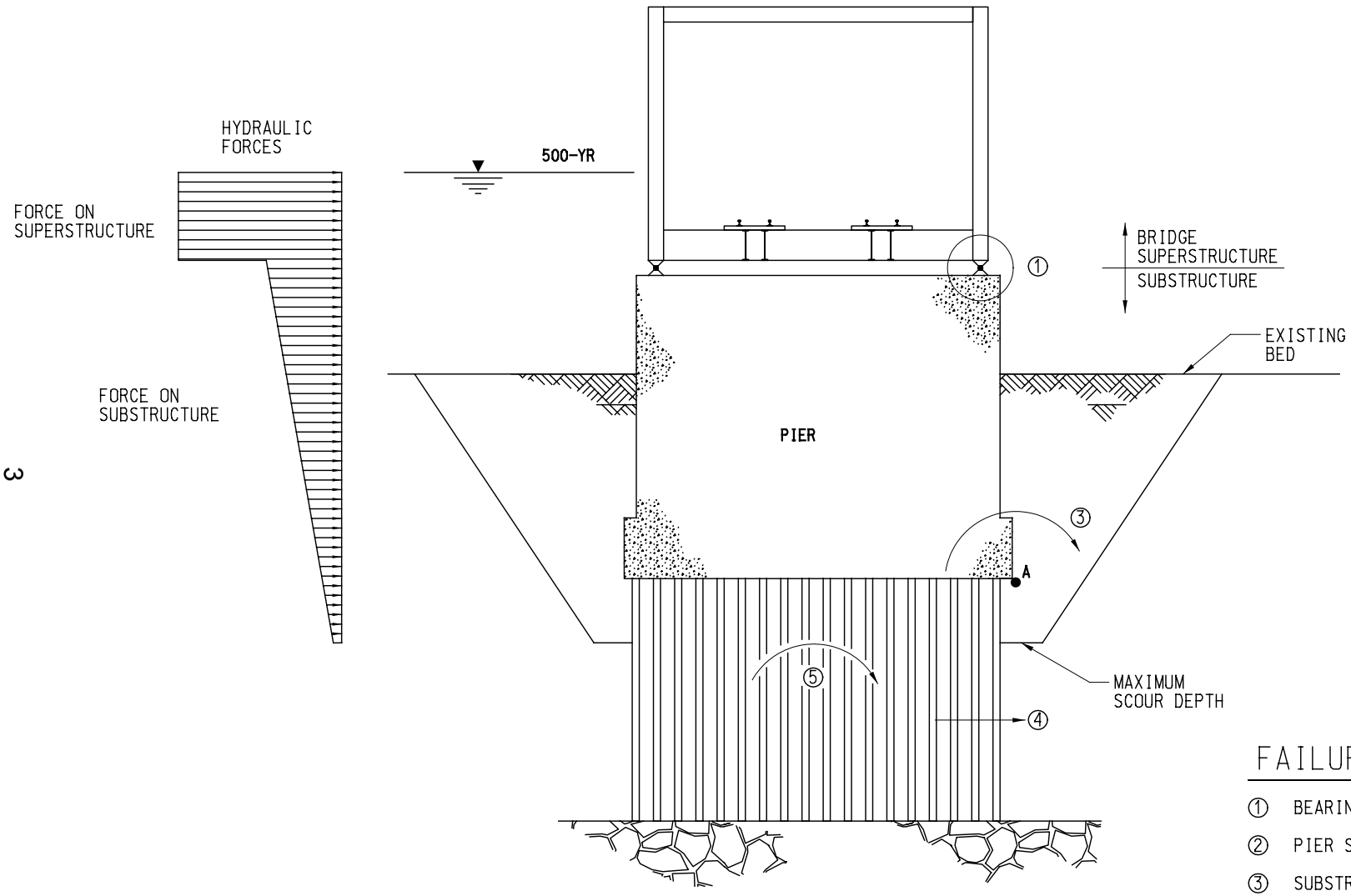
1. Bearing and anchor bolt overstress - The analysis will evaluate the bearings and anchor bolts for overstress that result from the uplift and lateral hydraulic forces on the superstructure.

2. Pier section overstress - The analysis will evaluate the pier section for shear and bending overstress that result from the lateral forces.

3. Substructure Overturning - The analysis will evaluate the substructure for exceeding allowable overturning resistance that results from lateral hydraulic forces.

4. Substructure Sliding - The analysis will evaluate the substructure for exceeding allowable sliding resistance that results from lateral forces.

5. Foundation overstress - The analysis will evaluate the substructure foundation for overstress that results from the lateral forces. Tension or pile capacity of the timber piles as well as bearing capacity of the piers on rock are to be evaluated as part of the foundation overstress.



FAILURE MODES

1. BEARING AND ANCHOR BOLT OVERSTRESS
2. PIER SECTION OVERSTRESS
3. SUBSTRUCTURE OVERTURNING
4. SUBSTRUCTURE SLIDING
5. FOUNDATION OVERSTRESS

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HNTB

Analysis should be completed for all five failure modes. Based on hydraulic forces, the most likely failure mode will be either substructure overturning or substructure sliding. However, each failure mode will need to be investigated to ensure the limiting failure mode has been identified and appropriate modifications are identified. Forces calculated for each flood event will be used for the analysis of each failure mode. The failure analysis calculations are not needed for the cases where the n500 water surface elevation does not exceed the elevation of the low chord. The lateral forces exerted on the bridge for this case are much less because the force from the water is not exerted along the length of the bridge. While it is possible that scour depth could be greater with a lower water surface elevation (and resultant higher velocity), the evaluation can be bypassed unless there is a known scour problem at a particular bridge.

The analysis may determine that the bridge or substructure component is overstressed. This analysis is based upon an allowable stress, the ultimate stress is typically much greater, but considering material variability an allowable stress that is lower than the ultimate stress is used. Allowable stress varies according to the age of the bridge and the process used for the original material, a recommendation of the allowable stress for the material used in each bridge will be included in a design memorandum and agreed upon as part of the future 3b tasks. The result of these stress calculations is that the member may be overstressed but not fail, so a retrofit will not be required in the case where the ultimate stress is not reached. In cases where the ultimate stress is reached, the member would fail and a retrofit or replacement will be recommended.

Failure modes; 3- Substructure overturning, 4-Substructure sliding and 5- Foundation overstress are a function of the maximum scour at the pier. Scour analysis for each river pier is recommended to ensure that the worst-case scenario is identified and included in the analysis.

For purposes of this study, it is assumed that failures resulting from existing maintenance or the life span of the structure are the responsibility of the owner. Future analysis will only consider the possible failures as a result of the proposed impacts of this study.

Ownership of the railroad structures is provided in the following sections. The U.S. Army Corps will provide a letter to each of the owners that will describe the study purpose and ask that several team members meet with them to discuss the study. During the meeting with the owners, the team will provide additional information regarding the study and answer questions that they may have. The team will request copies of the owner's bridge plans during the meeting.

1. Missouri Pacific #1 Bridge (River mile 0.26)

Research - The Missouri Pacific bridge is a single track, 4-span through truss with 82' deck plate girder on north end (3 @200', 1 @ 233', 1 @82' = 915'). The river piers are concrete bearing on rock. The fourth span of the bridge was added in 1917, with the substructure for the additional span constructed of concrete on timber piles driven to rock.

The low steel elevation of the bridge is at elevation 759.0. The Q500 WSEL is 756.9, 2.1 feet below the low steel elevation of the bridge. The Q500+3' WSEL is 760.9, which pressurizes flow 1.9' above the low steel elevation of the bridge.

The owner of the bridge is Union Pacific Railroad. The contact person and information is as follows:

David McKernan
Manager Industry & Public Projects
Phone: 314-331-0682

Opinion - The failure mode analyses should include the investigation of one river pier and a pier for the new span of the bridge that was added in 1917. The Q500 WSEL is below the low steel of the bridge and does not need to be investigated. No underwater inspection will be completed; the analysis will include a relative evaluation of a pile section that is agreed upon prior to the analysis.

Possible mitigation measures for the bridge include; raising the bridge on the existing alignment by a minimum of 1.9', converting the bridge to a lift span, reinforcing the bearings and reinforcing the piers.

Depending upon the mitigation measures for this bridge, the stoplogs on the west end of the bridge will need to tie into the high ground to the west. The proposed floodwall on the east end of the bridge will tie into the existing embankment.

2. Kansas City Southern Bridge (River mile 0.81)

Research - The Kansas City Southern bridge was built in 1916 and is not in use today. The bridge is a single track, 3-span through truss (2 @360', 1 @ 230'= 950'). The river piers are constructed of concrete on timber piles driven to rock.

The low steel elevation of the bridge is at elevation 759.4. The Q500 WSEL is 759.0, 0.4 feet below the low steel elevation of the bridge. The Q500+3' WSEL is 762.1, which pressurizes flow 2.7' above the low steel elevation of the bridge.

The owner of the bridge is the Kansas City Southern Railroad. The contact person and their information is as follows:

Srikanth Honnur
Director Track and Bridge Construction
Phone: 816-983-1138
Fax: 816-983-1186
shonnur@kcsouthern.com

Opinion - The failure mode analyses should include the investigation of one river pier and bearings. The Q500 WSEL is below the low steel of the bridge and does not need to be investigated. No underwater inspection will be completed; the analysis will include a relative evaluation of a pile section that is agreed upon prior to the analysis.

Possible mitigation measures for the bridge include; raising the bridge on the existing alignment by 2.7', removing the bridge, reinforcing the bearings and reinforcing the piers. If the analysis results in a bridge failure, complete removal of the existing bridge would be the most advantageous option from a river hydraulics standpoint.

The existing levee wall surrounds the abutments of this bridge and will need to be raised. No stoplogs are needed at this bridge.

3. Missouri Pacific 72 Bridge (River mile 1.62)

Research - The Missouri Pacific bridge was built in 1945 and is a double track 4-span through truss (3 @180', 1 @ 196'on W. end =736'). The piers and abutments are concrete on timber pile driven to rock.

The low steel elevation of the bridge is at elevation 758.9. The Q500 WSEL is 762.2, 2.3 feet above the low steel elevation of the bridge. The Q500+3' WSEL is 765.5, 6.6' above the low steel elevation of the bridge.

The owner of the bridge is Union Pacific Railroad. The contact person and information is as follows:

David McKernan
Manager Industry & Public Projects
Phone: 314-331-0682

Opinion - The failure mode analyses should include the evaluation of one river pier and bearings for both flood elevations since they are both above the low steel elevation of the bridge. Because this bridge is in close proximity to the Union Pacific Bridge (River mile 1.64) bearing overstress of the soil due to additional loads from the anticipated water elevations may be a possible mode of failure. No underwater inspection will be completed; the analysis will include a relative evaluation of a pile section that is agreed upon prior to the analysis.

Possible mitigation measures for the bridge include; raising the bridge on the existing alignment by a minimum of 6.6', converting the bridge to lift spans, reinforcing the bearings and reinforcing the piers.

Stoplogs at both the east and west abutment of the bridge will need to accommodate the increased height of the floodwall. Conceptual layouts of the stoplogs and where they tie to the floodwall or levee are shown in the original scope documents. Design of the stoplogs will need to accommodate a minimal disruption to train traffic. A micropile with a precast cap may be a good alternative that can be installed in a relatively short period of time and the installation equipment is mobile e.g. a large excavator can be used to install the micro-piles instead of a crane used to install driven piles or drilled shafts. This alternative will be dependant upon the soil conditions and loading on the stoplog. Alternates to stoplogs are a swing gate or miter gate for quicker closure.

4. Union Pacific Bridge (River mile 1.64)

Research - The Union Pacific bridge was built in 1945 and is a double track 4-span through truss (3 @180', 1 @ 196'on W. end =736'). The bridge has been retrofitted to raise 8.8' vertically on a tension screw lifting device and was last raised for the 1993 flood. The piers and abutments are constructed of concrete on timber piles driven to rock.

The low steel elevation of the bridge in a raised position is at elevation 762.7. The Q500 WSEL is 762.5, 0.2 feet below the low steel elevation of the bridge in a raised position. The Q500+3'

WSEL is 765.6, a minimum of 2.9' above the low steel elevation of the bridge in a raised position.

The owner of the bridge is Union Pacific Railroad. The contact person and information is as follows:

David McKernan
Manager Industry & Public Projects
Phone: 314-331-0682

Opinion - The failure mode analyses should include the investigation of one river pier and bearings for both flood elevations since they are both above the low steel elevation of the bridge. No underwater inspection will be completed; the analysis will include a relative evaluation of a pile section that is agreed upon prior to the analysis.

Tension screw lifting devices are a relatively reliable lifting mechanism and require limited maintenance. However, in the past the electric cables that provide power to the mechanisms has been stolen, rendering the lifting mechanism temporarily inoperable.

Stoplogs at both the east and west abutment of the bridge will need to accommodate the increased height of the floodwall. Conceptual layouts of the stoplogs and where they tie to the floodwall or levee are shown in the original scope documents. Design of the stoplogs will need to accommodate a minimal disruption to train traffic. A micropile with a precast cap may be a good alternative that can be installed in a relatively short period of time and the installation equipment is mobile; e.g. a large excavator can be used to install the micropiles instead of a crane used to install driven piles or drilled shafts. This alternative will be dependant upon the soil conditions and loading on the stoplog.

Possible mitigation measures for the bridge include; raising the bridge on the existing alignment by a minimum of 2.9', increasing the lift on the bridge from 8.8' to 11.7', reinforcing the bearings and reinforcing the piers.

5. Chicago Rock Island & Pacific Bridge (River mile 2.10)

Research - The Chicago Rock Island and Pacific bridge was built is a single track, 3-span through truss (2 @ 302', 1 @ 119'on E. end =723') and is not in use today. The center river pier is constructed of concrete on rock and the two adjacent piers are constructed of concrete on timber piles. The bridge is in the lifted position and is permanently shored to secure the raised position.

The low steel elevation of the bridge is at elevation 762.8. The Q500 WSEL is 764.3, a minimum of 1.5 feet above the low steel elevation of the bridge. The Q500+3' WSEL is 767.7, a minimum of 4.9' above the low steel elevation of the bridge.

The owner of the bridge is the City of Kansas City, Missouri. The contact person and information is:

Tom Degenhardt, P.E., R.L.S.
Assistant City Engineer
KCMO Public Works
19th Floor City Hall, 414 East 12th Street

Kansas City, Missouri 64106-2795
816-513-2506
816-513-2712 Fax
816-719-0191 Cell
tom_degenhardt@kcmo.org

Opinion - The failure mode analyses should include the investigation of one river pier this is on rock and one river pier that is concrete on timber piles driver to rock. The Q500 WSEL and Q500 +3 are both above the low steel of the bridge and both flood events will need to be investigated. No underwater inspection will be completed; the analysis will include a relative evaluation of a pile section that is agreed upon prior to the analysis.

Possible mitigation measures for the bridge include; raising the bridge on the existing alignment by a minimum of 4.5', removing the bridge, reinforcing the bearings and reinforcing the piers. If the analysis results in a bridge failure, complete removal of the existing bridge would be the most advantageous option from a river hydraulics standpoint.

The existing levee wall surrounds the abutments of this bridge and will need to be raised. No stoplogs are needed at this bridge.

6. Kansas City Terminal Bridge (River mile 2.53)
Research - The Kansas City Terminal bridge was built in 1914 and revised to a lift bridge in 1967 and is a bi-level, double track 3-span through truss (2 @300', 1 @ 132'on W. end =732'). The bridge has been retrofitted to raise 10.5' vertically with hydraulic cylinders. Two of the three spans were raised in the 1993 flood. The river piers are concrete on rock and the abutments are concrete piers on timber pile driven to rock.

The low steel elevation of the bridge in a raised position is at elevation 766.4. The Q500 WSEL is 766.7, a minimum of 0.3 feet above the low steel elevation of the bridge in a raised position. The Q500+3' WSEL is 766.7, a minimum of 3.3' above the low steel elevation of the bridge in a raised position.

The owner of the bridge is the Kansas City Terminal Railroad. The contact person and information is as follows:
Chuck Mader
Chief Engineer
4501 Kansas Avenue
Kansas City, MO 66106
Phone: 913-551-2596
cemader@kctrailway.com

Opinion - The failure mode analyses should include the investigation of one river pier and bearings for both flood elevations since they are both above the low steel elevation of the bridge. No underwater inspection will be completed.

There is a large amount of hydraulic fluid that has leaked onto the bridge piers and there is evidence that the hydraulic mechanisms do not operate adequately to lift the bridge.

Possible mitigation measures for the bridge include; raising the bridge on the existing alignment by a minimum of 3.3', increasing the lift on the bridge from 10.5' to 13.8', reinforcing the bearings and reinforcing the piers.

Stoplogs at both the east and west abutment of the bridge and yard immediately east of the bridge will need to accommodate the increased height of the floodwall. Conceptual layouts of the stoplogs and where they tie to the floodwall are included in the original scope documents. Design of the stoplogs will need to accommodate a minimal disruption to train traffic. A micropile with a precast cap may be a good alternative that can be installed in a relatively short period of time and the installation equipment is mobile e.g. a large excavator can be used to install the micropiles instead of a crane used to install driven piles or drilled shafts. This alternative will be dependant upon the soil conditions and loading on the stoplog.

7. East Kansas Avenue Bridge (River mile 2.17)

Research - The river bridge is a steel 3-span deck truss (1 @ 267.34', cantilever arm @ 48', 1 @ 317.5', cantilever arm @ 88' = 720.84'). The out to out bridge width 52'-6" and it has a concrete deck that will accommodate two lanes of traffic in each direction. The river piers are concrete shafts that bear on rock. The original bridge plans were not included with the plans provided but the 1953 plans for the 5' bridge raise were included. The owner of the bridge is The Unified Government of Wyandotte County, the contact is Fred Backus. The bridge is currently in service.

The low steel elevation of the bridge is 760.8. The Q500 WSEL is 764.9, a minimum of 4.1' above the low steel elevation of the bridge. The Q500+3' WSEL is 767.9, a minimum of 7.1' above the low steel elevation of the bridge.

Opinion - The potential failure mode analysis will include the investigation of the west river pier. This should be the pier that is most heavily loaded. Both flood events will need to be investigated since both events will have water on the low steel.

Potential mitigation measures for the bridge include strengthening the bearing devices, adding bearing bumper blocks, strengthening the pier and strengthening the foundation. Raising the bridge is also an option, but the height of raise will need to be carefully considered.

8. 7th Street Northbound Bridge (River mile 3.42)

Research - The river bridge is a steel 3-span continuous deck truss (1 @ 272.25', 1 @ 334.5', 1 @ 272.25' = 879'). The out to out bridge width in unknown since the plans provided did not have this information but it has a concrete deck that will accommodate two northbound lanes of traffic. The river piers are concrete piers that are supported by timber piles that have been driven to rock. The original bridge plans are dated 1933. The owner of the bridge is KDOT, the contact is Loren Risch. The bridge is currently in service.

The low steel elevation of the bridge is 756.0. The Q500 WSEL is 769.8, a minimum of 13.8' above the low steel elevation of the bridge. The Q500+3' WSEL is 772.8, a minimum of 16.8' above the low steel elevation of the bridge.

Opinion - The potential failure mode analysis should include the investigation of the east river pier. This should be the pier that is most heavily loaded and it receives direct flow from the

river. It was also observed in the field that at some time sheet pile had been placed around this pier and concrete had been added to fill the void between the pier and sheet piling. Both flood events will need to be investigated since both events will have excessive water on the low steel.

Potential mitigation measures for the bridge include strengthening the bearing devices, adding bearing bumper blocks, strengthening the pier and strengthening the foundation.

9. 18th Street Bridge (River mile 4.96)

Research - The river bridge is a steel 3-span continuous deck truss ((1 @ 329.88', 1 @ 424.12', 1 @ 330.86' = 1084.86'). The out to out bridge width is 62'-6" and it has a concrete deck that will accommodate two lanes of traffic in both directions. The river piers are concrete piers that are supported by timber piles that have been driven to rock. The original bridge plans are dated 1957. The owner of the bridge is KDOT, the contact is Loren Risch. The bridge is currently in service.

The low steel elevation of the bridge is 764.3. The Q500 WSEL is 772.9, 8.6' above the low steel elevation of the bridge. The Q500+3' WSEL is 775.9, 11.6' above the low steel elevation of the bridge.

Opinion - The potential failure mode analysis should include the investigation of the east river pier. This should be the pier that is most heavily loaded and it receives direct flow from the river. Both flood events will need to be investigated since both events will have water on the low steel.

Potential mitigation measures for the bridge include strengthening the bearing devices, adding bearing bumper blocks, strengthening the pier and strengthening the foundation. Raising the bridge is also an option, but the height of raise will need to be carefully considered.

Hydraulics/Scour Analysis Overview

The total scour at any waterway is comprised of three components: long-term scour (aggradation/degradation), contraction scour, and local scour. Long-term scour (aggradation/degradation) is the change in the river bottom that occurs over time, either naturally or due to man-made activities. Usually, detailed historical data for the study site is used to estimate how the stream bed will behave over a period of time. Observations and discussions with the Kaw Valley Drainage District indicate that bed degradation may have occurred in the Kansas River at one or more of these bridges. Original construction plans and Operation and Maintenance manuals will provide some insight to the original bed levels. More recent information from the Corps is currently being sought. In addition to more recent soundings or bed levels that may be available from the COE, the Kansas Department of Transportation should have some data for their bridges. In a worst case scenario, soundings would need to be taken to obtain a recent bed profile during the next phase of the study.

Contraction scour is a result of flow contraction created by narrowing of the floodplain at the bridge crossing location. Due to the existence of levees (or high ground) on both sides of the river and the span of the bridge from levee to levee, there is no hydraulic constriction created from an overall floodplain standpoint. Therefore there is generally no contraction scour present.

Local scour is caused by the vortices which occur when the flow impacts the support posts or footings. The action of the vortex removes bed material from around the structure. With the transport rate of sediment away from the structure greater than the transport rate into the region, a scour hole develops. With the increased water surface from the potential project improvements, local scour will increase directly. The parameters needed for the local scour calculations will be obtained from bridge plans, field observations, and the COE hydraulic models. The hydraulic models are assumed to be essentially complete, with the exception of updates to the low steel elevations and potential changes to the bed profile information.

Scour analysis typically consists of data collection and field inspection, hydrology and hydraulics, scour calculations and assessment, and countermeasure design. During the recent site visits for the Kansas City Levees Study, observations were made about scour potential. This included looking at evidence of present or past scour, channel stability, the approach angle of flow, soil composition, and existing countermeasures. Refer to the field notes in the Appendix for specific items noted at each bridge. Many photos were taken to document the observations as well.

Scour calculations will be performed using methodologies outlined in HEC-18. An updated procedure has been recently developed by FHWA for calculating pier scour in pressure flow situations due to apparent flaws in the latest published calculations. Although not yet released as an updated HEC-18 document, our opinion is that the procedure will be the most appropriate for the bridges in this study.

Geotechnical Analysis Overview

The role of the geotechnical staff will be to aid in the structural analysis of the failure modes which include the foundations. Depending upon foundation type, one of the following analyses may be performed; 1) calculating the tension capacity of existing piles or 2) providing an assessment of the allowable and ultimate bearing capacity of the piers founded on rock. In addition to the geotechnical evaluation of the foundations, we will provide grain size values for use in the calculation of scour. Soil grain size values will be obtained from the boring and laboratory testing information made available to HNTB by the U.S. Army Corps of Engineers, Kansas City District.

As part of the information gathering for this phase of the project, plans for the 12th Street Bridge over the Kansas River and W.B. Viaduct were obtained from HNTB files. Based on these plans, shale of the Pleasanton Group is the formation that supports the bridges included in this report. The rock referred to in this report is most likely the shale of the Pleasanton Group.

The purpose of our field reconnaissance was to observe the existing conditions near the bridges for slope instability, record the soil type at the ground surface and to observe existing conditions such as exposed piles or other observations that would have an impact on subsequent analyses. The reports of our observations are documented in the Geotechnical Site Visit Reports included in the Geotechnical Field Forms Appendix.

Conclusions

Five potential bridge failure modes should be evaluated for each bridge: bearing and anchor bolt overstress, pier section overstress, substructure overturning, substructure sliding, and foundation overstress. In order to potentially recommend a proper modification, all modes of failure should be tested. One retrofit could protect against one type of failure while leaving the bridge susceptible to another.

Scour analysis should be performed for all piers in the river to ensure that the worst-case scenario is identified and included in the structural analysis. The estimate of structural analysis effort should include opinions of how many piers will be analyzed for each bridge.

None of the bridges in the study were likely designed for an n500 water surface elevation, so they are all likely to be overstressed under proposed conditions from the information that is currently known. Some analyses for the n500 water surface elevations were left off of the Task 3b scope, which is reasonable for a feasibility level effort since they are below the low steel of the bridge. Subtasks were generally listed as OPTIONs for the n500 WSEL and BASE for the n500+3 WSEL if both are above the low steel of the bridge. The OPTION subtasks can be eliminated if the BASE analysis does not show an overstress failure. Other subtasks are broken out based on the distinction between operational immediately following an event and simply rendering it repairable at some point in the future. The recommended analysis for the study will not identify that distinction and therefore eliminate the need for several OPTION subtasks.

The embankment behind the abutments of several bridges is above the proposed flood wall elevation and no modification will be needed. The two bridges that have been abandoned have floodwalls that extend around the perimeter of the bridge abutment and the wall will need to be raised. The Missouri Pacific #72 bridge, Union Pacific Bridge and KCT Bridge all have stop gaps that will need to be modified or built at a new location.

It is desired that the organization of the Task 3b proposal minimize and narrow the scope of bridge analysis effort wherever possible, as long as it does not compromise formulation and economic decision making. The duration of Task 3b is estimated to be approximately six months, but can be expedited if necessary due to the ability to separate individual subtasks.

APPENDIX

Kansas City Levees Feasibility Study
Bridge Reconnaissance
10/23/08

Bridge Fact Sheet

1. Missouri Pacific 1 Bridge (River mile 0.26)

- 4-span through truss with 82' DPG on north end (3 @200', 1 @ 233', 1 @82' = 915')
- Single Track Bridge
- River piers- Concrete on rock
- 4th span added in 1917
- Low Steel Elevation : 759.0
- n500 WSEL: 756.9 (2.1' below low steel)
- n500+3' WSEL: 760.9 (1.9' above low steel)
- Owner: Union Pacific Railroad
- Contact: David McKernan
  Manager Industry & Public Projects
  Phone: 314-331-0682

2. Kansas City Southern Bridge (River mile 0.81)

- 3-span through truss (2 @360', 1 @ 230'= 950') – Not used
- Single Track Bridge
- River piers- Concrete on timber piles
- Constructed in 1916
- Low Steel Elevation : 759.4
- n500 WSEL: 759.0 (0.4' below low steel)
- n500+3' WSEL: 762.1 (2.7' above low steel)
- Owner:Kansas City Southern Railroad
- Contact: Srikanth Honnur
  Director Track and Bridge Construction
  Phone: 816-983-1138
  Fax: 816-983-1186
  shonnur@kcsouthern.com

3. Missouri Pacific 72 Bridge (River mile 1.62)

- 4-span through truss (3 @180', 1 @ 196'on W. end =736')
- Double Track Bridge
- Piers- Concrete on timber piles to rock

- Constructed in 1945
- Low Steel Elevation : 758.9
- n500 WSEL: 762.2 (2.3' above low steel)
- n500+3' WSEL: 765.5 (6.6' above low steel)
- Owner: Union Pacific Railroad
- Contact: David McKernan
  Manager Industry & Public Projects
  Phone: 314-331-0682

4. Union Pacific Bridge (River mile 1.64)

- 4-span through truss (3 @180', 1 @ 196'on W. end =736')
- Bridge raises 8.8' vertically on a tension screw lifting device
- Double Track Bridge
- Piers- Concrete on timber piles
- Constructed in 1945
- Low Steel Elevation : 753.9 *(762.7 in raised position)*
- n500 WSEL: 762.5 (8.6' above low steel) *(0.2' below low steel in raised position)*
- n500+3' WSEL: 765.6 (11.7' above low steel) *(2.9' above low steel in raised position)*
- Owner: Union Pacific Railroad
- Contact: David McKernan
  Manager Industry & Public Projects
  Phone: 314-331-0682

5. Chicago Rock Island & Pacific Bridge (River mile 2.10)

- 3-span through truss (2 @ 302', 1 @ 119'on E. end =723') Not used
- Bridge is in raised position with permanent shoring
- Single Track Bridge
- Piers- Concrete on timber piles to rock, river pier is on rock
- Constructed in 1945
- Low Steel Elevation : 762.8 (Current raised position)
- n500 WSEL: 764.3 (1.5' above low steel)
- n500+3' WSEL: 767.7 (4.9' above low steel)
- Owner: KCMO
- Contact: Tom Degenhardt, P.E., R.L.S.
  Assistant City Engineer
  KCMO Public Works
  19th Floor City Hall, 414 East 12th Street
  Kansas City, Missouri 64106-2795
  816-513-2506
  816-513-2712 Fax

816-719-0191 Cell
tom_degenhardt@kcmo.org

6. Kansas City Terminal Bridge (River mile 2.53)

- 3-span through truss (2 @300', 1 @ 132'on W. end =732')
- Bridge raises 10.5' vertically on hydraulic cylinders
- Double Track Two Level Ballast Deck Bridge
- River Piers – Concrete on Rock Abutments – Concrete on piles
- Constructed in 1914, revised to lift spans in 1967
- Low Steel Elevation : 755.9 *(766.4 in raised position)*
- n500 WSEL: 766.7 (10.8' above low steel) *(0.3' above low steel in raised position)*
- n500+3' WSEL: 769.7 (13.8' above low steel) *(3.3' above low steel in raised position)*
- Owner: Kansas City Terminal Railroad
- Contact: Chuck Mader
  Chief Engineer
  4501 Kansas Avenue
  Kansas City, MO 66106
  Phone: 913-551-2596
  cemader@kctrailway.com

7. East Kansas Avenue Bridge (River mile 2.17)

- 3-span deck truss (1 @ 267.34', cantilever arm @ 48', 1 @ 317.5', cantilever arm @ 88' = 720.84')
- Bridge raised 5' in 1953
- Out to out bridge width 52'-6". Two lanes each direction.
- River Bridge – West abutment on piles – River piers concrete shaft on rock
- Original plans not available. 1953 bridge modification plans available.
- Low Steel Elevation : 760.8
- n500 WSEL: 764.9 (4.1' above low steel)
- n500+3' WSEL: 767.9 (7.1' above low steel)
- The owner of the bridge is The Unified Government of Wyandotte County, the contact is Fred Backus
- The bridge is currently in service.

8. 7th Street Northbound Bridge (River mile 3.42)

- 3-span continuous deck truss (1 @ 272.25', 1 @ 334.5', 1 @ 272.25' = 879')
- Out to out bridge width unknown. Accommodates two lanes northbound.
- River Bridge – River piers on piles
- Original plans dated 1933.

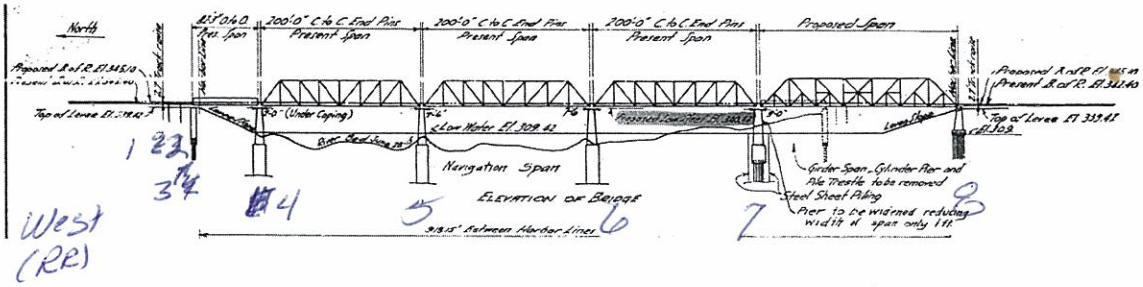
- Low Steel Elevation : 756.0
- n500 WSEL: 769.8 (13.8' above low steel)
- n500+3' WSEL: 772.8 (16.8' above low steel)
- The owner of the bridge is KDOT, the contact is Loren Risch
- The bridge is currently in service

9. 18th Street Bridge (River mile 4.96)

- 3-span continuous deck truss (1 @ 329.88', 1 @ 424.12', 1 @ 330.86' = 1084.86')
- Out to out bridge width is 62'-6". Accommodates two lanes of traffic in both directions.
- River Bridge – River piers on piles
- Original plans dated 1957.
- Low Steel Elevation : 764.3
- n500 WSEL: 772.9 (8.6' above low steel)
- n500+3' WSEL: 775.9 (11.6' above low steel)
- The owner of the bridge is KDOT, the contact is Loren Risch
- The bridge is currently in service

Observation Date: 10/14/08
Bridge: Missouri Pacific RR Br. #1
Stream/ River: Kansas River - 0.26 City/ County:

Superstructure: Through TWSS, TPG and West Approach with 2 Span Concrete Girder and Concrete Piles
Substructure: - Assessment and Plan
No observed displacement of Bearings
Access: West end of Levee along tracks - East Levee & along bike Path



Low Steel Elevation: 759.0 Source: NGVD29
Q500 WSEL: 756.9 Height from Low Steel: 2.1' Below L.S.
Q500 +3' WSEL: 760.9 Height from Low Steel: 1.9' Above Low Steel
Vc 12 Ft/sec

Condition Observed

Left Abutment: 2 Span Prestress Concrete with TPG
Pier 2: 3 Pile Concrete
Pier 3: 2 Pile with Concrete Cap
Pier 4: Concrete and Timber Piles
Pier 5: 7 Concrete and Timber Piles - Some concrete spalling
Right Abutment: - No observations

West Approach: Track goes under highway
East Approach: goes under I-70 & curves

Observations: - West approach - no stop log - would tie into High ground further West.

- Ernie Quinto - said that Timber Piles are exposed at low water.
East approach may need stop logs added

Signature: Date: 10/14/08

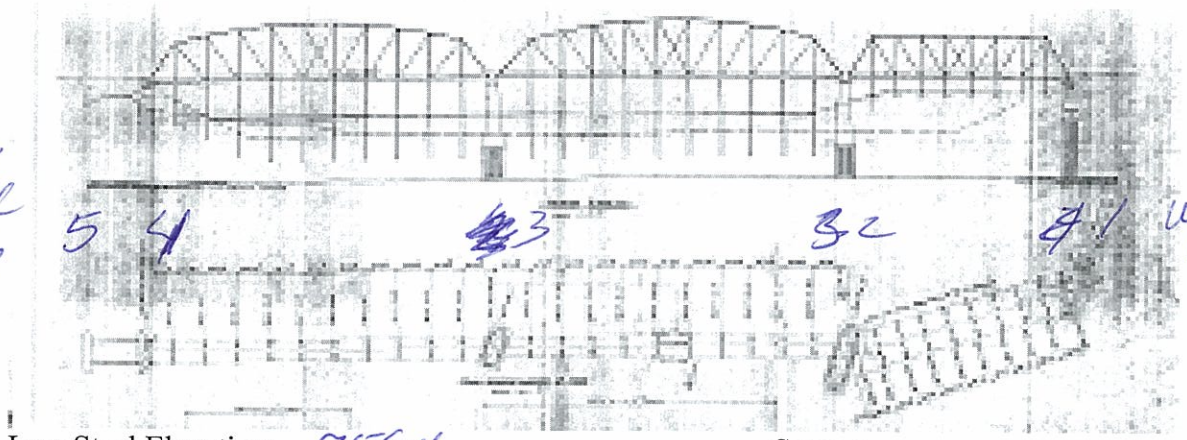
Observation Date: 10/15/08
Bridge: Kansas City Southern – Abandoned
Stream/ River: Kansas River - 0.81 City/ County:

Superstructure: As shown on Plans

Substructure: Concrete on Timber Piles

Access: Left & Right Levee

Single Track 1916



Low Steel Elevation: 759.4 Source:
Q500 WSEL: 759.0 Height from Low Steel: 0.4' Below L.S.
Q500 +3' WSEL: 762.1 Height from Low Steel: 2.7' Above L.S.
V=13 FT/sec

Condition Observed

Left Abutment: Some Spalling
Pier 2: Some Spalling & Horizontal Cracks
Pier 3: " " " "
Pier 4: " " " "
~~Pier 5:~~
Right Abutment: Some Spalling

West Approach: NA
East Approach: NA

Observations: West Abutment - Levee Surrounds Abutment
East Abutment ties into Levee

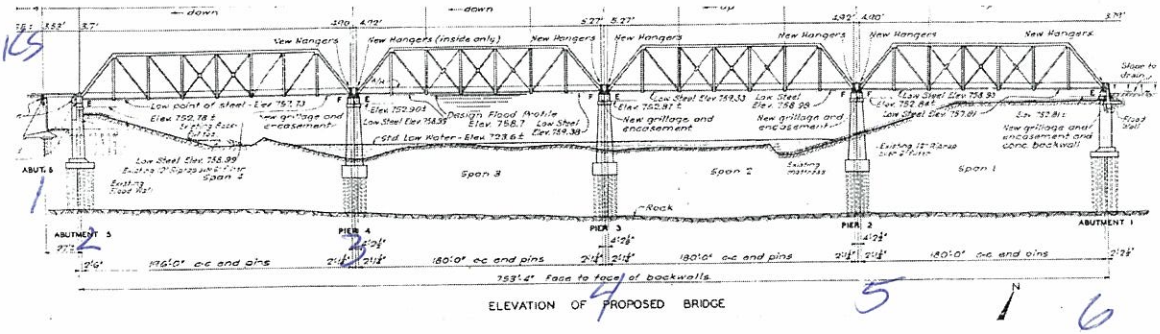
Signature: Date: 10/15/08

Observation Date: 10/14/08
Bridge: Missouri pacific Railroad Bridge 72
Stream/ River: Kansas River - 1.62 City/ County:

Superstructure: As Shown on Plan
- Small Beam Span Bridge @ west Approach
Substructure: Concrete on Timber Piles - As Shown on Plans

Access:

2-Tracks



West (RR)

Low Steel Elevation: 758.9 Source: NGVD 29
Q500 WSEL: 762.2 Height from Low Steel: 2.3' Above L.S.
Q500 +3' WSEL: 765.5 Height from Low Steel: 6.6' Above L.S.
V = 13 Ft/sec

Condition Observed

Left Abutment: Some Spalling & Horizontal Cracks
Pier 2: " " " "
Pier 3: " " " " Piers have been Raised ≈8'
Pier 4: " " " "
Pier 5: " " " "
Right Abutment: No Observation

West Approach: Curve to West Allows Raise - Turn out ≈ 50' West
East Approach: goes under Highway

Observations: West Approach was Previously used as a RR Under Bridge

- Ernie stated that he has observed exposed Timber Piles at Channel Area

- No Displacement of Bridge Substructure evident

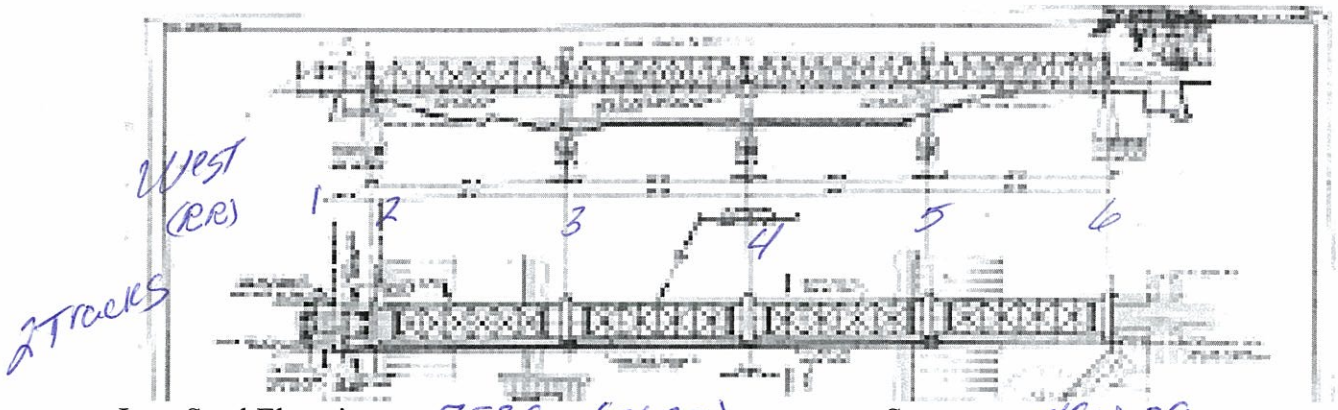
Signature: Date: 10/14/08

Observation Date: 10/14/08
Bridge: Union Pacific Railroad
Stream/ River: Kansas River 1.69 City/ County:

Superstructure:

Substructure:

Access: Levee Rd,



Low Steel Elevation: 753.9 (762.7) Source: NGVD 29
Q500 WSEL: 762.5 Height from Low Steel: 8.6' Above LS
Q500 +3' WSEL: 765.6 Height from Low Steel: 11.7' Above LS
V= 13 ft/sec

Condition Observed

Left Abutment: Abutment has some spalling
Pier 2: Added to Pier for movable Bridge support
Pier 3:
Pier 4: - in line with MO Pack Pier
Pier 5:
Right Abutment:

West Approach: Track could be Raised - T.O. @ Abutment
East Approach: Track goes under Roadway

Observations: Bridge was last Raised in 93 flood
- No stop block on west end
- Rail is continuous through Abutment ≈ 2.5' Below top

Stop logs - Not on E. approach for MO Pac
- Concrete flood wall @ UPRR

- Bridge moves 8.9' vertically with a tension screw lifting device

Signature: Date: 10/14/08

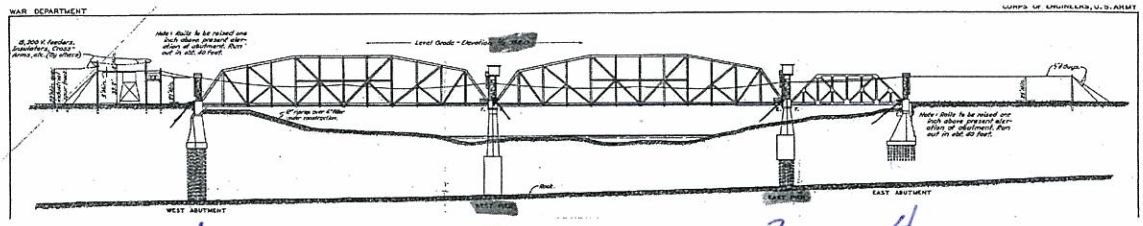
Observation Date: _____
Bridge: Chicago Rock Island & Pacific - Abandoned
Stream/ River: Kansas River 2.10 City/ County: _____

Superstructure: As shown on Plans

Substructure: As shown on Plans

Access: - Left & Right Levee

Single Track



1 2 3 4

Low Steel Elevation: 762.8 (NA - Already UP) ~~(762.8)~~ Source: NGVD 29
Q500 WSEL: 764.3 Height from Low Steel: 1.5' Above L.C.
Q500 +3' WSEL: 767.7 Height from Low Steel: 4.9' Above L.C.
V = 13 FT/sec

Condition Observed

Left Abutment: No major deterioration noted -
Pier 2: Some spalling & Horizontal cracks - exposed formwork
Pier 3: " " " "
~~Pier 4:~~
~~Pier 5:~~
Right Abutment: Some spalling & Horizontal Cracks

West Approach: NA
East Approach: NA

Observations:
Utilities on Bridge
- Bridge ~~int~~ is in Raised Position & Shored Under Span ends
- Tension Screws appear to be in ~~at~~ full upward position
- Levee Wall surrounds Abutments

Bridge moves 8' vertically with a tension screw lifting device.

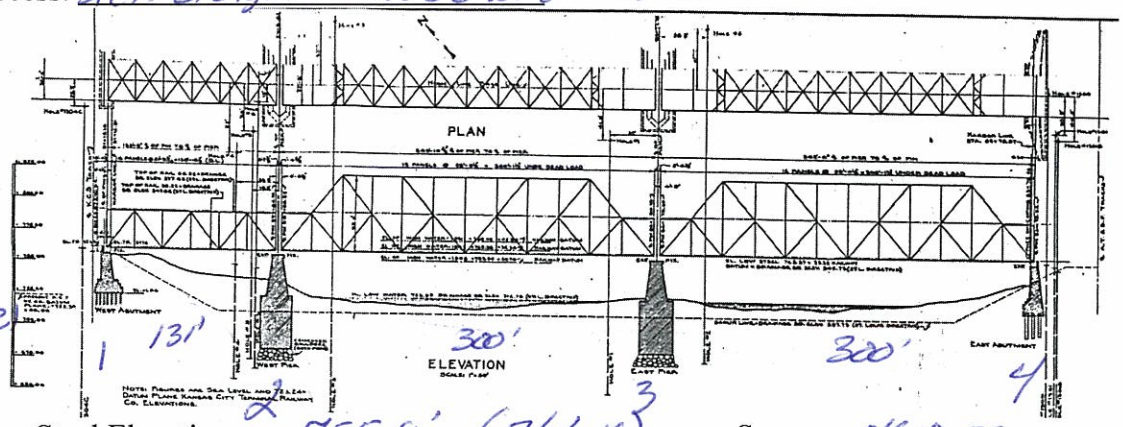
Signature: _____ Date: 10/15/08

Observation Date: 10/14/08
Bridge: Kansas City Terminal
Stream/ River: Kansas River - 2.53 City/ County:

Superstructure: Double track - 2 level Through Truss as shown on Plans
Substructure: Concrete Piers & Abutments as Shown on Plans

Access: Left & Right Lower ~~Roads~~ Roads

2 Tracks
Upper
Lower
W
Upper



Low Steel Elevation: 755.9' (766.4) Source: NGVD 29
Q500 WSEL: 766.7' Height from Low Steel: 10.8' Above L.C.
Q500 +3' WSEL: 769.7' Height from Low Steel: 13.8' Above L.C.
V = 12 FT/sec

Condition Observed

Left Abutment: Under stop log
Pier 2: Concrete in good condition
Pier 3: " " " "
~~Pier 4:~~
~~Pier 5:~~
Right Abutment: Covered - Not observed

West Approach: Curved Approach Bridge -
East Approach: Curve to North for lower track
- Upper tracks Curve to South - No Immediate vertical obstruction

Observations:
Ground ≈ 12' Below existing ~~flow~~ water line
Raised 1 Portion of Bridge in 93 - Right Bank
Stop logs @ Both end of Bridge @ Abutments
- Stop logs ~~to~~ further upstream @ West end of Yard
Bridge moves 10.5 feet vertically with Hydraulic Cylinders

Signature: Date: 10/14/08

Observation Date: 10-15-2008
Bridge: Kansas Avenue East
Stream/ River: Kansas River
City/ County: Kansas City, KS Wyandotte County

Superstructure: Recently rehabbed. Bottom chord repaired and partially painted. New deck recently installed.

Substructure: Riverpiers fair condition. Some concrete spalling and cavitation at waterline. One hole 12" deep.

Access:

Low Steel Elevation: 760.8 Source:
Q500 WSEL: 764.9 Height from Low Steel: 4.1'
Q500 +3' WSEL: 767.9 Height from Low Steel: 7.1

Condition Observed

Pier 1:

Pier 2:

Pier 3:

West Approach:

East Approach:

Observations:

Signature: Thomas J. Westerman Date: 10-15-2008

Observation Date: 10-15-2008
Bridge: 7th Street Northbound
Stream/ River: Kansas River
City/ County: Kansas City, KS Wyandotte County

Superstructure: Fair to good condition.

Substructure: Fair to good condition. At some time sheet piling added around east river pier and concrete placed between pier and sheet piling.

Access:

Low Steel Elevation: 756.0 Source:
Q500 WSEL: 769.8 Height from Low Steel: 13.8'
Q500 +3' WSEL: 772.8 Height from Low Steel: 16.8'

Condition Observed

Pier 5:

Pier 6:

Pier 7:

Pier 8:

North Approach:

South Approach:

Observations:

Signature: Thomas J. Wortmann Date: 10-15-08

Observation Date: 10-15-2008
Bridge: 18th Street
Stream/ River: Kansas River
City/ County: Kansas City, KS Wyandotte County

Superstructure: Fair to good condition

Substructure: The substructure in fair to good condition. Bridge currently being jacked and having bearings replace'd.

Access:

Low Steel Elevation: 764.3 Source:
Q500 WSEL: 772.9 Height from Low Steel: 8.6
Q500 +3' WSEL: 775.9 Height from Low Steel: 11.6

Condition Observed

Pier 7: some debris present

Pier 8:

Pier 9:

Pier 10:

North Approach:

South Approach:

Observations:

Signature: Thomas J. Wertzman Date: 10-15-2008

STREAM STABILITY ANALYSIS SHEET

Stream Name: Kansas River
Bridge No: Missouri Pacific #1 Job No.: 45529
Inspected By: Dave Renetzky Date: 10/14/08 Sheet No: 1

HNTB

1. Upstream Conditions:	2. Downstream Conditions:
a. Banks (Photo(s) # 12-17) *mostly stable* *some near vertical banks on outside of bend* *fairly good vegetation cover*	a. Banks (Photo(s) # 18-25) *stable* *some roots exposed* *fairly good vegetation cover*
b. Main Channel (Photo(s) #29) *clear channel* *point bar downstream on right bank* *may have degraded based on piers* *poor approach angle to piers ~10 degrees*	b. Main Channel (Photo(s) #19) *clear channel* *point bar downstream on right bank* *may have degraded based on piers* *poor approach angle to piers ~10 degrees*
c. Floodplain (Photo(s) #_____) *levees on both sides*	c. Floodplain (Photo(s) #_____) *levees on both sides*
d. Debris (Photo(s) # 26; 34) *right bank just upstream of bridge*	d. Debris (Photo(s) # 17-18; 23) *left bank just downstream of bridge* *right bank just downstream of bridge*
e. Other Features (Photo(s) #_____) *dumped gravel/rock at abutment on north side*	e. Other Features (Photo(s) #_____)

3. Conditions at Bridge:

a. Structure (Photo(s) # 1-12)
round nose piers, square at the bottom
spalling and light cracks in river piers
no evidence of scour at piers

b. Channel Protection & Scour Countermeasures (Photo(s) # 14-18; 32-33)
woody debris and tree limbs/roots on outside of bend; some scouring of bank
riprap protection on left bank upstream with piles or buried tree branches sticking out
riprap protection on upper banks

c. Waterway Area (Photo(s) # 19-20; 29)
clear
point bar downstream toward confluence
no debris on piers

4. Additional Comments:
Ernie (KVDD) has seen some exposed piles during very low water in the river
Ernie (KVDD) said there was no damage to the bridge in the 1993 flood
observed about 1.3 fps velocity on day of visit

P:\jobs\45529_TO1_KC_Levees\Bridge\Deliverable_LetterOfOpinion\Appendix\3_H&HFieldNotes\[ScourFieldInspectionMOPAC1.xls]Inspection

STREAM STABILITY ANALYSIS SHEET

Stream Name: Kansas River
Bridge No.: Missouri Pacific #1 Job No.: 45529
Inspected by: Dave Renetzky Date: 10/14/2008 Sheet No: 2

HNTB

GEOMORPHIC FACTORS

PROPERTIES	GEOMORPHIC FACTORS	COMMENTS
STREAM SIZE	Small (<100ft or 30 m wide) / Medium (100-500 ft or 30-150 m wide) / Wide (>500 ft or 150 m wide)	Wide
FLOW HABIT	Ephemeral / Intermittent / Perennial but flashy / Perennial	Perennial
BED MATERIAL	Silt-Clay / Silt / Sand / Gravel / Cobble or boulder	Sand, Sandy Silt
VALLEY SETTING (flat, hilly, mountainous)	No valley; alluvial fan / Low relief valley (<100 ft. or 30 m deep) / Moderate relief (100-1000 ft. or 30-300 m deep) / High relief (>1000 ft. or 300 m deep)	Low relief valley
FLOOD-PLAINS (width)	Little or none (<2X channel width) / Narrow (2 - 10X channel width) / Wide (>10X channel width)	Narrow between levees/floodwalls
NATURAL LEVEES	Little or none / Mainly on concave / Well developed on both banks	None; man-made levees/floodwalls
APPARENT INCISION (bank height vs channel width)	Not Incised / Probably Incised	Incised
CHANNEL BOUNDARIES (erosion)	Alluvial / Semi-alluvial / Non-alluvial	Alluvial
TREE COVER ON BANKS	<50 percent of bank line / 50-90 percent / >90 percent	50-90 percent
SINUOSITY (ratio of curved channel length to straight length)	Straight (Sinuosity 1 -1.05) / Sinuous (1.06 -1.25) / Meandering (1.26 -2.0) / Highly Meandering (>2.0)	Meandering
BRAIDED STREAMS (multiple and interlacing channels)	Not braided (<5 percent) / Locally braided (5 - 35 percent) / Generally braided (5 - 35 percent)	Not braided
ANABRANCHED STREAMS (substantial islands)	Not anabranched (<5 percent) / Locally anabranched (5 - 35 percent) / Generally anabranched (5 - 35 percent)	Not anabranched
VARIABILITY OF WIDTH AND DEVELOPMENT OF BARS (lateral stability)	Equiwidth / Wider at bends / Random Variation / Narrow Point Bars / Wide Point Bars / Irregular point and lateral bars	Equiwidth; some point bars

	Performed in Field
	Performed in Field and Office
	Performed in Office

Source: "Figure 12. Hydraulic and location factors that affect stream stability." HEC-20, *Stream Stability at Highway Structures,* Federal Highway Administration, 1991

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STREAM STABILITY ANALYSIS SHEET

Stream Name: Kansas River
Bridge No: Missouri Pacific #1 Job No.: 45529
Inspected By: Dave Renetzky Date: 10/14/08 Sheet No: 3

HNTB

Photo	Levee Side	Description
MoPac#1_001	Armourdale	looking northwest at north abutment (Bent 1)
MoPac#1_002		looking northwest at Bent 2
MoPac#1_003		looking north at north abutment area, Bent 1, Bent 2, and Bent 3
MoPac#1_004		looking south at Bent 4
MoPac#1_005		looking east along Bent 4; no evidence of scour
MoPac#1_006		exposed bands of cable around Bent 4
MoPac#1_007		looking south at Bent 5
MoPac#1_008		looking south at Bent 5
MoPac#1_009		looking across the downstream face of the bridge from left bank; Bents 5, 6, and 7
MoPac#1_010		looking at Bent 5 and Bent 6 from downstream left bank
MoPac#1_011		looking at Bent 6 and Bent 7 from downstream left bank
MoPac#1_012		looking south at upstream right bank
MoPac#1_013		looking south at upstream right bank
MoPac#1_014		looking upstream from the downstream left bank; Bent 5 and Bent 6
MoPac#1_015		looking southwest (upstream) at downstream left bank
MoPac#1_016		looking southwest at downstream left bank, woody debris
MoPac#1_017		looking southwest at downstream left bank, woody debris
MoPac#1_018		looking northeast at downstream left bank
MoPac#1_019		looking downstream toward confluence
MoPac#1_020		looking southeast at downstream right bank toward confluence
MoPac#1_021		looking southeast at downstream right bank toward confluence
MoPac#1_022		looking southeast at downstream right bank
MoPac#1_023		looking southeast at downstream right bank; exposed tree roots
MoPac#1_024		looking southeast at downstream right bank
MoPac#1_025		looking north at downstream right bank
MoPac#1_026	CID	looking at the upsteam face of the bridge; Bent 4, Bent 5 and Bent 6
MoPac#1_027		looking at the upsteam face of the bridge; Bent 4, Bent 5 and Bent 6
MoPac#1_028		looking at the upsteam face of the bridge; Bent 4, Bent 5 and Bent 6
MoPac#1_029		looking upstream from below I-70 bridge
MoPac#1_030		looking northwest at the left bank upstream
MoPac#1_031		looking at the left bank just upstream of I-70 bridge; evidence of abutment scour
MoPac#1_032		looking at the upstream left bank; riprap and piling?
MoPac#1_033		looking at the upstream left bank
MoPac#1_034		looking at the downstream left bank
MoPac#1_035		looking at the downstream right bank
MoPac#1_036		looking downstream from upsteam of bridge
MoPac#1_037		looking northeast at right bank under bridge; Bent 7
MoPac#1_038		looking northeast at right bank under bridge

STREAM STABILITY ANALYSIS SHEET

Stream Name: Kansas River
Bridge No: Kansas City Southern Job No.: 45529
Inspected By: Dave Renetzky Date: 10/14/08 Sheet No: 1

HNTB

1. Upstream Conditions:	2. Downstream Conditions:
a. Banks (Photo(s) #) *mostly stable* *good angle on bank material; some erosion* *good vegetation cover*	a. Banks (Photo(s) #) *stable* *some roots exposed* *fairly good vegetation cover*
b. Main Channel (Photo(s) #) *clear channel; minor woody debris* *some deposition on inside of bend* *pier is in a bend; decent approach angle*	b. Main Channel (Photo(s) #) *clear channel; minor woody debris* *some deposition on inside of bend*
c. Floodplain (Photo(s) #_____) *levees on both sides*	c. Floodplain (Photo(s) #_____) *levees on both sides*
d. Debris (Photo(s) #) *right bank just upstream of bridge* on pier	d. Debris (Photo(s) #) *left bank just downstream of bridge* *deposited material may indicate scour at pier*
e. Other Features (Photo(s) #_____)	e. Other Features (Photo(s) #_____)

3. Conditions at Bridge:

a. Structure (Photo(s) #)
round nose piers
spalling and light cracks in river piers

b. Channel Protection & Scour Countermeasures (Photo(s) #)
riprap protection on upper banks
soil entrenched riprap protection just upstream on outside of bend

c. Waterway Area (Photo(s) #)
clear
light debris on pier

4. Additional Comments:

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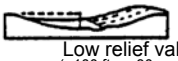
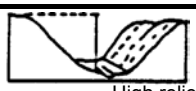
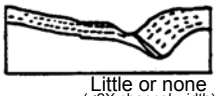
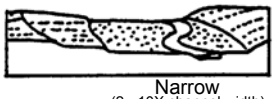
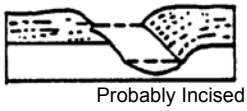
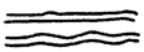
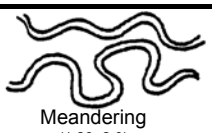
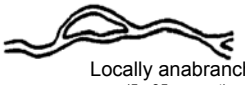
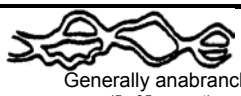
STREAM STABILITY ANALYSIS SHEET

Stream Name: Kansas River
Bridge No.: Kansas City Southern Job No.: 45529
Inspected by: Dave Renetzky Date: 10/14/2008 Sheet No: 2

HNTB

GEOMORPHIC FACTORS

PROPERTIES	GEOMORPHIC FACTORS	COMMENTS
STREAM SIZE	Small (<100ft or 30 m wide) / Medium (100-500 ft or 30-150 m wide) / Wide (>500 ft or 150 m wide)	Wide
FLOW HABIT	Ephemeral / Intermittent / Perennial but flashy / Perennial	Perennial
BED MATERIAL	Silt-Clay / Silt / Sand / Gravel / Cobble or boulder	Sand, Sandy Silt
VALLEY SETTING (flat, hilly, mountainous)	No valley; alluvial fan  Low relief valley (<100 ft. or 30 m deep) Moderate relief (100-1000 ft. or 30-300 m deep)  High relief (>1000 ft. or 300 m deep)	Low relief valley
FLOOD-PLAINS (width)	 Little or none (<2X channel width)  Narrow (2 - 10X channel width) Wide (>10X channel width)	Narrow between levees/floodwalls
NATURAL LEVEES	Little or none Mainly on concave Well developed on both banks	None; man-made levees/floodwalls
APPARENT INCISION (bank height vs channel width)	Not Incised  Probably Incised	Incised
CHANNEL BOUNDARIES (erosion)	Alluvial Semi-alluvial Non-alluvial	Alluvial
TREE COVER ON BANKS	<50 percent of bank line / 50-90 percent / >90 percent	50-90 percent
SINUOSITY (ratio of curved channel length to straight length)	 Straight (Sinuosity 1 -1.05) Sinuous (1.06 -1.25)  Meandering (1.26 -2.0) Highly Meandering (>2.0)	Meandering
BRAIDED STREAMS (multiple and interlacing channels)	Not braided (<5 percent) Locally braided (5 - 35 percent) Generally braided (5 - 35 percent)	Not braided
ANABRANCHED STREAMS (substantial islands)	Not anabranched (<5 percent)  Locally anabranched (5 - 35 percent)  Generally anabranched (5 - 35 percent)	Not anabranched
VARIABILITY OF WIDTH AND DEVELOPMENT OF BARS (lateral stability)	Equiwidth Wider at bends Random Variation Narrow Point Bars Wide Point Bars Irregular point and lateral bars	Equiwidth; some point bars

	Performed in Field
	Performed in Field and Office
	Performed in Office

Source: "Figure 12. Hydraulic and location factors that affect stream stability." HEC-20, *Stream Stability at Highway Structures,* Federal Highway Administration, 1991

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STREAM STABILITY ANALYSIS SHEET

Stream Name: Kansas River
Bridge No: Kansas City Southern Job No.: 45529
Inspected By: Dave Renetzky Date: 10/14/08 Sheet No: 3

HNTB

Photo	Levee Side	Description
KCS_001	CID	looking southwest across the bridge
KCS_002		looking at the original bridge design plate
KCS_003		looking at the original bridge design plate
KCS_004		looking southwest across the upstream face of the bridge
KCS_005		looking at the upstream right bank
KCS_006		looking south at the upstream right bank
KCS_007		looking at the channel and upstream right bank
KCS_008		looking at the upstream left bank
KCS_009		looking across the tracks from the middle of the bridge
KCS_010		looking west at the downstream left bank
KCS_011		looking further downstream on the left bank
KCS_012		looking further downstream on the left bank
KCS_013		looking further downstream on the left bank
KCS_014		looking at the downstream channel and right bank
KCS_015		looking at the right bank downstream from bridge
KCS_016		looking north at the upper bank protection downstream of the bridge
KCS_017		looking south at the abutment area (Bent 4)
KCS_018		looking northeast across the bridge
KCS_019		looking at upstream face of bridge
KCS_020		looking at upstream right bank
KCS_021		looking further upstream at the right bank
KCS_022		looking at the upstream channel and left bank
KCS_023		looking at the upstream channel and left bank
KCS_024	Armourdale	looking at the upstream left bank riprap protection
KCS_025		looking at the high bank protection on the downstream left bank
KCS_026		looking at the high bank protection on the downstream left bank
KCS_027		looking at the downstream left bank from just upstream of the bridge
KCS_028		looking at Bent 2
KCS_029		looking downstream at the channel
KCS_030		looking downstream at the channel
KCS_031		looking across the channel at Bent 3; note debris

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STREAM STABILITY ANALYSIS SHEET

Stream Name: Kansas River
Bridge No: Missouri Pacific #72 Job No.: 45529
Inspected By: Dave Renetzky Date: 10/14/08 Sheet No: 1

HNTB

1. Upstream Conditions:	2. Downstream Conditions:
a. Banks (Photo(s) #) *mostly stable* *fairly good vegetation cover*	a. Banks (Photo(s) #) *fairly stable* *right bank has lost vegetation* *riprap protection just downstream*
b. Main Channel (Photo(s)) *clear channel* *may have degraded based on piers*	b. Main Channel (Photo(s) #) *debris along banks* *piers upstream and downstream* *good approach angle to piers ~10 degrees*
c. Floodplain (Photo(s) #_____) *levees on both sides*	c. Floodplain (Photo(s) #_____) *levees on both sides*
d. Debris (Photo(s) #) *on Bents of upstream UP#3 bridge*	d. Debris (Photo(s) #) *along downstream right bank*
e. Other Features (Photo(s) #_____) *UP#3 bridge piers line up*	e. Other Features (Photo(s) #_____) riprap on high banks

3. Conditions at Bridge:

a. Structure (Photo(s) #)
sharp nose piers, square at the bottom
spalling and light cracks in river piers
possible scour evidence at Bent 4

b. Channel Protection & Scour Countermeasures (Photo(s) #)
woody debris and some scouring of bank
riprap protection on right bank downstream
riprap protection on upper banks

c. Waterway Area (Photo(s) #)

4. Additional Comments:

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STREAM STABILITY ANALYSIS SHEET

Stream Name: Kansas River
Bridge No.: Missouri Pacific #72 Job No.: 45529
Inspected by: Dave Renetzky Date: 10/14/2008 Sheet No: 2

HNTB

GEOMORPHIC FACTORS

PROPERTIES	GEOMORPHIC FACTORS	COMMENTS
STREAM SIZE	Small (<100ft or 30 m wide) / Medium (100-500 ft or 30-150 m wide) / Wide (>500 ft or 150 m wide)	Wide
FLOW HABIT	Ephemeral / Intermittent / Perennial but flashy / Perennial	Perennial
BED MATERIAL	Silt-Clay / Silt / Sand / Gravel / Cobble or boulder	Sand, Sandy Silt
VALLEY SETTING (flat, hilly, mountainous)	No valley; alluvial fan / Low relief valley (<100 ft. or 30 m deep) / Moderate relief (100-1000 ft. or 30-300 m deep) / High relief (>1000 ft. or 300 m deep)	Low relief valley
FLOOD-PLAINS (width)	Little or none (<2X channel width) / Narrow (2 - 10X channel width) / Wide (>10X channel width)	Narrow between levees/floodwalls
NATURAL LEVEES	Little or none / Mainly on concave / Well developed on both banks	None; man-made levees/floodwalls
APPARENT INCISION (bank height vs channel width)	Not Incised / Probably Incised	Incised
CHANNEL BOUNDARIES (erosion)	Alluvial / Semi-alluvial / Non-alluvial	Alluvial
TREE COVER ON BANKS	<50 percent of bank line / 50-90 percent / >90 percent	50-90 percent
SINUOSITY (ratio of curved channel length to straight length)	Straight (Sinuosity 1 -1.05) / Sinuous (1.06 -1.25) / Meandering (1.26 -2.0) / Highly Meandering (>2.0)	Meandering
BRAIDED STREAMS (multiple and interlacing channels)	Not braided (<5 percent) / Locally braided (5 - 35 percent) / Generally braided (5 - 35 percent)	Not braided
ANABRANCHED STREAMS (substantial islands)	Not anabranched (<5 percent) / Locally anabranched (5 - 35 percent) / Generally anabranched (5 - 35 percent)	Not anabranched
VARIABILITY OF WIDTH AND DEVELOPMENT OF BARS (lateral stability)	Equiwidth / Wider at bends / Random Variation / Narrow Point Bars / Wide Point Bars / Irregular point and lateral bars	Equiwidth; some point bars

	Performed in Field
	Performed in Field and Office
	Performed in Office

Source: "Figure 12. Hydraulic and location factors that affect stream stability." HEC-20, *Stream Stability at Highway Structures,* Federal Highway Administration, 1991

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STREAM STABILITY ANALYSIS SHEET

Stream Name: Kansas River
Bridge No: Missouri Pacific #72 Job No.: 45529
Inspected By: Dave Renetzky Date: 10/14/08 Sheet No: 3

Photo	Levee Side	Description
MoPac#72_001	Armourdale	looking north under the slot area
MoPac#72_002		looking north at Bent 5
MoPac#72_003		looking north at Bent 5
MoPac#72_004		looking north at Bent 5
MoPac#72_005		looking downstream at the right bank
MoPac#72_006	CID	looking downstream at the left bank
MoPac#72_007		looking downstream at the left bank
MoPac#72_008		looking downstream at the left bank
MoPac#72_009		looking downstream at the left bank
MoPac#72_010		looking northeast across the downstream face of the bridge
MoPac#72_011		looking at the downstream right bank
MoPac#72_012		looking north at the downstream channel
MoPac#72_013		looking north at the downstream channel
MoPac#72_014	Armourdale	looking at the right bank of the downstream bridge
MoPac#72_015		looking north at the downstream channel
MoPac#72_016		looking at the downstream left bank and slot area
MoPac#72_017		looking at the bank just downstream of the MoPac #72 bridge
MoPac#72_018		looking southwest across the downstream face of the bridge
MoPac#72_019	CID	looking southwest across the downstream face of the bridge
MoPac#72_020		looking southeast at the abutment area, Bent 5

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STREAM STABILITY ANALYSIS SHEET

Stream Name: Kansas River
Bridge No: Union Pacific #3 Job No.: 45529
Inspected By: Dave Renetzky Date: 10/14/08 Sheet No: 1

HNTB

1. Upstream Conditions:	2. Downstream Conditions:
a. Banks (Photo(s) # 10-12) *stable* *fairly good vegetation cover*	a. Banks (Photo(s) # 18-25) *stable* *fairly good vegetation cover* *steeper banks on right side*
b. Main Channel (Photo(s) #8-13) *clear channel* *in a straight reach* *may have degraded based on piers*	b. Main Channel (Photo(s) #19) *clear channel* *some deposited rocky material on right bank* *may have degraded based on piers*
c. Floodplain (Photo(s) #_____) *levees on both sides*	c. Floodplain (Photo(s) #_____) *levees on both sides*
d. Debris (Photo(s) #2-5) *on Bent 3*	d. Debris (Photo(s) #)
e. Other Features (Photo(s) #_____) *upstream of MoPac bridge; piers line up*	e. Other Features (Photo(s) #_____)

3. Conditions at Bridge:

a. Structure (Photo(s) #)
pionted nose piers, square at the bottom
spalling on river piers
debris could be an issue with square base

b. Channel Protection & Scour Countermeasures (Photo(s) #)
possible protecton on Bent 4
riprap protection on upper banks

c. Waterway Area (Photo(s) #)
clear, except for multiple piers in the area

4. Additional Comments:
replaced the jump span concrete a few years ago
was raised for 1993 flood event

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STREAM STABILITY ANALYSIS SHEET

Stream Name: Kansas River
Bridge No.: Union Pacific #3 Job No.: 45529
Inspected by: Dave Renetzky Date: 10/14/2008 Sheet No: 2

HNTB

GEOMORPHIC FACTORS

PROPERTIES	GEOMORPHIC FACTORS	COMMENTS
STREAM SIZE	Small (<100ft or 30 m wide) / Medium (100-500 ft or 30-150 m wide) / Wide (>500 ft or 150 m wide)	Wide
FLOW HABIT	Ephemeral / Intermittent / Perennial but flashy / Perennial	Perennial
BED MATERIAL	Silt-Clay / Silt / Sand / Gravel / Cobble or boulder	Sand, Sandy Silt
VALLEY SETTING (flat, hilly, mountainous)	No valley; alluvial fan / Low relief valley (<100 ft. or 30 m deep) / Moderate relief (100-1000 ft. or 30-300 m deep) / High relief (>1000 ft. or 300 m deep)	Low relief valley
FLOOD-PLAINS (width)	Little or none (<2X channel width) / Narrow (2 - 10X channel width) / Wide (>10X channel width)	Narrow between levees/floodwalls
NATURAL LEVEES	Little or none / Mainly on concave / Well developed on both banks	None; man-made levees/floodwalls
APPARENT INCISION (bank height vs channel width)	Not Incised / Probably Incised	Incised
CHANNEL BOUNDARIES (erosion)	Alluvial / Semi-alluvial / Non-alluvial	Alluvial
TREE COVER ON BANKS	<50 percent of bank line / 50-90 percent / >90 percent	50-90 percent
SINUOSITY (ratio of curved channel length to straight length)	Straight (Sinuosity 1 -1.05) / Sinuous (1.06 -1.25) / Meandering (1.26 -2.0) / Highly Meandering (>2.0)	Meandering
BRAIDED STREAMS (multiple and interlacing channels)	Not braided (<5 percent) / Locally braided (5 - 35 percent) / Generally braided (5 - 35 percent)	Not braided
ANABRANCHED STREAMS (substantial islands)	Not anabranched (<5 percent) / Locally anabranched (5 - 35 percent) / Generally anabranched (5 - 35 percent)	Not anabranched
VARIABILITY OF WIDTH AND DEVELOPMENT OF BARS (lateral stability)	Equiwidth / Wider at bends / Random Variation / Narrow Point Bars / Wide Point Bars / Irregular point and lateral bars	Equiwidth; some point bars

	Performed in Field
	Performed in Field and Office
	Performed in Office

Source: "Figure 12. Hydraulic and location factors that affect stream stability." HEC-20, *Stream Stability at Highway Structures,* Federal Highway Administration, 1991

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STREAM STABILITY ANALYSIS SHEET

Stream Name: Kansas River
Bridge No: Union Pacific #3 Job No.: 45529
Inspected By: Dave Renetzky Date: 10/14/08 Sheet No: 3

HNTB

Photo	Levee Side	Description
UP#3_001	CID	looking north at the upstream face of the bridge
UP#3_002		looking north at the upstream face of the bridge; Bent 3 and Bent 4
UP#3_003		looking north at the upstream face of the bridge; Bent 3 is in the middle
UP#3_004		looking north at Bent 3
UP#3_005		looking north at Bent 3; debris
UP#3_006		looking north at Bent 4
UP#3_007		looking at the swirling water between Bent 3 and the MoPac bridge
UP#3_008		looking southwest at Bent 3
UP#3_009		looking southwest at debris on Bent 3
UP#3_010		looking southwest at upstream left bank
UP#3_011		looking further upstream at left bank
UP#3_012		looking upstream along right bank
UP#3_013		looking south through slot area
UP#3_014		looking south at bridge
UP#3_015		looking southeast at bridge
UP#3_016		looking northeast at bridge
UP#3_017	Armourdale	looking northeast along downstream face of bridge
UP#3_018		looking at Bent 4, possible scour protection
UP#3_019		looking at Bent 3
UP#3_020		looking at Bent 2
UP#3_021		looking at abutment area (Bent 1)
UP#3_022		looking northeast at the downstream right bank
UP#3_023		looking northeast at the downstream right bank
UP#3_024	CID	looking southwest across the upstream face of the bridge
UP#3_025		looking west at the bridge
UP#3_026		looking west at the bridge
UP#3_027		looking northwest at the left bank upstream
UP#3_028		looking north at the upstream channel

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STREAM STABILITY ANALYSIS SHEET

Stream Name: Kansas River
Bridge No: CRI&P Job No.: 45529
Inspected By: Dave Renetzky Date: 10/15/08 Sheet No: 1

HNTB

1. Upstream Conditions:	2. Downstream Conditions:
a. Banks (Photo(s) #) *fairly stable* *fairly good vegetation cover* *deposited trees, roots, and woody debris*	a. Banks (Photo(s) #) *stable* *fairly good vegetation cover* *sparse riprap protection on outside of bend*
b. Main Channel (Photo(s) #) *upstream bridge piers* *deposited sediment on inside of bend* *fair approach angle on piers*	b. Main Channel (Photo(s) #) *woody debris*
c. Floodplain (Photo(s) #_____) *levees on both sides*	c. Floodplain (Photo(s) #_____) *levees on both sides*
d. Debris (Photo(s) #) *left bank just upstream of bridge* *wood debris; trees* *silt and debris on west bank*	d. Debris (Photo(s) #)
e. Other Features (Photo(s) #_____)	e. Other Features (Photo(s) #_____)

3. Conditions at Bridge:

a. Structure (Photo(s) #)
square nose piers, square at the bottom
spalling and a few fairly deep cracks in river pier
channel may be degraded based on exposed wooden forms

b. Channel Protection & Scour Countermeasures (Photo(s) #)
riprap protection on upper banks
sparse riprap on outside of bend

c. Waterway Area (Photo(s) #)
clear
deposition on inside of bend
no debris on piers

4. Additional Comments:
the bridge is abandoned
the bridge is in a permanently raised position

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STREAM STABILITY ANALYSIS SHEET

Stream Name: Kansas River
Bridge No.: CRI&P Job No.: 45529
Inspected by: Dave Renetzky Date: 10/14/2008 Sheet No: 2

HNTB

GEOMORPHIC FACTORS

PROPERTIES						COMMENTS
STREAM SIZE	Small (<100ft or 30 m wide)		Medium (100-500 ft or 30-150 m wide)		Wide (>500 ft or 150 m wide)	Wide
FLOW HABIT	Ephemeral	Intermittent		Perennial but flashy	Perennial	Perennial
BED MATERIAL	Silt-Clay	Silt	Sand	Gravel	Cobble or boulder	Sand, Sandy Silt
VALLEY SETTING (flat, hilly, mountainous)	No valley; alluvial fan		Low relief valley (<100 ft. or 30 m deep)	Moderate relief (100-1000 ft. or 30-300 m deep)	High relief (>1000 ft. or 300 m deep)	Low relief valley
FLOOD-PLAINS (width)	Little or none (<2X channel width)		Narrow (2 - 10X channel width)		Wide (>10X channel width)	Narrow between levees/floodwalls
NATURAL LEVEES	Little or none		Mainly on concave		Well developed on both banks	None; man-made levees/floodwalls
APPARENT INCISION (bank height vs channel width)	Not Incised				Probably Incised	Incised
CHANNEL BOUNDARIES (erosion)	Alluvial		Semi-alluvial		Non-alluvial	Alluvial
TREE COVER ON BANKS	<50 percent of bank line		50-90 percent		>90 percent	50-90 percent
SINUOSITY (ratio of curved channel length to straight length)	Straight (Sinuosity 1 -1.05)	Sinuous (1.06 -1.25)	Meandering (1.26 -2.0)		Highly Meandering (>2.0)	Meandering
BRAIDED STREAMS (multiple and interlacing channels)	Not braided (<5 percent)		Locally braided (5 - 35 percent)		Generally braided (5 - 35 percent)	Not braided
ANABRANCHED STREAMS (substantial islands)	Not anabranched (<5 percent)		Locally anabranched (5 - 35 percent)		Generally anabranched (5 - 35 percent)	Not anabranched
VARIABILITY OF WIDTH AND DEVELOPMENT OF BARS (lateral stability)	Equiwidth	Narrow Point Bars	Wider at bends	Wide Point Bars	Random Variation / Irregular point and lateral bars	Equiwidth; some point bars

	Performed in Field
	Performed in Field and Office
	Performed in Office

Source: "Figure 12. Hydraulic and location factors that affect stream stability." HEC-20, *Stream Stability at Highway Structures,* Federal Highway Administration, 1991

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STREAM STABILITY ANALYSIS SHEET

Stream Name: Kansas River
Bridge No: CRI&P
Job No.: 45529
Inspected By: Dave Renetzky
Date: 10/15/08
Sheet No: 3

HNTB

Photo	Levee Side	Description
CRI&P_001	Armourdale	looking south at the west abutment (Bent 1)
CRI&P_002		looking at Bent 1
CRI&P_003		looking at abutment area and lift mechanism
CRI&P_004		looking at abutment area and lift mechanism
CRI&P_005		looking east along downstream bridge face
CRI&P_006		looking east just upstream of the bridge at the right bank
CRI&P_007		looking at the upstream channel
CRI&P_008		looking at the upstream left bank
CRI&P_009		looking at the deposition and debris on the left bank
CRI&P_010		looking at the storm sewer outlet on the left bank just downstream of the bridge
CRI&P_011		looking at the storm sewer outlet on the left bank just downstream of the bridge
CRI&P_012		looking at the erosion from the storm sewer outlet
CRI&P_013		looking at the erosion from the storm sewer outlet
CRI&P_014		looking downstream at the left bank
CRI&P_015		looking downstream at the channel and the right bank
CRI&P_016		looking across the channel at downstream right bank
CRI&P_017		looking across the channel at riprap protection under the bridge
CRI&P_018		looking at the cavitation and cracks in Bent 2
CRI&P_019		looking at the exposed wooden forms? around Bent 2
CRI&P_020		looking south at the upstream right bank from the east side of the bridge
CRI&P_021		looking at the downstream face of the bridge
CRI&P_022		looking at the downstream left and right banks
CRI&P_023		looking at the downstream channel
CRI&P_024	CID	looking further downstream of the bridge
CRI&P_025		looking south (upstream) toward the river meander
CRI&P_026		looking south (upstream) toward the river meander
CRI&P_027		looking southwest to the right bank of the bridge
CRI&P_028		looking at the lift mechanism under the abutment

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STREAM STABILITY ANALYSIS SHEET

Stream Name: Kansas River
Bridge No: Kansas City Terminal Job No.: 45529
Inspected By: Dave Renetzky Date: 10/14/08 Sheet No: 1

HNTB

1. Upstream Conditions:	2. Downstream Conditions:
a. Banks (Photo(s) # 12-15) *mostly stable* *some lost vegetation and erosion* *fairly good vegetation cover*	a. Banks (Photo(s) # 18-22) *stable* *some erosion from local runoff on left bank* *fairly good vegetation cover*
b. Main Channel (Photo(s) #13) *clear channel* *decent approach angle to piers*	b. Main Channel (Photo(s) #19-20) *clear channel* *some deposited or placed material on right bank*
c. Floodplain (Photo(s) #_____) *levees on both sides*	c. Floodplain (Photo(s) #_____) *levees on both sides*
d. Debris (Photo(s)) *none*	d. Debris (Photo(s) # 20) *left bank just downstream of bridge*
e. Other Features (Photo(s) # 24) *high bank protection on left*	e. Other Features (Photo(s) # 31) high bank protection on left

3. Conditions at Bridge:

a. Structure (Photo(s) # 7-11)
square nose piers, exposed caisson at the bottom

b. Channel Protection & Scour Countermeasures (Photo(s))
riprap protection on upper banks

c. Waterway Area (Photo(s))
clear
no debris on piers

4. Additional Comments:
silty sand and sandy silt on the banks
clay lumps on the downstream side of the bridge
right span was raised in 1993

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STREAM STABILITY ANALYSIS SHEET

Stream Name: Kansas River
Bridge No.: Kansas City Terminal Job No.: 45529
Inspected by: Dave Renetzky Date: 10/14/2008 Sheet No: 2

HNTB

GEOMORPHIC FACTORS

PROPERTIES	GEOMORPHIC FACTORS	COMMENTS
STREAM SIZE	Small (<100ft or 30 m wide); Medium (100-500 ft or 30-150 m wide); Wide (>500 ft or 150 m wide)	Wide
FLOW HABIT	Ephemeral; Intermittent; Perennial but flashy; Perennial	Perennial
BED MATERIAL	Silt-Clay; Silt; Sand; Gravel; Cobble or boulder	Sandy Silt; Clay
VALLEY SETTING (flat, hilly, mountainous)	No valley; alluvial fan; Low relief valley (<100 ft. or 30 m deep); Moderate relief (100-1000 ft. or 30-300 m deep); High relief (>1000 ft. or 300 m deep)	Low relief valley
FLOOD-PLAINS (width)	Little or none (<2X channel width); Narrow (2 - 10X channel width); Wide (>10X channel width)	Narrow between levees/floodwalls
NATURAL LEVEES	Little or none; Mainly on concave; Well developed on both banks	None; man-made levees/floodwalls
APPARENT INCISION (bank height vs channel width)	Not Incised; Probably Incised	Incised
CHANNEL BOUNDARIES (erosion)	Alluvial; Semi-alluvial; Non-alluvial	Alluvial
TREE COVER ON BANKS	<50 percent of bank line; 50-90 percent; >90 percent	50-90 percent
SINUOSITY (ratio of curved channel length to straight length)	Straight (Sinuosity 1 -1.05); Sinuous (1.06 -1.25); Meandering (1.26 -2.0); Highly Meandering (>2.0)	Meandering
BRAIDED STREAMS (multiple and interlacing channels)	Not braided (<5 percent); Locally braided (5 - 35 percent); Generally braided (5 - 35 percent)	Not braided
ANABRANCHED STREAMS (substantial islands)	Not anabranched (<5 percent); Locally anabranched (5 - 35 percent); Generally anabranched (5 - 35 percent)	Not anabranched
VARIABILITY OF WIDTH AND DEVELOPMENT OF BARS (lateral stability)	Equiwidth; Wider at bends; Random Variation; Narrow Point Bars; Wide Point Bars; Irregular point and lateral bars	Equiwidth; some point bars

	Performed in Field
	Performed in Field and Office
	Performed in Office

Source: "Figure 12. Hydraulic and location factors that affect stream stability." HEC-20, *Stream Stability at Highway Structures,* Federal Highway Administration, 1991

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STREAM STABILITY ANALYSIS SHEET

Stream Name: Kansas River
Bridge No: Kansas City Terminal Job No.: 45529
Inspected By: Dave Renetzky Date: 10/14/08 Sheet No: 3

HNTB

Photo	Levee Side	Description
KCT_001	Armourdale	looking along downstream face of bridge from northwest abutment (Bent 1)
KCT_002		looking southwest at Bent 1 and lift mechanism
KCT_003		looking southwest at riprap protection along abutment area
KCT_004		looking southwest at riprap protection along abutment area
KCT_005		looking under bridge at Bent 1
KCT_006		looking south at Bent 2
KCT_007		looking south across downstream face of bridge
KCT_008		looking at the north side of Bent 2
KCT_009		looking at the south side of Bent 2
KCT_010		looking at the south side of Bent 2 (local flow erosion along pier)
KCT_011		looking at the south side of Bent 2
KCT_012		looking north (upstream) at the left bank
KCT_013		looking north (upstream) at the banks
KCT_014		looking northwest (upstream) at the right bank
KCT_015		looking northwest across the channel at Bent 3 and upstream
KCT_016		looking northwest across the channel at Bent 3
KCT_017		looking northwest at Bent 3 and wooden caisson forms?
KCT_018		looking northwest across the channel at Bent 3 and downstream
KCT_019		looking west at the downstream right bank
KCT_020		looking downstream at the channel and banks
KCT_021		looking northwest at the left bank downstream of bridge
KCT_022		looking downstream at left bank erosion from Bent 2
KCT_023		looking at the outlet of OK Creek on downstream right bank
KCT_024	CID	looking upstream at the high bank riprap protection
KCT_025		looking at the upstream face from the southeast abutment (Bent 4)
KCT_026		looking across the channel at Bent 3 on the upstream side
KCT_027		looking southwest at Bent 4
KCT_028		looking at the downstream face from the southeast abutment (Bent 4)
KCT_029		looking across the channel at Bent 3 on the downstream side
KCT_030		looking north at the downstream channel
KCT_031		looking downstream along the high left bank protection
KCT_032		looking at the stoplog gap area
KCT_033		looking at the stoplog gap area

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STREAM STABILITY ANALYSIS SHEET

Stream Name: Kansas River
Bridge No: Kansas Avenue East Job No.: 45529
Inspected By: Dave Renetzky Date: 10/15/08 Sheet No: 1

HNTB

1. Upstream Conditions:	2. Downstream Conditions:
a. Banks (Photo(s) #) *stable* *good vegetation cover*	a. Banks (Photo(s) #) *mostly stable* *fairly good vegetation cover* *some erosion, woody debris between bridges*
b. Main Channel (Photo(s) #) *clear channel* *poor approach angle to piers ~10 degrees*	b. Main Channel (Photo(s) #) *clear channel* *decent approach angle to piers - maybe 5 degrees*
c. Floodplain (Photo(s) #_____) *levees on both sides*	c. Floodplain (Photo(s) #_____) *levees on both sides*
d. Debris (Photo(s) #) *some deposition on left bank just upstream*	d. Debris (Photo(s) #) *left bank just downstream of bridge* *right bank downstream of bridge*
e. Other Features (Photo(s) #_____) *bridge just downstream* force main dumps in on left bank just upstream	e. Other Features (Photo(s) #_____) grouted riprap at outfall

3. Conditions at Bridge:

a. Structure (Photo(s) #)
round nose piers
heavy cracks, spalling, and cavitation on river pier
no evidence of scour at piers

b. Channel Protection & Scour Countermeasures (Photo(s) #)
sparse riprap downstream right bank
riprap protection under abutment
riprap protection on high banks

c. Waterway Area (Photo(s) #)
clear
small amount of woody debris
bridge in close proximity downstream

4. Additional Comments:
recent rehab to the lower portion of the superstructure

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STREAM STABILITY ANALYSIS SHEET

Stream Name: Kansas River
Bridge No.: Kansas Avenue East Job No.: 45529
Inspected by: Dave Renetzky Date: 10/14/2008 Sheet No: 2

HNTB

GEOMORPHIC FACTORS

PROPERTIES	GEOMORPHIC FACTORS	COMMENTS
STREAM SIZE	Small (<100ft or 30 m wide); Medium (100-500 ft or 30-150 m wide); Wide (>500 ft or 150 m wide)	Wide
FLOW HABIT	Ephemeral; Intermittent; Perennial but flashy; Perennial	Perennial
BED MATERIAL	Silt-Clay; Silt; Sand; Gravel; Cobble or boulder	Sand, Sandy Silt
VALLEY SETTING (flat, hilly, mountainous)	No valley; alluvial fan; Low relief valley (<100 ft. or 30 m deep); Moderate relief (100-1000 ft. or 30-300 m deep); High relief (>1000 ft. or 300 m deep)	Low relief valley
FLOOD-PLAINS (width)	Little or none (<2X channel width); Narrow (2 - 10X channel width); Wide (>10X channel width)	Narrow between levees/floodwalls
NATURAL LEVEES	Little or none; Mainly on concave; Well developed on both banks	None; man-made levees/floodwalls
APPARENT INCISION (bank height vs channel width)	Not Incised; Probably Incised	Incised
CHANNEL BOUNDARIES (erosion)	Alluvial; Semi-alluvial; Non-alluvial	Alluvial
TREE COVER ON BANKS	<50 percent of bank line; 50-90 percent; >90 percent	50-90 percent
SINUOSITY (ratio of curved channel length to straight length)	Straight (Sinuosity 1 -1.05); Sinuous (1.06 -1.25); Meandering (1.26 -2.0); Highly Meandering (>2.0)	Meandering
BRAIDED STREAMS (multiple and interlacing channels)	Not braided (<5 percent); Locally braided (5 - 35 percent); Generally braided (5 - 35 percent)	Not braided
ANABRANCHED STREAMS (substantial islands)	Not anabranched (<5 percent); Locally anabranched (5 - 35 percent); Generally anabranched (5 - 35 percent)	Not anabranched
VARIABILITY OF WIDTH AND DEVELOPMENT OF BARS (lateral stability)	Equiwidth; Wider at bends; Random Variation; Narrow Point Bars; Wide Point Bars; Irregular point and lateral bars	Equiwidth; some point bars

Performed in Field
Performed in Field and Office
Performed in Office

Source: "Figure 12. Hydraulic and location factors that affect stream stability." HEC-20, *Stream Stability at Highway Structures,* Federal Highway Administration, 1991

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STREAM STABILITY ANALYSIS SHEET

Stream Name: Kansas River
Bridge No: Kansas Avenue East Job No.: 45529
Inspected By: Dave Renetzky Date: 10/15/08 Sheet No: 3

HNTB

Photo	Levee Side	Description
KSAveE_001	Armourdale	looking east along the upstream face of the bridge
KSAveE_002		looking south along the upstream face of the bridge
KSAveE_003		looking east at Bent 2 and Bent 3
KSAveE_004		looking at the USGS gage on the bridge
KSAveE_005		looking at the old USGS station
KSAveE_006		looking east at Bent 2
KSAveE_007		looking east at upstream right bank
KSAveE_008		looking further upstream at the right bank
KSAveE_009		looking at the channel upstream of the bridge
KSAveE_010		looking south at the left high bank upstream of the bridge
KSAveE_011		looking at the left bank just downstream of the bridge
KSAveE_012		looking northeast across the channel at the downstream right bank
KSAveE_013		looking at a significant outfall along the downstream right bank
KSAveE_014		looking across the channel at Bent 2 and Bent 3
KSAveE_015		looking southeast at Bent 2
KSAveE_016		closeup of cavitation on Bent 2
KSAveE_017		closeup of cavitation on Bent 3
KSAveE_018	CID	looking at the east abutment area
KSAveE_019		looking at the east end of the bridge

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STREAM STABILITY ANALYSIS SHEET

Stream Name: Kansas River
Bridge No: 7th Street Northbound Job No.: 45529
Inspected By: Dave Renetzky Date: 10/15/08 Sheet No: 1

HNTB

1. Upstream Conditions:	2. Downstream Conditions:
a. Banks (Photo(s) #) *mostly stable* *fairly good vegetation cover* *some vegetation loss on left bank*	a. Banks (Photo(s) #) *stable* *some debris and rocks* *fairly good vegetation cover*
b. Main Channel (Photo(s) #) *clear channel* *point bar developed just upsteram of bridge* *may have degraded based on piers*	b. Main Channel (Photo(s) #) *clear channel* *may have degraded based on piers*
c. Floodplain (Photo(s) #_____) *levee on one side; high ground on the other*	c. Floodplain (Photo(s) #_____) *levee on one side; high ground on the other*
d. Debris (Photo(s) #) *left bank just upstream of bridge*	d. Debris (Photo(s) #) *left bank just downstream of bridge*
e. Other Features (Photo(s) #_____) *rock protecting levee slope at abutment*	e. Other Features (Photo(s) #_____)

3. Conditions at Bridge:

a. Structure (Photo(s) #)
round nose piers, square at the bottom
exposed sheet pile
evidence of possible scour at Bent 2

b. Channel Protection & Scour Countermeasures (Photo(s) #)

c. Waterway Area (Photo(s) #)
clear
deposition occurring upstream near left bank
no debris on piers

4. Additional Comments:

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STREAM STABILITY ANALYSIS SHEET

Stream Name: Kansas River
Bridge No.: 7th Street Northbound Job No.: 45529
Inspected by: Dave Renetzky Date: Date: 10/15 Sheet No: 2

HNTB

GEOMORPHIC FACTORS

PROPERTIES	GEOMORPHIC FACTORS	COMMENTS
a. Banks (Photo(s) #) SIZE	Small (<100ft or 30 m wide); a. Banks (Photo(s) #) Medium (100-500 ft or 30-150 m wide); Wide (>500 ft or 150 m wide)	Wide
FLOW HABIT	Ephemeral; Intermittent; Perennial but flashy; Perennial	Perennial
BED b. Main Channel (Photo(s) #)	Silt-Clay; Silt; Sand; b. Main Channel (Photo(s) #) Gravel; Cobble or boulder	Sand, Sandy Silt
VALLEY SETTING (flat, hilly, mountainous)	No valley; alluvial fan; Low relief valley (<100 ft. or 30 m deep); Moderate relief (100-1000 ft. or 30-300 m deep); High relief (>1000 ft. or 300 m deep)	Low relief valley
FLOOD-PLAINS (width)	Little or none (<2X channel width); Narrow (2 - 10X channel width); Wide (>10X channel width)	Narrow between levees/floodwalls
NATURAL d. Debris (Photo(s) #)	Little or none; Mainly on concave; Well developed on both banks	None; man-made levees/floodwalls
APPARENT INCISION (bank height vs channel width)	Not Incised; Probably Incised	Incised
CHANNEL BOUNDARIES (erosion)	Alluvial; Semi-alluvial; Non-alluvial	Alluvial
a. Structure (Photo(s) #) ON BANKS	<50 percent of bank line; 50-90 percent; >90 percent	50-90 percent
SINUOSITY (ratio of curved channel length to b. Channel Protection & Scour Countermeasures (Photo(s) #)	Straight (Sinuosity 1 -1.05); Sinuous (1.06 -1.25); Meandering (1.26 -2.0); Highly Meandering (>2.0)	Meandering
BRAIDED STREAMS (multiple and interlacing channels)	Not braided (<5 percent); Locally braided (5 - 35 percent); Generally braided (5 - 35 percent)	Not braided
c. Waterway Area (Photo(s) #) STREAMS (substantial islands)	Not anabranched (<5 percent); Locally anabranched (5 - 35 percent); Generally anabranched (5 - 35 percent)	Not anabranched
VARIABILITY OF WIDTH AND DEVELOPMENT OF BARS (lateral stability)	Equiwidth; Wider at bends; Random Variation; Narrow Point Bars; Wide Point Bars; Irregular point and lateral bars	Equiwidth; some point bars

	Performed in Field
	Performed in Field and Office
	Performed in Office

Source: "Figure 12. Hydraulic and location factors that affect stream stability." HEC-20, *Stream Stability at Highway Structures,* Federal Highway Administration, 1991

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STREAM STABILITY ANALYSIS SHEET

Stream Name: Kansas River
Bridge No: 7th Street Northbound Job No.: 45529
Inspected By: Dave Renetzky Date: 10/15/08 Sheet No: 3

HNTB

Photo	Levee Side	Description
7thStN_001	Armourdale	looking south across the downstream face of the bridge
7thStN_002		looking south across the downstream face of the bridge
7thStN_003		looking south across the downstream face of the bridge
7thStN_004		looking south across the downstream face of the bridge
7thStN_005		looking southeast across the upstream face of the bridge
7thStN_006		looking southeast at Bent 3
7thStN_007		looking along left upstream bank
7thStN_008		looking upstream from left bank
7thStN_009		looking at upstream right bank from left bank
7thStN_010		looking at downstream right bank just downstream of bridge
7thStN_011		looking at downstream right bank further downstream of bridge
7thStN_012		looking at downstream channel and left bank
7thStN_013		looking at downstream channel and left bank
7thStN_014		looking southeast at Bent 3
7thStN_015		looking southeast at Bent 3 sheetpile
7thStN_016		looking north from Bent 2 area
7thStN_017		looking at possible scour of Bent 2
7thStN_018		looking at possible scour of Bent 2
7thStN_019		looking at possible scour of Bent 2
7thStN_020		looking at possible scour of Bent 2
7thStN_021		looking at possible scour of Bent 3
7thStN_022		looking at possible scour of Bent on Southbound bridge; likely local flow erosion
7thStN_023		looking at possible scour of Bent on Southbound bridge; likely local flow erosion
7thStN_024		looking at possible scour of Bent on Southbound bridge; likely local flow erosion
7thStN_025		looking southeast toward Bent 2
7thStN_026		looking northwest at Bent 1
7thStN_027		looking southeast from Bent 1

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STREAM STABILITY ANALYSIS SHEET

Stream Name: Kansas River
Bridge No: 18th Street Job No.: 45529
Inspected By: Dave Renetzky Date: 10/15/08 Sheet No: 1

HNTB

1. Upstream Conditions:	2. Downstream Conditions:
a. Banks (Photo(s) #) *stable* *fairly good vegetation cover*	a. Banks (Photo(s) #) *stable* *fairly good vegetation cover*
b. Main Channel (Photo(s) #) *vegetated point bar upstream* *piers are aligned with river*	b. Main Channel (Photo(s) #) *clear channel*
c. Floodplain (Photo(s) #_____) *levees on both sides*	c. Floodplain (Photo(s) #_____) *levees on both sides*
d. Debris (Photo(s) #) *right bank just upstream of bridge* heavy on piers	d. Debris (Photo(s) #)
e. Other Features (Photo(s) #_____) *high bank protection*	e. Other Features (Photo(s) #_____) high bank protection

3. Conditions at Bridge:

a. Structure (Photo(s) #)
round nose piers
spalling on the river piers
no evidence of scour at piers

b. Channel Protection & Scour Countermeasures (Photo(s) #)
some abutment riprap protections
riprap protection on upper banks

c. Waterway Area (Photo(s) #)
clear
point bar upstream dividing channel
heavy debris on piers

4. Additional Comments:
repair work going on at time of site visit; bearing repair/replacement

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STREAM STABILITY ANALYSIS SHEET

Stream Name: Kansas River
Bridge No.: 18th Street Job No.: 45529
Inspected by: Dave Renetzky Date: Date: 10/15 Sheet No: 2

HNTB

GEOMORPHIC FACTORS

PROPERTIES		COMMENTS
a. Banks (Photo(s) #) SIZE	Small (<100ft or 30 m wide); a. Banks (Photo(s) #) Medium (100-500 ft or 30-150 m wide); Wide (>500 ft or 150 m wide)	Wide
FLOW HABIT	Ephemeral; Intermittent; Perennial but flashy; Perennial	Perennial
BED b. Main Channel (Photo(s) #)	Silt-Clay; Silt; Sand; b. Main Channel (Photo(s) #) Gravel; Cobble or boulder	Sand, Sandy Silt
VALLEY SETTING (flat, hilly, mountainous)	No valley; alluvial fan; Low relief valley (<100 ft. or 30 m deep); Moderate relief (100-1000 ft. or 30-300 m deep); High relief (>1000 ft. or 300 m deep)	Low relief valley
FLOOD-PLAINS (width)	Little or none (<2X channel width); Narrow (2 - 10X channel width); Wide (>10X channel width)	Narrow between levees/floodwalls
NATURAL d. Debris (Photo(s) #)	Little or none; Mainly on concave; Well developed on both banks	None; man-made levees/floodwalls
APPARENT INCISION (bank height vs channel width)	Not Incised; Probably Incised	Incised
CHANNEL BOUNDARIES (erosion)	Alluvial; Semi-alluvial; Non-alluvial	Alluvial
a. Structure (Photo(s) #) ON BANKS	<50 percent of bank line; 50-90 percent; >90 percent	50-90 percent
SINUOSITY (ratio of curved channel length to b. Channel Protection & Scour Countermeasures (Photo(s) #)	Straight (Sinuosity 1 -1.05); Sinuous (1.06 -1.25); Meandering (1.26 -2.0); Highly Meandering (>2.0)	Meandering
BRAIDED STREAMS (multiple and interlacing channels)	Not braided (<5 percent); Locally braided (5 - 35 percent); Generally braided (5 - 35 percent)	Not braided
c. Waterway Area (Photo(s) #) STREAMS (substantial islands)	Not anabranched (<5 percent); Locally anabranched (5 - 35 percent); Generally anabranched (5 - 35 percent)	Not anabranched
VARIABILITY OF WIDTH AND DEVELOPMENT OF BARS (lateral stability)	Equiwidth; Wider at bends; Random Variation; Narrow Point Bars; Wide Point Bars; Irregular point and lateral bars	Equiwidth; some point bars

	Performed in Field
	Performed in Field and Office
	Performed in Office

Source: "Figure 12. Hydraulic and location factors that affect stream stability." HEC-20, *Stream Stability at Highway Structures,* Federal Highway Administration, 1991

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STREAM STABILITY ANALYSIS SHEET

Stream Name: Kansas River
Bridge No: 18th Street Job No.: 45529
Inspected By: Dave Renetzky Date: 10/15/08 Sheet No: 3

Photo	Levee Side	Description
18thSt_001	Argentine	looking east from south abutment area (Bent 4)
18thSt_002		looking across the upstream face of the bridge
18thSt_003		looking down the bridge from the south abutment; Bent 3
18thSt_004		looking at the south abutment (Bent 4) and riprap
18thSt_005		looking at the upper bank protection along the right bank upstream
18thSt_006		looking at the right bank upstream
18thSt_007		looking northwest at the upstream channel
18thSt_008		looking northwest at the upstream channel and left bank
18thSt_009		looking across the channel at Bent 2
18thSt_010		looking across the channel at Bent 4
18thSt_011		looking east from south abutment area at downstream left bank
18thSt_012		looking downstream at channel and right bank
18thSt_013		looking downstream at the high bank protection
18thSt_014		looking across the downstream face of the bridge from the north abutment (Bent 1)
18thSt_015		looking at equipment being used to replace bearings
18thSt_016		looking at Bent 1
18thSt_017		looking at Bent 1
18thSt_018	Armourdale	looking at upstream side of Bent 2 and Bent 3; note debris and spalling
18thSt_019		looking at upstream side of Bent 3; note debris
18thSt_020		looking at upstream side of Bent 2; note debris and spalling
18thSt_021		looking at the upstream right bank
18thSt_022		looking further upstream at the right bank

P:\jobs\45529_TO1_KC_Levees\Bridge\Deliverable_LetterOfOpinion\Appendix\3_H&HFieldNotes\[ScourFieldInspection18thSt.xls]PhotoLog

Kansas City Levees Flood Risk Management Project Feasibility Study Phase 2

Bridge: Missouri Pacific #1
Job No. 45529
Date: 10/14/08
Evaluated by: AKB
Reviewed by: KAK

Geotechnical Site Visit Report

Bridge over: Kansas River Description: Railroad Bridge

Notes: Pier footings supported on rock and piers supported on timber piles.

1. Type of surface material of riverbank (sand, clay, silt, riprap, etc.) Any vegetation present?

Lean clay. Banks are well-vegetated. Vegetation consists of small trees and underbrush.

2. Any sliding earth fills or slopes at bridge site? Give details below:

None observed.

3. Describe the land use in each of the four quadrants near the bridge (pasture, crops, brush, developed, etc.)

Upstream Left: Roadway intersection	Upstream Right: Interstate 70
Downstream Left: Park	Downstream Right: Buildings

4. Note any improvements in the vicinity of the bridge, including residences, businesses, other buildings, crop fields, etc.

Buildings and Interstate Overpass

5. Additional Remarks:

Ernie Quinto from the KAW Valley Drainage District indicated that damage to the bridge was not evident after the 1993 flood.

Kansas City Levees Flood Risk Management Project Feasibility Study Phase 2

Bridge: Kansas City Southern
Job No. 45529
Date: 10/15/08
Evaluated by: AKB
Reviewed by: KAK

Geotechnical Site Visit Report

Bridge over: Kansas River Description: Abandoned Railroad Bridge

Notes: Piers supported on timber piles.

1. Type of surface material of riverbank (sand, clay, silt, riprap, etc.) Any vegetation present?

Clay. Banks are well-vegetated. Vegetation consists of small trees and underbrush.

2. Any sliding earth fills or slopes at bridge site? Give details below:

None observed.

3. Describe the land use in each of the four quadrants near the bridge (pasture, crops, brush, developed, etc.)

Upstream Left:	Railyard	Upstream Right:	Railyard
Downstream Left:	Railyard	Downstream Right:	Railyard

4. Note any improvements in the vicinity of the bridge, including residences, businesses, other buildings, crop fields, etc.

Railyards

5. Additional Remarks:

Kansas City Levees Flood Risk Management Project Feasibility Study Phase 2

Bridge: Missouri Pacific #72
Job No. 45529
Date: 10/14/08
Evaluated by: AKB
Reviewed by: KAK

Geotechnical Site Visit Report

Bridge over: Kansas River Description: Railroad Bridge

Notes: Piers founded on timber piles.

1. Type of surface material of riverbank (sand, clay, silt, riprap, etc.) Any vegetation present?

Clay. Banks are well-vegetated. Vegetation consists of small trees and underbrush.

2. Any sliding earth fills or slopes at bridge site? Give details below:

None observed.

3. Describe the land use in each of the four quadrants near the bridge (pasture, crops, brush, developed, etc.)

Upstream Left: Union Pacific #3 Bridge	Upstream Right: Union Pacific #3 Bridge
Downstream Left: Warehouse	Downstream Right: Open Land

4. Note any improvements in the vicinity of the bridge, including residences, businesses, other buildings, crop fields, etc.

Warehouses, highways

5. Additional Remarks:

Bank on right side showed signs of erosion.

Kansas City Levees Flood Risk
Management Project Feasibility Study
Phase 2

Bridge: Union Pacific #3
Job No. 45529
Date: 10/14/08
Evaluated by: AKB
Reviewed by: KAK

Geotechnical Site Visit Report

Bridge over: Kansas River Description: Railroad Bridge

Notes: Piers founded on timber piles.

1. Type of surface material of riverbank (sand, clay, silt, riprap, etc.) Any vegetation present?

Clay. Banks are well-vegetated. Vegetation consists of small trees and underbrush.

2. Any sliding earth fills or slopes at bridge site? Give details below:

None observed.

3. Describe the land use in each of the four quadrants near the bridge (pasture, crops, brush, developed, etc.)

Upstream Left:	Warehouse	Upstream Right:	I-70/Open Land
Downstream Left:	Missouri Pacific #72 Bridge	Downstream Right:	Missouri Pacific #72 Bridge

4. Note any improvements in the vicinity of the bridge, including residences, businesses, other buildings, crop fields, etc.

Warehouses, highways

5. Additional Remarks:

Kansas City Levees Flood Risk Management Project Feasibility Study Phase 2

Bridge: Chicago Rock Island & Pacific
Job No. 45529
Date: 10/15/08
Evaluated by: AKB
Reviewed by: KAK

Geotechnical Site Visit Report

Bridge over: Kansas River Description: Abandoned Railroad Bridge

Notes: Main river pier is a footing on rock, adjacent piers are founded on timber piles.

1. Type of surface material of riverbank (sand, clay, silt, riprap, etc.) Any vegetation present?

Clay. Banks are well-vegetated. Vegetation consists of small trees and underbrush.

2. Any sliding earth fills or slopes at bridge site? Give details below:

None observed.

3. Describe the land use in each of the four quadrants near the bridge (pasture, crops, brush, developed, etc.)

Upstream Left:	Commercial Storage/Trucking	Upstream Right:	Commercial Building
	Road Bridge		Road Bridge
Downstream Left:	Commercial Buildings	Downstream Right:	Kemper Arena

4. Note any improvements in the vicinity of the bridge, including residences, businesses, other buildings, crop fields, etc.

Commercial buildings, storage

5. Additional Remarks:

Timber grillage/sofit slab exposed at main river pier. In addition, right bank showed signs of erosion.

Kansas City Levees Flood Risk
Management Project Feasibility Study
Phase 2

Bridge: Kansas City Terminal
Job No. 45529
Date: 10/14/08
Evaluated by: AKB
Reviewed by: KAK

Geotechnical Site Visit Report

Bridge over: Kansas River Description: Railroad Bridge

Notes: Main piers are footings on rock, abutments are supported on timber piles.

1. Type of surface material of riverbank (sand, clay, silt, riprap, etc.) Any vegetation present?

Silty sand underlain by clay. Banks are well-vegetated. Vegetation consists of small trees and underbrush.

2. Any sliding earth fills or slopes at bridge site? Give details below:

None observed.

3. Describe the land use in each of the four quadrants near the bridge (pasture, crops, brush, developed, etc.)

Upstream Left: Commercial Buildings	Upstream Right: Abandoned Building
Downstream Left: Commercial Buildings	Downstream Right: Railroad

4. Note any improvements in the vicinity of the bridge, including residences, businesses, other buildings, crop fields, etc.

Commercial buildings, railroad

5. Additional Remarks:

The bridge span over the right bank was raised in 1993 due to the flood conditions.

Grillage/sofit slab exposed at main river pier.

Kansas City Levees Flood Risk Management Project Feasibility Study Phase 2

Bridge: East Kansas Avenue
Job No. 45529
Date: 10/15/08
Evaluated by: AKB
Reviewed by: KAK

Geotechnical Site Visit Report

Bridge over: Kansas River Description: Highway Bridge

Notes: Main piers are footings on rock and abutments are supported on timber piles.

1. Type of surface material of riverbank (sand, clay, silt, riprap, etc.) Any vegetation present?

Clay. Banks are well-vegetated. Vegetation consists of small trees and underbrush.

2. Any sliding earth fills or slopes at bridge site? Give details below:

None observed.

3. Describe the land use in each of the four quadrants near the bridge (pasture, crops, brush, developed, etc.)

Upstream Left: Commercial Storage/Trucking	Upstream Right: Commercial Building
Downstream Left: Commercial Buildings	Downstream Right: Kemper Arena
Abandoned Railroad Bridge	

4. Note any improvements in the vicinity of the bridge, including residences, businesses, other buildings, crop fields, etc.

Commercial buildings, storage

5. Additional Remarks:

Kansas City Levees Flood Risk Management Project Feasibility Study Phase 2

Bridge: 7th Street (Northbound)
Job No. 45529
Date: 10/15/08
Evaluated by: AKB
Reviewed by: KAK

Geotechnical Site Visit Report

Bridge over: Kansas River Description: Highway Bridge

Notes: Bridge piers supported on footings or piles.

1. Type of surface material of riverbank (sand, clay, silt, riprap, etc.) Any vegetation present?

Sandy silt. Banks are well-vegetated. Vegetation consists of small trees and underbrush.

2. Any sliding earth fills or slopes at bridge site? Give details below:

None observed.

3. Describe the land use in each of the four quadrants near the bridge (pasture, crops, brush, developed, etc.)

Upstream Left: Vegetated Land	Upstream Right: Railroad
Downstream Left: Commercial Buildings	Downstream Right: Railroad

4. Note any improvements in the vicinity of the bridge, including residences, businesses, other buildings, crop fields, etc.

Commercial buildings, railroad

5. Additional Remarks:

Kansas City Levees Flood Risk Management Project Feasibility Study Phase 2

Bridge: 18th Street
Job No. 45529
Date: 10/15/08
Evaluated by: AKB
Reviewed by: KAK

Geotechnical Site Visit Report

Bridge over: Kansas River Description: Highway Bridge

Notes: Piers supported on piles.

1. Type of surface material of riverbank (sand, clay, silt, riprap, etc.) Any vegetation present?

Silty sand. Banks are well-vegetated. Vegetation consists of small trees and underbrush.

2. Any sliding earth fills or slopes at bridge site? Give details below:

None observed.

3. Describe the land use in each of the four quadrants near the bridge (pasture, crops, brush, developed, etc.)

Upstream Left:	Vegetated Land	Upstream Right:	Railroad
Downstream Left:	Commercial Buildings	Downstream Right:	Railroad

4. Note any improvements in the vicinity of the bridge, including residences, businesses, other buildings, crop fields, etc.

Railroad, commercial buildings

5. Additional Remarks:

Repairs are currently being made to bearings.

HAZUS MR4 TECHNICAL MANUAL EXERPT

Analyzing losses for lifeline facilities is for the most part similar to that discussed in the general building stock chapter, but the damage functions for lifelines really define the potential damage to components of the lifeline system that are either uniquely vulnerable to inundation (such as electrical components) or are expensive or difficult to repair/replace (such as motors, controllers, etc.).

7.2.1 Input Requirements and Output Format

7.2.2 Form of the Damage Functions

With the obvious exception of bridges (discussed below) the damage functions for lifelines are very similar to the depth to damage curves used to the general building stock. The depth of flooding within the facility is compared to the height of critical components and the amount of damage can be estimated. In most cases, the elevation of the equipment also provides for a depth of flooding at which point the functionality of the facility starts to become questionable.

7.2.3 Transportation Bridges

In discussions with the FHWA, no comprehensive database of bridge damage could be identified. As a result, the proposed damage relationships are estimates that should be calibrated once the overall flood module is operable.

HAZUS comes with the national bridge inventory database as part of the default data and the objective is to use as much of the information in that database as possible. This database includes all bridges in the U.S. with a span of 20-feet or greater. In discussions with an FHWA representative it was suggested that possible fields within the bridge inventory database include: scour potential, waterway adequacy, and span type (simple versus continuous). The FHWA also provided other references for further information.

The database field discussed, the scour potential rating, has values that range from 0 to 9, where 0 indicates the bridge is closed as a result of scour damage, and 9 indicates that the bridge is not over water. Scour ratings 4-9 are not used in HAZUS. Ratings of significance to the flood model are:

- 1 – closed
- 2 – existing problem
- 3 – 100-year flood could damage.

There appears to be a very low probability of failure due to flooding for bridges with a scour potential greater than 3. As bridges are designed for 500-year floods, for single span bridges over water (i.e. – scour potential < 9), the HAZUS Flood Model assumes a 1% probability of failure for floods with a return period of 100 years, and 1.5% probability for floods with a return period

of 1000 years. For continuous bridges, the HAZUS Flood Model uses 25% of the values for single span bridges.

The waterway adequacy gives some indication how much the bridge is restricting the channel, but there is no known correlation to bridge damage due to flooding.
Most bridge failures are simple spans. Scour of bridge piers on continuous spans does not usually result in collapse. Expected damage for continuous span bridges is taken to be 25% of that for single span bridges. Similarly, bridges with multiple piers provide redundancy that reduces their vulnerability. The span type is included in the National Bridge Database, but the number of piers is not.

The relationships for single-span and continuous-span bridge damage due to flooding is shown below.

Table 7.2 Highway Single-span Bridge Damage Relationship

Flood Return Period	Scour Potential[1]/Probability of Failure (percent)				
	1	**2**	**3**	**4-8**	**9**
100-year	5	2	1	0	N/A
500-year (2x 100-year probability)	10	4	2	0	N/A
1000-year (1.5x 500-year probability)	15	6	3	0	N/A

The Scour Potential is a field in the HAZUS Bridge database and is from the FHWA inventory of bridges

Table 7.3 Highway Continuous-Span Bridge Damage Relationship

Flood Return Period	Scour Potential[1]/Probability of Failure (percent)				
	1	**2**	**3**	**4-8**	**9**
100-year	1.25	0.5	0.25	0	N/A
500-year (2x 100-year probability)	2.5	1	0.5	0	N/A
1000-year (1.5x 500-year probability)	3.75	1.5	0.75	0	N/A

[1] The Scour Potential is a field in the HAZUS Bridge database and is from the FHWA inventory of bridges

In the future, it may be possible to develop damage relationships for different bridge span materials (concrete, steel, wood), but no data exists, and the focus is on the bridge foundation vulnerability rather than the span.

"Failure" is defined to be loss of function due to flood/scour damage. As there is very limited data, the preliminary recommendation is that "failure" represents a damage value of 25% of replacement cost. This is a mean value taking into account damage that could be scour/undercutting of a single pier, to collapse of a span. This same relationship is applied to rail and light rail bridges. The damage relationships are applicable to pipelines supported on highway bridges.