Maricopa County Department of Transportation
(MCDOT)
W.O. TT199 Contract 2006-036

SCOUR ANALYSIS REPORT

for

Dobson Road Bridges at Salt River

Prepared by

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1. INTRODUCTION

This report documents the revised bridge scour analysis of the Salt River with the proposed configurations of the Dobson Road, McKellips Road and Gilbert Road Bridges. The bridge hydraulic study was performed both with HEC-RAS models that were prepared based on a FEMA model and with 2-D models using SMS FESWMS Flo2DH programs. The results of the hydraulic study and scour analyses were used as part of the bridge length and foundation design analysis. The area of the study is shown on the Project Aerial photo in Figure 1.

2. BRIDGE SCOUR

Bridge scour analysis was performed for the three proposed bridges to provide information on the bridge's foundation design. The scour depths were estimated for both the 100-year and 500-year flow events. The peak discharges after the Roosevelt Dam modifications were adopted for the hydraulic study of the three bridges as required by the Flood Control District of Maricopa County.

The bridge's local scour estimate basically follows the 2001 FHWA HEC No.18 procedure, and the general scour estimate followed the U.S. Department of the Interior Bureau of Reclamation Technical Guideline for Computing Degradation and Local Scour. The Draft Drainage Design Manual for Maricopa County, Chapter 11-Sedimentation, was referenced throughout the scour analysis process to make sure that the procedures used comply with the County's requirements.

The following components of vertical incisement of the channel bed were considered for the total scour:

1. Long-term degradation of the river bed (Z_{deg});
2. General scour for a specific reach of the river (Z_{gs});
3. Scour induced due to a bend in the river (Z_{bs});
4. Local scour - pier and abutment scour (Z_{ls});
5. Bed-form trough depth (Z_{bf});
6. Scour due to low-flow incisement (Z_{lf}).

$$Z_{Tot} = Z_{ls} + FS_2 (Z_{deg} + Z_{gs} + Z_{bs} + Z_{bf} + Z_{lf}) \quad (1)$$

where, FS is a safety factor for non-local scour components.

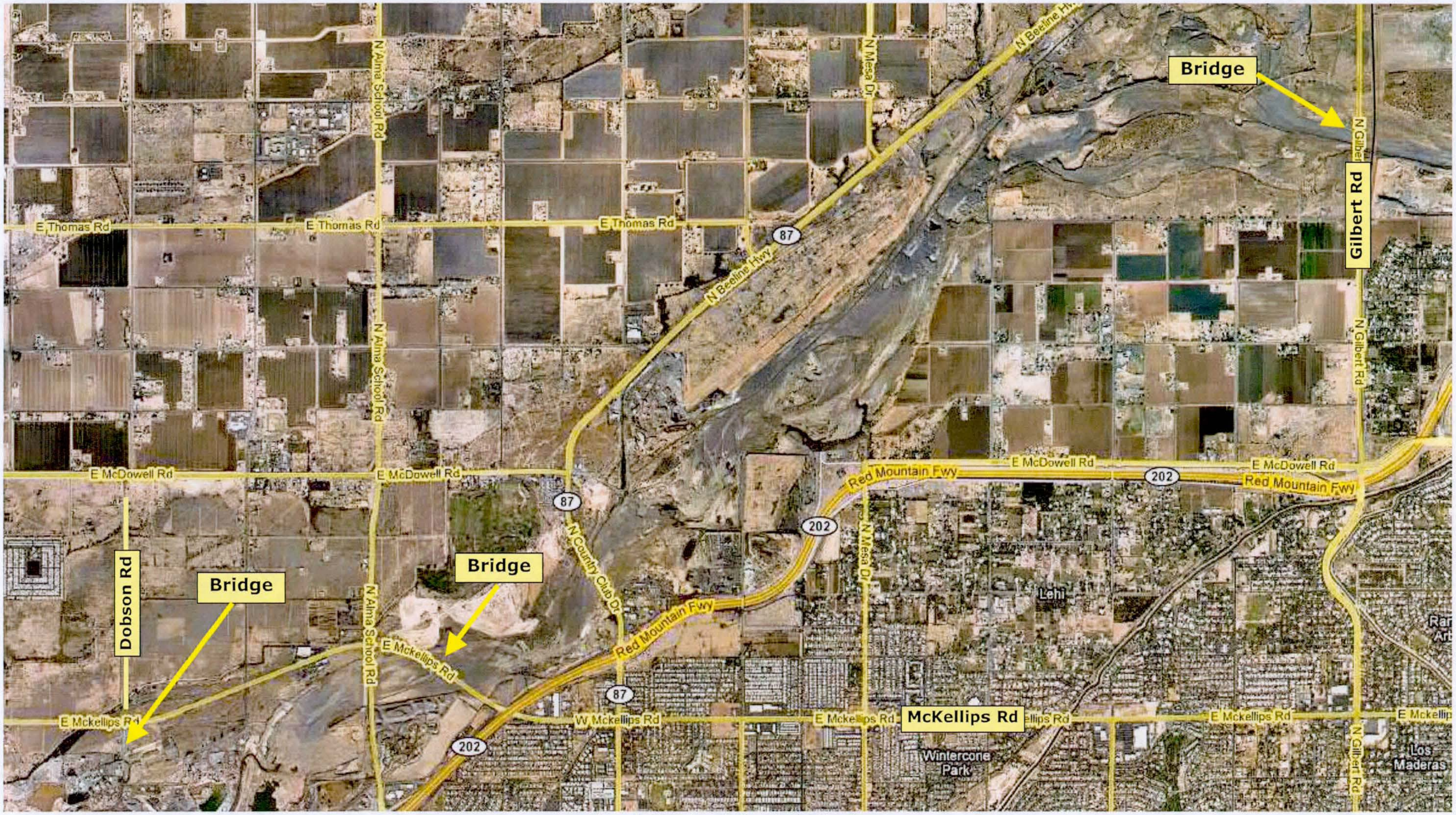


Fig. 1 Project Aerial Photo

2.1 Bridge Scour Equations

The General Scour and the Local Bridge Scour and their equations are discussed in the following sections. Other components of the Total Scour will be discussed separately for each Bridge.

2.1.1 General Scour

General or mainly "*Contraction*" scour occurs when the flow area of a stream at flood stage is reduced, either by a natural contraction of the stream channel or by a Bridge. The contraction of flow at a bridge can be caused by either a natural decrease in flow area of the stream channel or by abutments projecting into the channel and/or piers blocking a portion of the flow area. Contraction can also be caused by the approaches to a bridge cutting off floodplain flow. There are some other general scour causes as documented in HEC-18.

The General scour was estimated by computing the average of three regime equations, namely, the Blench Zero Bed-Sediment Transport Equation, Eq. (2), Lacy Equation, Eq. (3) and Neill Equation, Eq. (4). This method was developed by the US Bureau of Reclamation and it provides a multipurpose approach for estimating depths of scour due to bends, piers, grade-control structures and vertical rock banks or walls. These equations are presented below.

- ***Blench equation***

$$y_B = q_d^{0.67} / F_{bo}^{0.33} \quad ; \; y_S = Z \times y_B \qquad (2)$$

where:

y_B = *depth for zero bed-sediment transport*
q_d = *design flow discharge per unit width*
F_{bo} = *Blench's zero bed factor, from Figure A-1 in Appendix A.*
y_S = *Scour depth*
Z = *Adjustment factor*

- ***Lacy's equation***

$$y_L = 0.47\,(Q/f)^{.33} \quad ; \; y_S = Z \times y_L \qquad (3)$$

where:

y_L = *mean depth at design discharge*
Q = *design discharge*
f = *Lace's silt factor* = $1.76\,(D_{50})^{0.5}$; *where:* D_{50} = *median grain size of bed material*
y_S = *scour depth*
Z = *adjustment factor*

- ***Neill's equation***

$$y_n = y_{bf}(q_d / q_{bf})^m \quad ; y_S = Z \times y_n \tag{4}$$

where:

y_n = *scoured depth below design-flow level which is adjusted in*
y_{bf} = *average bankfull flow depth*
q_d = *design-flow discharge per unit width*
q_{bf} = *bankfull flow discharge per unit width*
m = *exponent varying from 0.67 for sand to 0.85 for coarse gravel*

2.1.2 *Local Scour*

Local scour at the bridge piers is caused by a vortex system that develops at the piers. The pier scour at the bridge was estimated using the Modified Colorado State University equation, Eq. (5), as recommended in HEC No. 18.

$$\frac{Y_s}{a} = 2.0 K_1\ K_2\ K_3\ K_4 \times \left(\frac{Y_1}{a}\right)^{0.35} \times Fr_1^{0.43} \tag{5}$$

where:

Y_s = Scour depth (ft)
a = Width of pier (ft), 10 feet plus 4 feet for debris was used.
Y_1 = Water depth upstream of the bridge pier (ft)
Fr_1 = Upstream Froude number
K_1 = Correction factor for pier nose shape, 1.0 was used.
K_2 = Correction factor for angle of attack of the flow, 15° was used to consider the uncertainty of flow direction versus pier orientation, and K_2 was calculated using Equation 6.4 as documented in HEC No. 18.

K_3 = Correction factor for the bed condition. It was set to 1.0 as recommended by the Draft Drainage Manual for Maricopa County since the bed form trough depth was calculated individually.
K_4 = Correction factor for armoring, which was set at 1.0 to be conservative.

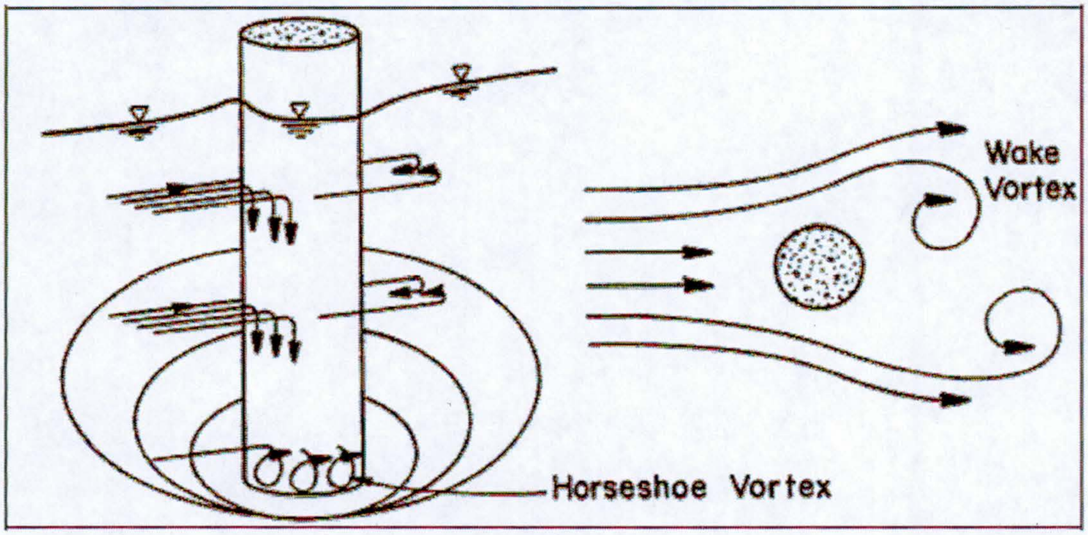
2.1.2.1 Impact of debris on local pier scour

Debris lodged on a pier can increase local scour at the pier. The debris may increase pier width and deflect a component of flow downward. This increases the transport of sediment out of the scour hole. When floating debris is lodged on the pier, the effect of the debris in increasing scour depths is taken into account by adding a width, W_d, to the sides and front of the pier. Two scenarios were considered:

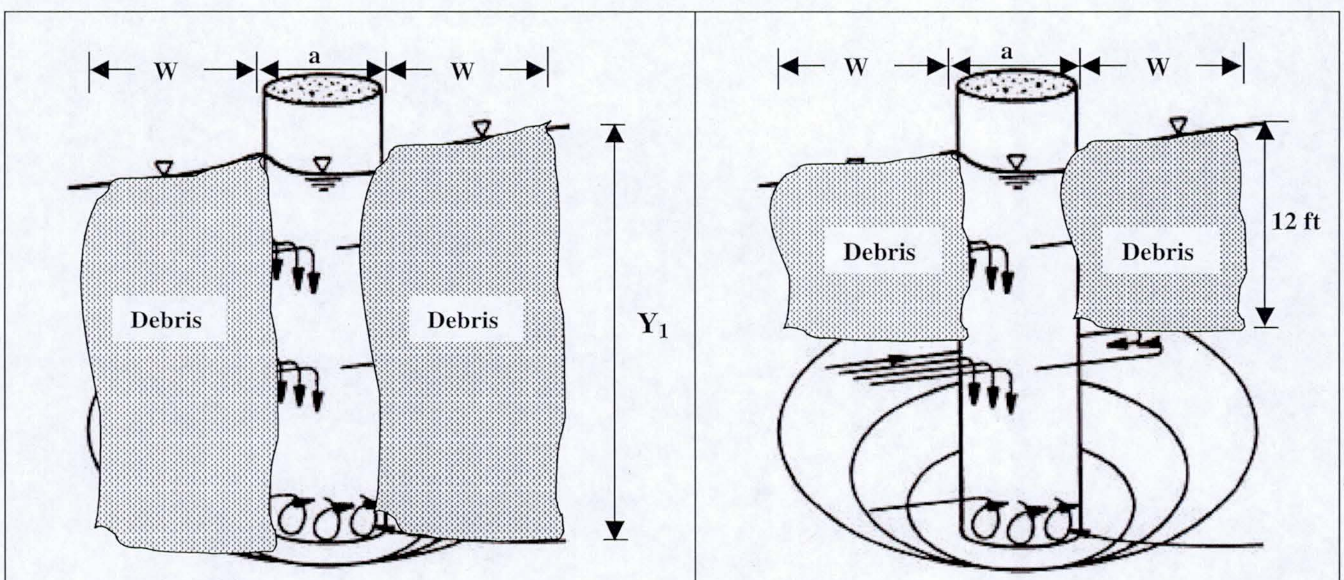
(1) No debris, i.e. $W_d = 0$

(2) Debris width is 2 feet on each side of the pier, i.e. $W_d = 4$ feet, and lodged up to the top 12 ft of the pier length based on the ADOT Bridge Design Guidelines.

Fig. 2 shows a schematic of the possible scenarios. For each bridge, the most appropriate scenario was selected based on the geometric and hydraulic conditions and/or the Flood Control District of Maricopa County recommendations.



a) No debris



b) Debris lodged to the whole depth Y1

c) Debris lodged to the top 12 ft only

Fig. 2. Impact of Debris on Local Pier Scour

3. GILBERT ROAD BRIDGE

3.1 Long-Term Degradation

Long-term degradation occurs over a long period of time in response to changes that cause an imbalance between the sediment transport capacity of the channel and the dominant sediment supply to the channel. Long-term changes could be the result of natural processes or of human activities. Common human activities that could have an effect include dams constructed upstream or downstream of a reach and sand and gravel mining activities.

Historically, the project segments of the Salt River have experienced heavy sand and gravel mining activities. The range of future sand and gravel mining activities are difficult to predict. To control potential long-term degradation, a grade control structure will be constructed just downstream of the proposed Gilbert Road Bridge. With the grade control structure in place, we anticipate that there will not be any long-term scour occurring at the bridge location. In other words, $Z_{deg}=0$.

3.2 General Scour

For the proposed Gilbert Road Bridge, General scour was calculated by using Equations (2), (3) and (4) presented in section 2.1.1. An average value of the results obtained from the three equations was calculated. The estimated general scour for Gilbert Road Bridge was found to be 5.17 feet for the 100-year event, and 6.11 feet for the 500-year event.

3.3 Bed-form Trough Depth

Since the flow at Gilbert Road Bridge is within the lower regime flow, the dune trough depth was estimated using the equation documented in the draft Drainage Design Manual for Maricopa County. The dune trough depth was estimated to be 0.25 feet for both the 100- year and 500-year flow events.

3.4 Local Scour at Piers

As mentioned before the local scour was calculated according to equation (5). As the flow depth is in the range of 12 ft, scenario (2) of adding 2 ft of debris on each side of the pier was adopted as explained in section 2.1.2.1. The computed scour depth at the piers was 30.26 feet for the 100- year peak discharge and 32.07 feet for the 500-year peak discharge.

3.5 Local Scour at Abutments

No abutments are planned to be constructed in the main channel of the Salt River at this time. No local scour at abutments was calculated.

3.6 Bend Scour

There is no significant bend present at this bridge.

3.7 Low-Flow Incisement

The Flood Control District of Maricopa County (FCDMC) recommended using 1.5 feet for future low-flow incisement.

3.8 Total Scour

Since pier scour has been estimated with relatively conservative methods, no safety factor was applied to the pier scour. A safety factor of 1.3 has been applied to the remaining components of the calculated scour. The final total scour for Gilbert Road Bridge is 39 feet for the 100-year flow event and 42 feet for the 500-year flow event.

Scour measurements should be counted from the bottom of the existing low-flow channel. Supporting calculation sheets are presented in Appendix B.

4. DOBSON ROAD BRIDGE

The bridge at Dobson Road is a curved bridge. We assume that there will be 9 piers, each of which is composed of a three 10-foot columns aligned parallel to the flow direction, with 140 feet between each pier (net flow width). Peak discharges after the Roosevelt Dam modifications were used for Dobson Road Bridge.

4.1 Long-Term Degradation

Simons, Li & Associates, Inc. (SLA) conducted a sediment transport and scour analysis for the reach of the Salt River from Dobson Road to the Pima Freeway, and they published an equilibrium slope of 0.00047 ft/ft in the Hydraulic and Sediment Transport Analysis Report, Salt River Bank Protection Design, South Bank Upstream of Pima Freeway, Bank STA 33+00 to 73+00, April 1994. This equilibrium slope was pivoted about Grade Control #5, which is located just downstream of McClintock Drive, approximately 2.35 miles downstream of Dobson Road Bridge.

Using this equilibrium slope and the elevation of the existing grade control structure of 1151 feet, the ultimate elevation at Dobson Road Bridge was calculated to be 1157 feet, which is higher than the current minimum channel elevation of 1147.0 at Dobson Road Bridge's location. We therefore anticipate that there will not be any long-term scour occurring at the bridge location. In other words, $Z_{deg}=0$.

4.2 General Scour and Bend Scour

For the proposed Dobson Road Bridge, both General Scour and Bend Scour were computed using Equations (2), (3) and (4) presented in section 2.1.1. An average value of the results obtained from the three equations was calculated.

The General Scour estimated for Dobson Road Bridge is 10.59 feet for the 100-year event, and 12.60 feet for the 500-year event.

4.3 Bed-form Trough Depth

Since the flow at Dobson Road Bridge is within Lower Regime Flow, the dune trough depth was estimated using the equation documented in the draft Drainage Design Manual for Maricopa County. The dune trough depth was estimated to be 1.3 feet for the 100- year flow event and 1.7 feet for the 500-year event.

4.4 Local Scour at Piers

The pier scour at the bridge was estimated using equation (5). Since the flow depth is relatively high (>30 ft), no debris effect was considered and scenario (1) in section 2.1.2.1 was applied as suggested by FCDMC. According to this equation, the scour depth at the piers is approximately 28.8 feet for the 100-year peak discharge and 31.0 feet for the 500-year peak discharge.

4.5 Local Scour at Abutments

No abutments is planned to be constructed in the main channel of the Salt River at this time. Therefore, no local scour at abutments was calculated.

4.6 Low-Flow Incisement

The Flood Control District Maricopa County (FCDMC) recommended using 1.5 feet as the future low-flow incisement.

4.7 Total Scour

Since pier scour was estimated using relatively conservative methods, no safety factor was applied to the pier scour. A safety factor of 1.3 was applied to the remaining components of the calculated scour. The final total scour for Dobson Road Bridge is 35 feet for the 100-year flow event and 38 feet for the 500-year flow event. Scour measurement should be counted from the bottom of the existing low-flow channel. Supporting calculation sheets are presented in Appendix C

5. MCKELLIPS ROAD BRIDGE

The bridge at McKellips Road is a curved bridge that crosses the north channel of the Salt River diagonally. We assume that there are 8 piers groups, each of which is composed of three 10-foot columns aligned parallel to the flow direction, with 150 feet between each pier (net flow width). Peak discharges after the Roosevelt Dam modifications were used for calculations concerning McKellips Road Bridge.

5.1 Long-Term Degradation

Downstream of McKellips Road, a grade control structure was constructed at Alma School Road to limit the impact of the sand and gravel mining downstream of Alma School Road Bridge. The top elevation of the grade control structure is 1184.98 feet, which is about the same as the minimum channel elevation at the most upstream pier location of the McKellips Road Bridge. Therefore, we anticipate that there will not be any long-term scour occurring at this bridge location. In other words, Zdeg=0.

5.2 General Scour

The General Scour was calculated using equations (2), (3) and (4) presented in section 2.1.1. No significant contraction existed at the proposed bridge location, thus contraction scour is neglected at McKellips Road Bridge.

The largest General Scour estimated for McKellips Road Bridge is at the most downstream Piers at Sta 226.835 with 8.4 feet for the 100-year event and 10.1 feet for the 500-year event.

5.3 Bed-form Trough Depth

Since the flow at McKellips Road Bridge is within Lower Regime Flow, the dune trough depth was estimated using the equation documented in the draft Drainage Design Manual for Maricopa County. The largest dune trough depth was estimated to be 1.0 foot for the 100- year flow event and 1.3 feet for the 500-year event at the most upstream piers at Sta 226.98.

5.4 Local Scour at Piers

The pier scour at the bridge was estimated using equation (5). Since the flow is relatively deep (>20 ft), no debris effect was considered and scenario (1) in section 2.1.2.1 was applied as suggested by FCDMC. Calculations resulted in a largest scour depth at the most downstream Piers of approximately 28.8 feet for the 100-year peak discharge and 31.1 feet for the 500-year peak discharge at Sta 226.835.

5.5 Local Scour at Abutments

No abutments is planned to be constructed in the main channel of the Salt River at this time. Therefore, no local scour at abutments was calculated.

5.6 Bend Scour

There is no significant bend at this bridge.

5.7 Low-Flow Incisement

The Flood Control District of Maricopa County (FCDMC) recommended using 1.5 feet for the future low-flow incisement.

5.8 Total Scour

Since pier scour was estimated using relatively conservative methods, no safety factor was applied to the pier scour. A safety factor of 1.3 was applied to the remaining components of the calculated scour. The final maximum total scour for McKellips Road Bridge is 42 feet for the 100-year flow event and 46 feet for the 500-year flow event at sta 226.835. Scour measurements should be counted from the bottom of the existing low-flow channel. Supporting calculation sheets are presented in Appendix D.

6. SUMMARY RESULTS

The following table summarizes the scour analysis results for the three bridges. The values shown in the table are the scour depths in feet for the different component of scour for both 100-year and 500-year storm events.

Table 1. Summary of the bridge scour results

Scour Type	Gilbert Road Bridge		Dobson Road Bridge		McKellips Road Bridge*	
	100-yr	500-yr	100-yr	500-yr	100-yr	500-yr
Long term scour	0	0	0	0	0	0
General scour	5.2	6.1	10.6	12.6	8.4	10.1
Pier local scour	30.3	32.1	23.1	24.9	28.8	31.1
Bed-form scour	0.25	0.25	1.3	1.7	0.32	0.29
Low-flow incisement	1.5	1.5	1.5	1.5	1.5	1.5
Total scour depth (FS = 1.3)	**39**	**42**	**41**	**45**	**42**	**46**
Min Channel⁺ Bottom Elevation	**1227.0**	**1227.0**	**1147.1**	**1147.1**	**1188.7**	**1188.7**
Scour Elevation	**1188.0**	**1185.0**	**1106.1**	**1102.1**	**1146.7**	**1142.7**

* Scour values shown at the most DS Piers at Sta 226.835

⁺ Based on the latest survey data

APPENDIX A

Parameters Determination

- **Determination of Blench's zero bed factor (F_{b0})**

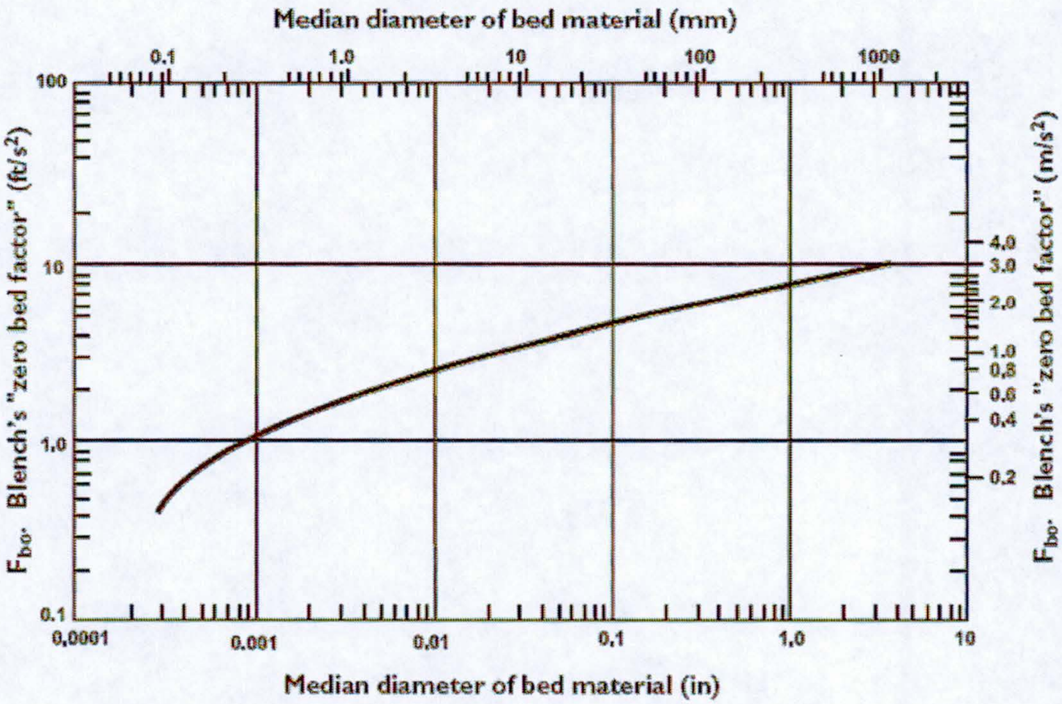


Fig. A-1 Chart for estimation of F_{b0} in Blench Equation

- **Determination of the K1 exponent in the Modified Laursen's Equation**

The value of K1 can be determined from the following procedures as per HEC-18

V_*/ω	k_1	Mode of Bed Material Transport
<0.50	0.59	Mostly contact bed material discharge
0.50 to 2.0	0.64	Some suspended bed material discharge
>2.0	0.69	Mostly suspended bed material discharge

V_* = $(\tau_o/\rho)^{½} = (gy_1\ S_1)^{½}$, shear velocity in the upstream section, m/s (ft/s)

ω = Fall velocity of bed material based on the D_{50}, m/s (Figure 5.8)
For fall velocity in English units (ft/s) multiply ω in m/s by 3.28

g = Acceleration of gravity (9.81 m/s^2) (32.2 ft/s^2)

S_1 = Slope of energy grade line of main channel, m/m (ft/ft)

τ_o = Shear stress on the bed, Pa (N/m^2) (lb/ft^2)
ρ = Density of water (1000 kg/m^3) (1.94 slugs/ft^3)

Notes:

1. Q_2 may be the total flow going through the bridge opening as in cases 1a and 1b. **It is not the total flow for Case 1c**. For Case 1c contraction scour must be computed separately for the main channel and the left and/or right overbank areas.

2. Q_1 is the flow in the main channel upstream of the bridge, not including overbank flows.

3. The Manning's n ratio is eliminated in Laursen live-bed equation to obtain Equation 5.2 (Appendix C).This was done for the following reasons. The ratio can be significant for a condition of dune bed in the upstream channel and a corresponding plane bed, washed out dunes or antidunes in the contracted channel. However, Laursen's equation does not correctly account for the increase in transport that will occur as the result of the bed planning out (which decreases resistance to flow, increases the velocity and the transport of bed material at the bridge). That is, Laursen's equation indicates a decrease in scour for this case, whereas in reality, there would be an increase in scour depth. In addition, at flood flows, a plane bedform will usually exist upstream and through the bridge waterway, and the values of Manning's n will be equal. Consequently, the n value ratio is not recommended or presented in Equation 5.2.

4. W_1 and W_2 are not always easily defined. In some cases, it is acceptable to use the topwidth of the main channel to define these widths. Whether topwidth or bottom width is used, it is important to be consistent so that W_1 and W_2 refer to either bottom widths or top widths.

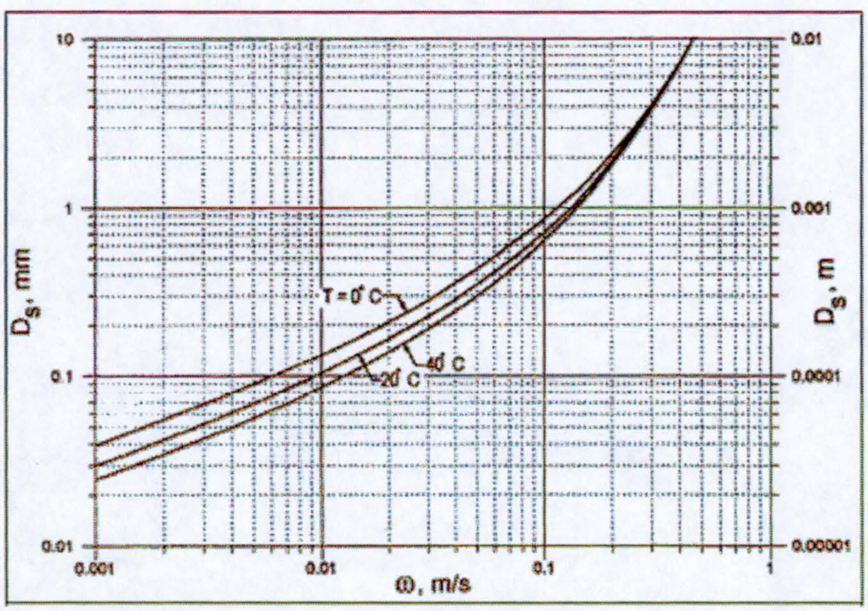


Figure 5.8. Fall velocity of sand-sized particles with specific gravity of 2.65 in metric units.

5. The average width of the bridge opening (W_2) is normally taken as the bottom width, with the width of the piers subtracted.

6. Laursen's equation will overestimate the depth of scour at the bridge if the bridge is located at the upstream end of a natural contraction or if the contraction is the result of the bridge abutments and piers. At this time, however, it is the best equation available.

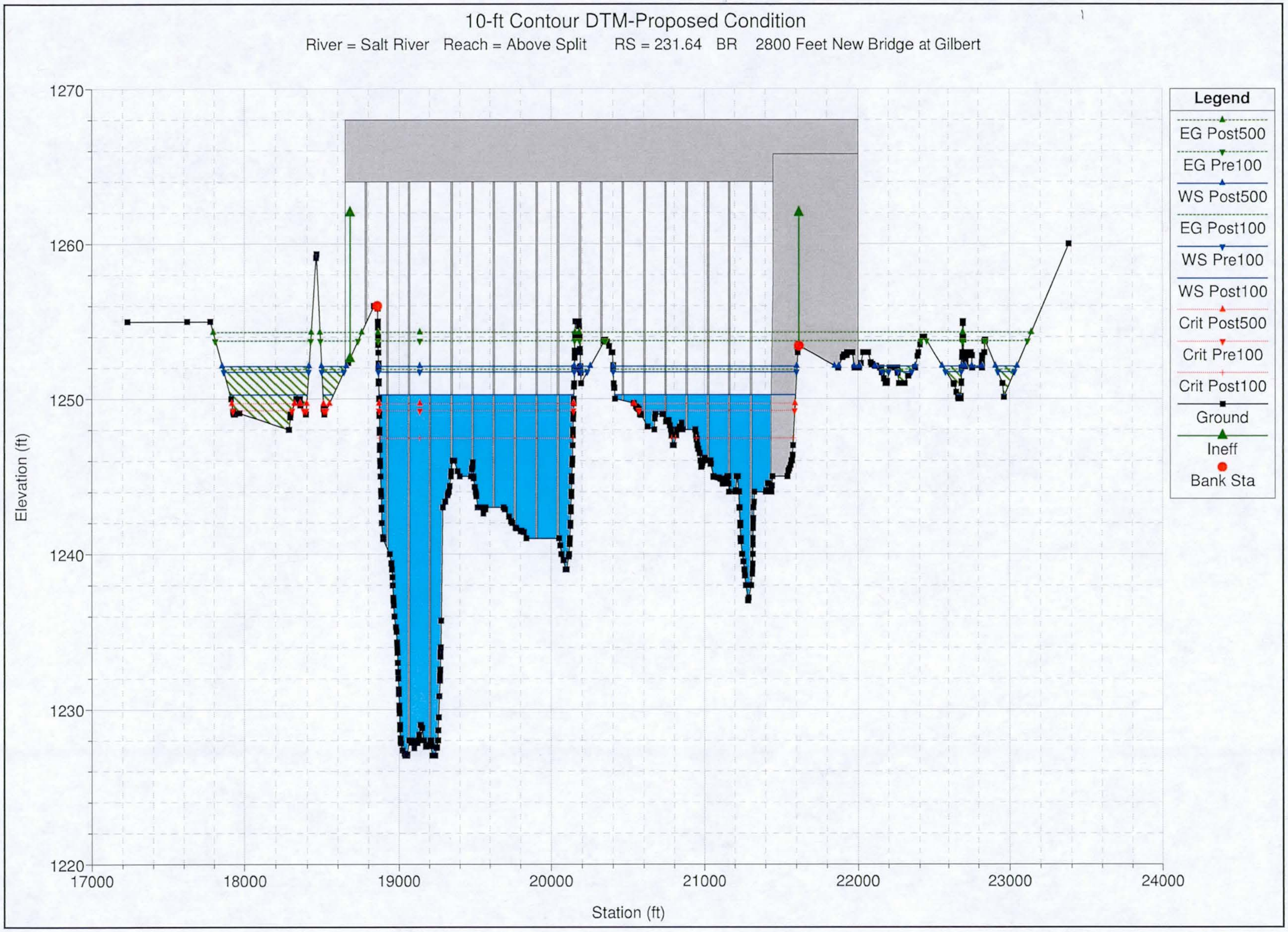
7. In sand channel streams where the contraction scour hole is filled in on the falling stage, the y_0 depth may be approximated by y_1. Sketches or surveys through the bridge can help in determining the existing bed elevation.

8. **Scour depths with live-bed contraction scour may be limited by coarse sediments in the bed material armoring the bed. Where coarse sediments are present, it is recommended that scour depths be calculated for live-bed scour conditions using the clear-water scour equation (given in the next section) in addition to the live-bed equation, and that the smaller calculated scour depth be used.**

APPENDIX B

Gilbert Road Bridge

Scour Calculation Sheets



10-ft Contour DTM-Proposed Condition
River = Salt River Reach = Above Split RS = 231.64 BR 2800 Feet New Bridge at Gilbert
Legend
EG Post500
EG Pre100
WS Post500
EG Post100
WS Pre100
WS Post100
Crit Post500
Crit Pre100
Crit Post100
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
1270
1260
1250
1240
1230
1220
17000
18000
19000
20000
21000
22000
23000
24000

Gilbert Road Bridge

Primatech, LLC

Modified: 10/14/2008

Computed by Xin Zhou

Updated by:THT

Assume: 10-ft Pier Column, 3 Pier Collum Group 10-ft Drill Shaft

Data Obtained from HEC-RAS Model:

River Station 231.67

Return Yrs	Q(cfs)	WSE	Min Ch El	Y1(ft)	Fr1 Ch	Vel Ch	Flow A	Top W
Post 100	175,000	1252.13	1240.91	11.22	0.62	9.71	19206	3601
Post 500	250,000	1253.89	1240.91	12.98	0.63	10.92	24165	4516

Calculated info

Ave. W	Hyd. D	qf
1711.76	5.33	102.23
1861.71	5.35	134.29

Local Pier Scour Calculation:

Return Yrs	Q(cfs)	Debris	Y_1(ft)	K_1	K_2*	K_3	K_4	a(ft)	Fr_1 Ch	$(Y_1/a)^{0.35}$	$Fr_1^{0.43}$	Y_s/a	Y_s(ft)
Post 100	175,000	**Yes**	11.22	1.00	1.43	1.00	1.00	14.00	0.62	0.9254	0.8142	2.16	30.26
Post 500	250,000	**Yes**	12.98	1.00	1.43	1.00	1.00	14.00	0.63	0.9739	0.8198	2.29	32.07

* Assume 15° angle of attack

Bedform Trough Depth (Y_s):

Lower Regime Flow, Dune height $d_h = 0.066Y_h^{1.21}$, where, Y_h is hydraulic depth.

Return Yrs	Q(cfs)	Y_h(ft)	d_h(ft)	Y_s(ft)
Post 100	175,000	5.33	0.50	0.25
Post 500	250,000	5.35	0.50	0.25

Y_h is at Sta. 231.67 100-Yr

General Scour:

Surface Sediment Gradation Data for Salt River at McKellips Road from Tetra Tech 2000 report

	D50	D75	D90	D_m	D95
(mm)	9	27	48	11.25	60.00
(in)	0.35	1.06	1.89	0.44	2.36
(ft)	0.03	0.09	0.16	0.04	0.20

Method 1 - Zero bed-sediment transport equation by Blench:

$$d_{fo} = \frac{q_f^{\ 2/3}}{F_{bo}^{\ 1/3}}$$

Return Yrs	Q(cfs)	D_m(mm)	q_f(sf/s)	$F_{bo}(ft/s^2)$	d_{fo}(ft)	Z -Blench	Y_s(ft)-B
Post 100	175,000	11.25	102.23	3.30	14.69	0.60	8.81
Post 500	250,000	11.25	134.29	3.30	17.61	0.60	10.57

Method 2 - Emperical Regime Equation by Lacey

$$d_m = 0.47 \left(\frac{Q}{f}\right)^{1/3}$$

Return Yrs	Q(cfs)	D_m(mm)	f	dm (ft)	Z factor	Y_s(ft)-L
Post 100	175,000	11.25	5.90	14.55	0.25	3.64
Post 500	250,000	11.25	5.90	16.38	0.25	4.10

Method 3 - Emperical Regime Equation by Neill

$$d_f = d_i \left(\frac{q_f}{q_i}\right)^m$$

Qi (cfs) = bankfull discharge = The 10-year flow rate = 58000 cfs

Flow Ai = 8623.32 sq. ft from HEC-RAS

Max. Channel Depth, di_{max} = 7.23 ft from HEC-RAS

Ave. Width, Bi = 1192.71 ft

Top Width, Ti = 2326.54 ft from HEC-RAS

m = 0.67

di (ft) = flow area/top width = 3.71

Return Yrs	Q(cfs)	q_f(sf/s)	qi(sf/s)	df	Z factor	Y_s(ft)-N
Post 100	175,000	102.23	49	6.10	0.50	3.05
Post 500	250,000	134.29	49	7.32	0.50	3.66

The General Scour will be computed as the average of Blench, Lacy and Neill scour values

Post 100 General Scour =	**5.17**	ft
Post 500 General Scour =	**6.11**	ft

Long Term Scour:

Grade Control Structure will be constructed just downstream of Gilbert Road Bridge
Long Term Scour is considered to be not applicable at Gilbert Road Bridge.

Low-Flow Incisement:

Scour measurement will count from bottom of the existing low-flow channel to take care of low-flow incisement

Use 1.50

Total Scour:

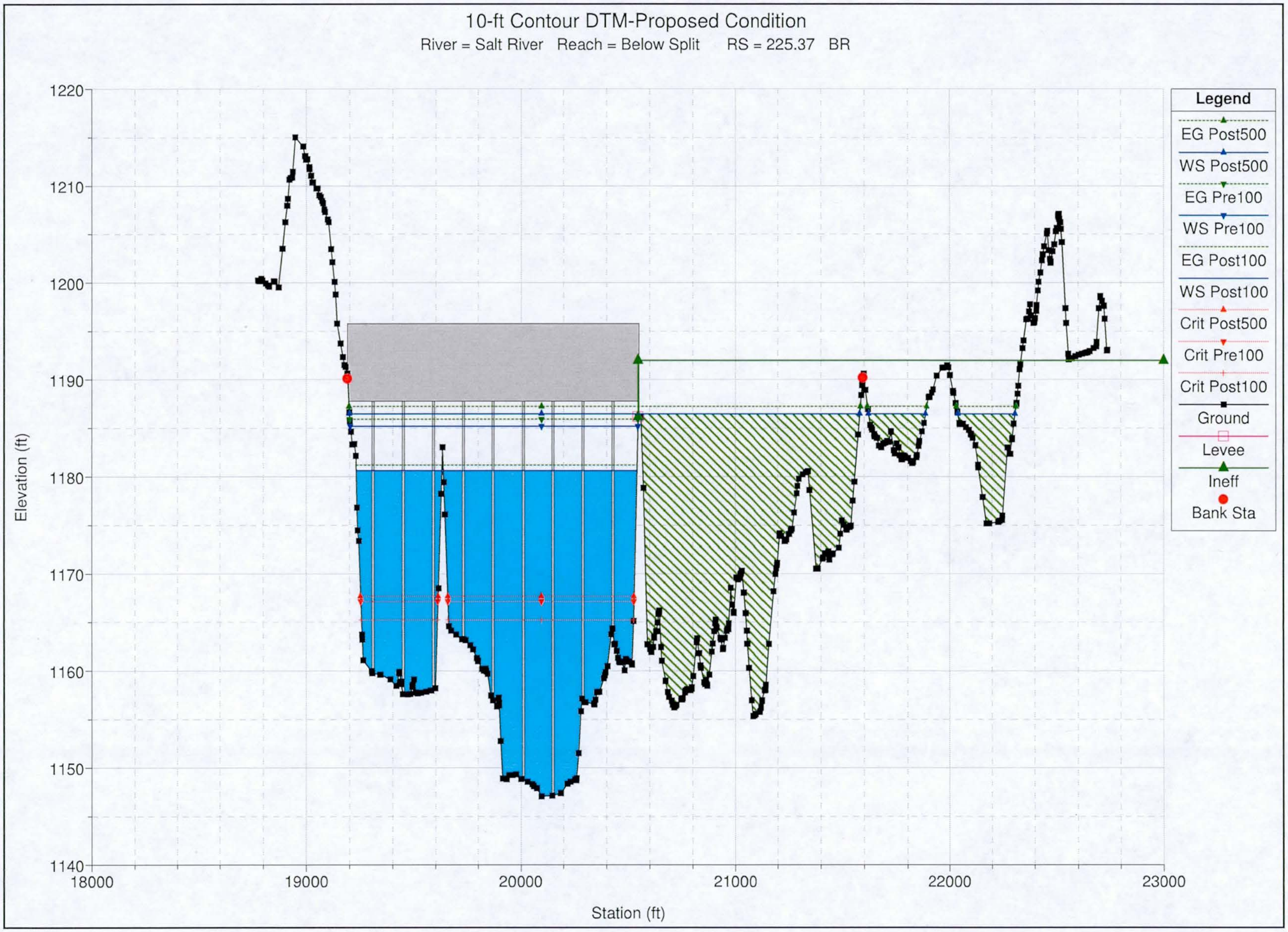
With Fs=1.3 For Non Pier Scour Components

Return Yrs	Q(cfs)	Ys (ft)
Post 100	175,000	**39**
Post 500	250,000	**42**

APPENDIX C

Dobson Road Bridge

Scour Calculation Sheets



10-ft Contour DTM-Proposed Condition
River = Salt River Reach = Below Split RS = 225.37 BR
Elevation (ft)
Station (ft)
1220
1210
1200
1190
1180
1170
1160
1150
1140
18000
19000
20000
21000
22000
23000
Legend
EG Post500
WS Post500
EG Pre100
WS Pre100
EG Post100
WS Post100
Crit Post500
Crit Pre100
Crit Post100
Ground
Levee
Ineff
Bank Sta

Dobson Road Bridge

Primatech, LLC

Modified: 10/14/2008

Computed by Xin Zhou

Updated by:THT

Data Obtained from HEC-RAS:

River Station 225.384

Return Yrs	Q(cfs)	WSE	Min Ch El	Y_1(ft)	Fr_1 Ch	Vel Ch	Flow A	Top W
Post 100	**172,000**	1178.57	1147.40	31.17	0.24	6.34	27150	1297
Post 500	**246,000**	1184.10	1147.40	36.70	0.25	7.14	34443	1340

Calculated info

Ave. W	Hyd. D	qf
871.04	20.94	197.47
938.50	25.70	262.12

Pier Scour Calculation:

Assume: Pier Diameter=10 ft, 3 Pier Collum Group 10-ft Drill Shaft

Return Yrs	Q(cfs)	Debris	Y_1(ft)	K_1	K_2*	K_3	K_4	a(ft)	Fr_1 Ch	$(Y_1/a)^{0.35}$	$Fr_1^{0.43}$	Y_s/a	Y_s(ft)
Post 100	172,000	**N/A**	31.17	1.00	1.43	1.00	1.00	10.00	0.24	1.4887	0.5414	2.31	23.12
Post 500	246,000	**N/A**	36.70	1.00	1.43	1.00	1.00	10.00	0.25	1.5763	0.5510	2.49	24.92

* Assume 15° angle of attack

Bedform Trough Depth (Y_s):

Lower Regime Flow, Dune height $d_h = 0.066Y_h^{1.21}$, where, Y_h is hydraulic depth.

Return Yrs	Q(cfs)	Y_h(ft)	d_h(ft)	Y_s(ft)
Post 100	172,000	20.94	2.62	1.31
Post 500	246,000	25.70	3.35	1.68

General Scour:

Surface Sediment Gradation Data for Salt River at McKellips Road from Tetra Tech 2000 report

	D50	D75	D90	D_m
(mm)	9	27	48	11.25
(in)	0.35	1.06	1.89	0.44
(ft)	0.03	0.09	0.16	0.04

Method 1 - Zero bed-sediment transport equation by Blench:

$$d_{fo} = \frac{q_f^{2/3}}{F_{bo}^{1/3}}$$

$Q(cfs)$	$D_m(mm)$	$q_f(sf/s)$	$F_{bo}(ft/s^2)$	$d_{fo}(ft)$	Z -Blench	$Y_s(ft)$-B
172,000	11.25	197.47	3.30	22.78	0.60	13.67
246,000	11.25	262.12	3.30	27.51	0.60	16.51

Method 2 - Emperical Regime Equation by Lacey

$$d_m = 0.47 \left(\frac{Q}{f}\right)^{1/3}$$

Return Yrs	$Q(cfs)$	$D_m(mm)$	f	dm (ft)	Z factor	$Y_s(ft)$-L
Post 100	172,000	11.25	5.90	14.46	0.50	7.23
Post 500	246,000	11.25	5.90	16.29	0.50	8.15

Method 3 - Emperical Regime Equation by Neil

$$d_f = d_i \left(\frac{q_f}{q_i}\right)^m$$

Qi (cfs) = bankfull discharge = The 10-year flow rate = 58000 cfs

Flow Ai = 13108.96 sq. ft from HEC-RAS

Max. Channel Depth, di_{max} = 20.08 ft from HEC-RAS

Ave. Width, Bi = 652.84 ft

Top Width, Ti = 1234.99 ft from HEC-RAS

m = 0.67

di (ft) = flow area/top width = 10.61

Return Yrs	$Q(cfs)$	$q_f(sf/s)$	qi(sf/s)	df	Z factor	$Y_s(ft)$-N
Post 100	172,000	197.47	89	18.13	0.60	10.88
Post 500	246,000	262.12	89	21.91	0.60	13.15

The General Scour will be computed as the average of Blench, Lacy and Neill scour values

Post 100 General Scour =	**10.59**	ft
Post 500 General Scour =	**12.60**	ft

Long Term Scour:

McClintock Drive Grade Control Structure (#5) Elevation: 1147.00

River Distance from the Structure at Cross-Section 223.02 to Dobson Road Bridge at Cross-Section 225.37 is: 12408 ft

Use the Equilibrium Slope of 0.00047 ft/ft, published in 1994 SLA report, which was pivoted about Grade Control #5 located just DS of McClintock Drive.

The generated elevation at Dobson Road Bridge should be: 1152.83 > Min Channel Elevation of 1147.40 at Dobson Road Bridge

Long Term Scour is considered to be not applicable at Dobson Road Bridge.

Low-Flow Incisement:

Scour measurement will count from bottom of the existing low-flow channel to take care of low-flow incisement.

Use 1.5

Total Scour:

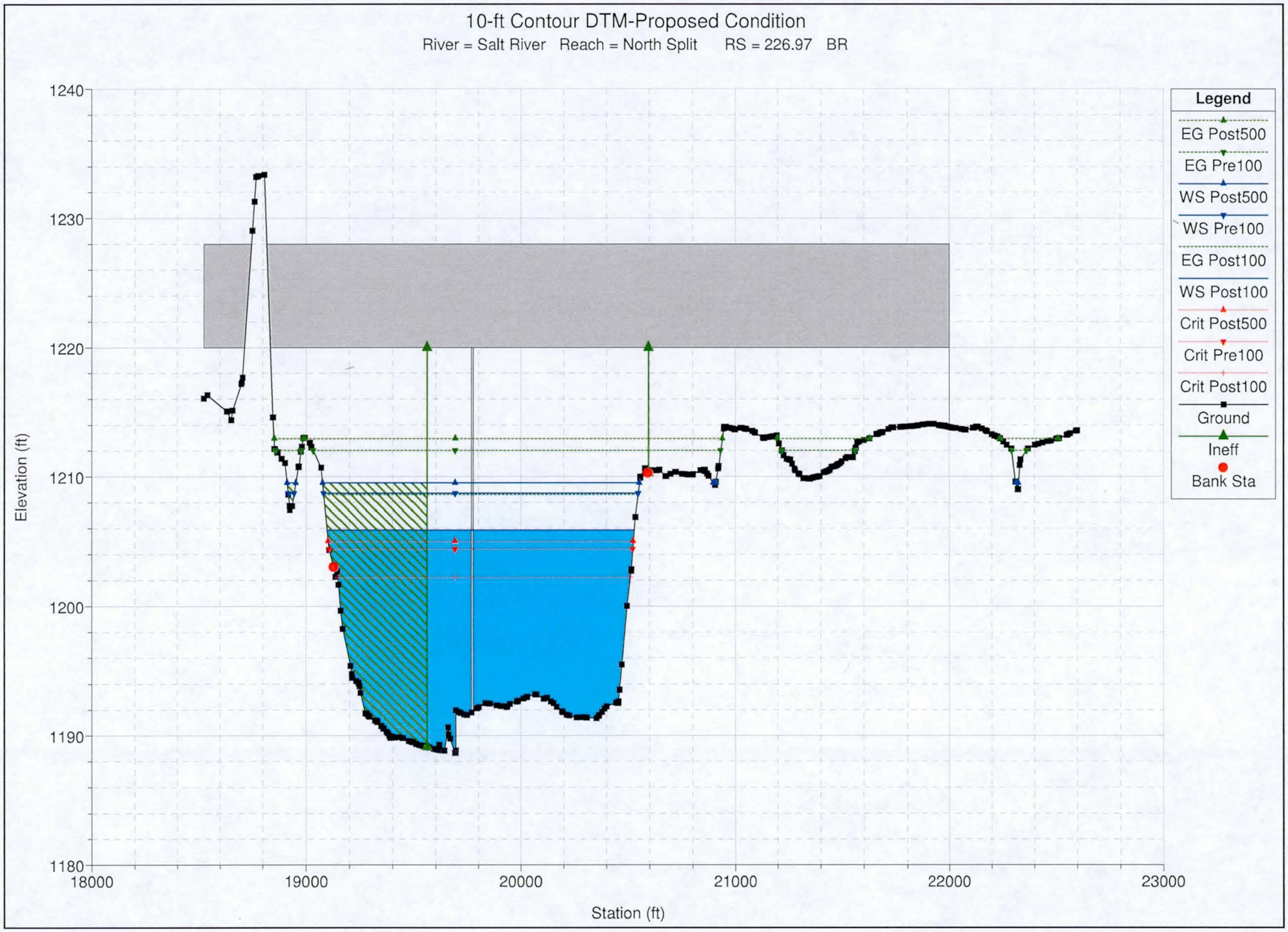
With Fs=1.3 for Non-Local Scour

Return Yrs	Q(cfs)	Ys (ft)
Pre 100	172,000	**41**
Pre 500	246,000	**45**

APPENDIX D

McKellips Road Bridge

Scour Calculation Sheets



10-ft Contour DTM-Proposed Condition
River = Salt River Reach = North Split RS = 226.97 BR
Elevation (ft)
Station (ft)
1240
1230
1220
1210
1200
1190
1180
18000
19000
20000
21000
22000
23000
Legend
EG Post500
EG Pre100
WS Post500
WS Pre100
EG Post100
WS Post100
Crit Post500
Crit Pre100
Crit Post100
Ground
Ineff
Bank Sta

McKellips Road Bridge Modeling Option 1
Multiple Single Pier Bridges

Primatech, LLC

Modified: 10/14/2008

Computed by Xin Zhou

Updated by:THT

Data Obtained from HEC-RAS:

Most US Pier
River Station 226.98

Return Yrs	Q(cfs)	WSE	Min Ch El	Y_1(ft)	Fr_1 Ch	Vel Ch	Flow A	Top W
Post 100	172,000	1204.24	1185.00	19.24	0.53	11.85	14515	1628
Post 500	246,000	1208.30	1185.00	23.30	0.55	13.35	18431	2336

Calculated info

Ave. W	Hyd. D	qf
754.42	8.92	227.99
791.03	7.89	310.99

Middle Pier
River Station 226.92

Return Yrs	Q(cfs)	WSE	Min Ch El	Y_1(ft)	Fr_1 Ch	Vel Ch	Flow A	Top W
Post 100	172,000	1203.84	1182.82	21.02	0.54	11.49	14964	2147
Post 500	246,000	1208.03	1182.82	25.21	0.53	12.62	19486	3196

Ave. W	Hyd. D	qf
711.89	6.97	241.61
772.95	6.10	318.26

Most DS Pier
River Station 226.84

Return Yrs	Q(cfs)	WSE	Min Ch El	Y_1(ft)	Fr_1 Ch	Vel Ch	Flow A	Top W
Post 100	172,000	1203.13	1179.94	23.19	0.51	11.28	15245	2353
Post 500	246,000	1207.29	1179.94	27.35	0.53	12.63	19474	3254

Ave. W	Hyd. D	qf
657.40	6.48	261.64
712.03	5.98	345.49

Local Pier Scour Calculation:

Assume: Pier Diameter = 6 ft, 3 Pier Collum Grou| 10-ft Drill Shaft

Most US Pier **River Station 226.98**

Return Yrs	Q(cfs)	Debris	Y_1(ft)	K_1	K_2*	K_3	K_4	a(ft)	Fr_1 Ch	$(Y_1/a)^{0.35}$	$Fr_1^{0.43}$	Y_s/a	Y_s(ft)
Post 100	172,000	N/A	19.24	1.00	1.43	1.00	1.00	10.00	0.53	1.2574	0.7611	2.75	27.46
Post 500	246,000	N/A	23.30	1.00	1.43	1.00	1.00	10.00	0.55	1.3445	0.7733	2.98	29.83

* Assume 15° angle of attack

Middle Pier **River Station 226.92**

Return Yrs	Q(cfs)	Debris	Y_1(ft)	K_1	K_2*	K_3	K_4	a(ft)	Fr_1 Ch	$(Y_1/a)^{0.35}$	$Fr_1^{0.43}$	Y_s/a	Y_s(ft)
Post 100	172,000	N/A	21.02	1.00	1.43	1.00	1.00	10.00	0.54	1.2969	0.7672	2.85	28.55
Post 500	246,000	N/A	25.21	1.00	1.43	1.00	1.00	10.00	0.53	1.3821	0.7611	3.02	30.18

* Assume 15° Angle of Attach

Most DS Pier **River Station 226.835**

Return Yrs	Q(cfs)	Debris	Y_1(ft)	K_1	K_2*	K_3	K_4	a(ft)	Fr_1 Ch	$(Y_1/a)^{0.35}$	$Fr_1^{0.43}$	Y_s/a	Y_s(ft)
Post 100	172,000	N/A	23.19	1.00	1.43	1.00	1.00	10.00	0.51	1.3423	0.7486	2.88	28.83
Post 500	246,000	N/A	27.35	1.00	1.43	1.00	1.00	10.00	0.53	1.4221	0.7611	3.11	31.05

* Assume 15° Angle of Attach

Bedform Trough Depth (Y_s):

Lower Regime Flow, Dune height $d_h = 0.066 Y_h^{1.21}$, where, Y_h is hydraulic depth.

River Station	Return Yrs	Q(cfs)	Y_h(ft)	d_h(ft)	Y_s(ft)
226.98	**Post 100**	172,000	8.92	0.93	0.47
	Post 500	246,000	7.89	0.80	0.40
226.92	**Post 100**	172,000	6.97	0.69	0.35
	Post 500	246,000	6.10	0.59	0.29
226.835	**Post 100**	172,000	6.48	0.63	0.32
	Post 500	246,000	5.98	0.58	0.29

General Scour:

No Significant Contraction Exist, so that Contraction Scour is considered to be not applicable at McKellips Road Bridge.

Surface Sediment Gradation Data for Salt River at McKellips Road from Tetra Tech 2000 report

	D50	D75	D90	D_m
(mm)	9	27	48	11.25
(in)	0.35	1.06	1.89	0.44
(ft)	0.03	0.09	0.16	0.04

Method 1 - Zero bed-sediment transport equation by Blench:

$$d_{fo} = \frac{q_f^{2/3}}{F_{bo}^{1/3}}$$

Q(cfs)	D_m(mm)	q_f(sf/s)	F_{bo}(ft/s^2)	d_{fo}(ft)	Z -Blench	Y_s(ft)-B
172,000	11.25	261.64	3.30	27.48	0.60	16.49
246,000	11.25	345.49	3.30	33.07	0.60	19.84

Method 2 - Emperical Regime Equation by Lacey

$$d_m = 0.47 \left(\frac{Q}{f}\right)^{1/3}$$

Return Yrs	Q(cfs)	D_m(mm)	f	dm (ft)	Z factor	Y_s(ft)-L
Post 100	172,000	11.25	5.90	14.46	0.25	3.62
Post 500	246,000	11.25	5.90	16.29	0.25	4.07

Method 3 - Emperical Regime Equation by Neil

$$d_f = d_i \left(\frac{q_f}{q_i}\right)^m$$

m = 0.67

Qi (cfs) = bankfull discharge = The 10-year flow rate = 58000 cfs

Flow Ai = 7877.85 sq. ft from HEC-RAS

Max. Channel Depth, di_{max} = 15.62 ft from HEC-RAS

Ave. Width, Bi = 504.34 ft

Top Width, Ti = 1308.40 ft from HEC-RAS

di(ft) = flow area/top width = 6.02

Return Yrs	Q(cfs)	q_f(sf/s)	qi(sf/s)	df	Z factor	Y_s(ft)-N
Post 100	172,000	261.64	115	10.44	0.50	5.22
Post 500	246,000	345.49	115	12.58	0.50	6.29

The General Scour will be computed as the average of Blench, Lacy and Neill scour values

Post 100	**General Scour =**	**8.44**	ft
Post 500	**General Scour =**	**10.07**	ft

Long Term Scour:

Alma School Drop Structure Elevati 1184.98 . = Min Channel Elevation at the most upstream pier of 1185
Long Term Scour is considered to be not applicable at McKellips Road Bridge.

Low-Flow Incisement:

Scour measurement will count from bottom of the existing low-flow channel to take care of low-flow incisement.

Use 1.50

Total Scour:

With Fs=1.3

River Station	Return Yrs	Q(cfs)	Ys (ft)
226.98	Post 100	172,000	**41**
	Post 500	246,000	**45**
226.92	Post 100	172,000	**42**
	Post 500	246,000	**46**
226.835	Post 100	172,000	**42**
	Post 500	246,000	**46**