

CE 717 RIVER MECHANICS

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Homework #5 – River Engineering and Physical Modeling - Chapters 9 & 10 due May 5, 2009

Problem #1 (100%)

Consider the reach of the Choctaw Bar reach of the Mississippi River described in Case Study 9.3 (RM p. 330-332). Your firm is considering the design of a physical model to determine the sediment accumulation in the vicinity of the chute cutoff. Explore the feasibility of building a physical model with mobile-bed for the reach shown on p. 331.

Examine the attached cross section data and bed particle size distribution. Those measurements are located downstream of the site but can be considered representative of the Mississippi River near Choctaw Bar. You simply need to get an estimate of the flow width, depth and mean flow velocity at a discharge of about 1,000,000 cfs. In terms of sediment transport you are interested in the median diameter of the bed material, which you can estimate from the samples attached - for instance the data from February 27 may be appropriate.

Determine the following:

- 1) Estimate a representative top width, mean flow depth and mean flow velocity for this reach.
 - 2) Also determine a representative grain size for the bed material.
 - 3) What are the similitude criteria for your model?
 - 4) How many degrees of freedom do you have and what are the parameters that you select?
 - 5) Provide a table with the lengths, widths and depths for your model, prototype and ratio;
 - 6) What type of granular material (size and density) would you use in your model;
 - 7) What would be the model discharge, and would your model be possible if the outdoor flat space available is 800ft x 1200 ft;
 - 8) Is your model distorted and/or tilted;
 - 9) What are the time scales for the flow and sediment transport; and
 - 10) Do you expect the bedforms to be the same in the model and prototype.
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Table B.8. ADCP flow velocity and direction data at Tarbert.

February 27, 1998											
Distance from the Right Bank (ft)											
1417		2204		2797		3409					
Depth	Vel.	Q Dir.	Depth	Vel.	Q Dir.	Depth	Vel.	Q Dir.	Depth		
7.05	3.87	258.109	7.05	8.00	249.097	7.05	5.23	250.020	7.05	5.13	255.262
8.69	4.05	259.127	8.69	8.47	247.737	8.69	5.90	248.057	8.69	4.80	251.070
10.34	4.22	252.904	10.34	7.87	246.481	10.34	5.25	246.557	10.34	4.84	255.446
11.98	3.76	257.054	11.98	8.01	244.789	11.98	4.77	248.696	11.98	4.21	249.773
13.62	3.72	258.650	13.62	8.17	248.493	13.62	4.60	246.361	13.62	4.28	252.357
15.26	3.61	257.556	15.26	8.09	248.867	15.26	5.17	241.517	15.26	4.41	254.113
16.90	3.68	260.152	16.90	8.35	246.819	16.90	4.66	243.922	16.90	4.44	247.829
18.54	3.47	264.187	18.54	7.75	247.496	18.54	4.27	245.129	18.54	4.34	247.290
20.18	3.73	256.208	20.18	7.43	245.416	20.18	4.43	246.969	20.18	4.31	252.407
21.82	3.78	258.895	21.82	7.75	247.856	21.82	4.43	245.616	21.82	4.09	255.015
23.46	3.04	261.564	23.46	7.10	246.457	23.46	4.17	249.898	23.46	4.32	257.093
25.10	3.66	252.394	25.10	7.57	248.139	25.10	4.59	257.396	25.10	4.33	257.217
26.74	3.36	251.370	26.74	7.72	249.401	26.74	4.37	253.416	26.74	4.27	248.084
28.38	3.48	251.548	28.38	8.09	248.130	28.38	4.43	250.144	28.38	4.27	249.629
30.02	3.61	257.974	30.02	7.59	245.640	30.02	4.36	256.142	30.02	4.11	249.947
31.66	3.57	248.736	31.66	7.74	246.741	31.66	4.25	253.356	31.66	4.62	249.958
33.30	3.44	248.837	33.30	7.79	245.886	33.30	3.82	250.803	33.30	4.69	248.942
34.94	3.28	248.699	34.94	7.57	247.701	34.94	3.87	253.040	34.94	4.74	247.572
36.58	3.42	266.424	36.58	7.95	245.720	36.58	4.73	253.465	36.58	4.92	246.395
38.22	3.47	252.834	38.22	7.98	250.448	38.22	4.56	246.937	38.22	4.37	246.417
39.86	3.11	254.337	39.86	7.51	247.357	39.86	4.48	246.779	39.86	4.41	247.272
41.50	3.45	254.429	41.50	7.77	247.767	41.50	4.10	252.392	41.50	3.64	243.366
43.15	3.28	256.422	43.15	7.91	247.351	43.15	4.29	247.262	43.15	3.68	244.897
44.79	2.86	254.370	44.79	7.68	243.172	44.79	4.30	246.446	44.79	3.43	230.398
46.43	2.78	251.309	46.43	7.28	244.289	46.43	4.46	249.567	46.43	3.08	261.353
48.07	3.11	255.100	48.07	5.08	239.011	48.07	4.01	253.135			
49.71	2.89	250.968				49.71	3.58	259.554			
51.35	2.43	265.037				51.35	2.66	277.230			
52.99	1.50	242.090				52.99	2.11	236.359			
54.63	1.57	245.258									

March 23, 1998											
Distance from the Right Bank (ft)											
1368		2169		3023		3378					
Depth	Vel.	Q Dir.	Depth	Vel.	Q Dir.	Depth	Vel.	Q Dir.	Depth		
7.05	3.48	247.447	7.05	6.51	262.997	7.05	6.77	244.044	7.05	6.50	248.177
8.69	3.57	247.182	8.69	6.64	261.962	8.69	6.93	244.649	8.69	6.65	247.421
10.34	3.08	245.763	10.34	6.97	263.404	10.34	6.57	244.779	10.34	6.60	246.506
11.98	3.23	239.966	11.98	7.11	261.586	11.98	6.78	244.538	11.98	6.01	246.428
13.62	3.34	240.995	13.62	6.66	260.018	13.62	6.99	244.915	13.62	6.21	249.621
15.26	3.36	239.478	15.26	6.90	262.875	15.26	6.09	248.026	15.26	6.02	247.532
16.90	3.10	242.188	16.90	6.28	262.920	16.90	6.79	248.034	16.90	6.67	244.682
18.54	2.72	249.121	18.54	6.55	263.558	18.54	6.71	248.162	18.54	6.90	242.972
20.18	2.90	249.353	20.18	6.32	260.626	20.18	6.65	247.243	20.18	6.59	239.902
21.82	2.97	244.822	21.82	6.69	263.809	21.82	7.07	246.135	21.82	6.30	246.213
23.46	3.04	249.784	23.46	6.12	264.088	23.46	6.75	243.883	23.46	6.46	240.233
25.10	2.91	246.793	25.10	6.68	263.284	25.10	6.06	240.505	25.10	6.24	239.103
26.74	2.90	238.325	26.74	6.56	264.321	26.74	6.12	243.806	26.74	6.22	242.462
28.38	2.84	243.050	28.38	6.66	264.149	28.38	6.21	243.611	28.38	6.21	244.423
30.02	3.21	246.555	30.02	6.40	262.514	30.02	6.17	242.971	30.02	6.39	240.657
31.66	2.98	251.525	31.66	6.31	266.660	31.66	6.26	243.328	31.66	5.89	246.445
33.30	2.72	247.672	33.30	5.81	262.955	33.30	6.26	241.541	33.30	6.22	243.746
34.94	3.02	247.145	34.94	5.91	260.224	34.94	5.80	239.970	34.94	6.30	241.817
36.58	2.61	249.216	36.58	5.75	259.075	36.58	5.90	238.042	36.58	5.65	235.793
38.22	2.66	249.287	38.22	6.33	263.512	38.22	6.36	242.232	38.22	5.29	229.603
39.86	2.92	254.514	39.86	6.43	259.985	39.86	5.88	245.493	39.86	5.08	227.908
41.50	2.83	250.600	41.50	5.86	267.785	41.50	6.14	244.051	41.50	4.92	228.109
43.15	2.39	244.912	43.15	5.46	266.003	43.15	5.91	238.862	43.15	4.74	227.414
44.79	3.39	249.794	44.79	5.67	266.647	44.79	5.69	242.415	44.79	4.92	231.793
46.43	2.91	248.763	46.43	6.08	266.007	46.43	5.39	241.470	46.43	4.13	224.875
48.07	2.61	244.338	48.07	4.44	275.850	48.07	5.08	257.365	48.07	1.42	223.781
49.71	2.30	253.684				49.71	2.99	255.705			
51.35	2.27	253.396				51.35	2.63	206.341			
52.99	2.39	249.104				52.99	2.39	217.122			
54.63	2.36	246.644				54.63	1.92	174.027			
56.27	1.71	256.017				56.27	1.88	188.463			

April 10, 1998											
Distance from the Right Bank (ft)											
1371		2129		2730		3369					
Depth	Vel.	Q Dir.	Depth	Vel.	Q Dir.	Depth	Vel.	Q Dir.	Depth		
7.05	4.85	255.738	7.05	5.99	256.086	7.05	6.42	249.204	7.05	5.56	251.042
8.69	4.52	255.792	8.69	5.54	257.479	8.69	6.83	250.659	8.69	5.26	245.225
10.34	4.29	260.288	10.34	5.29	253.508	10.34	6.16	248.737	10.34	5.47	246.386
11.98	4.62	257.772	11.98	5.16	250.873	11.98	6.06	249.426	11.98	5.16	247.887
13.62	4.18	255.822	13.62	5.04	255.955	13.62	6.47	246.439	13.62	4.84	244.495
15.26	4.52	254.986	15.26	4.94	257.174	15.26	6.37	247.355	15.26	5.30	240.260
16.90	4.18	258.320	16.90	5.06	258.894	16.90	6.47	250.076	16.90	5.24	245.954
18.54	4.11	252.288	18.54	4.94	263.824	18.54	6.54	250.956	18.54	5.26	244.729
20.18	4.40	253.661	20.18	4.61	260.035	20.18	6.50	250.541	20.18	5.34	240.190
21.82	4.55	259.621	21.82	4.49	259.822	21.82	6.50	251.035	21.82	5.19	244.164
23.46	4.34	254.263	23.46	4.22	264.205	23.46	6.19	247.172	23.46	5.52	239.153
25.10	4.35	255.859	25.10	4.11	263.312	25.10	6.49	248.365	25.10	5.74	237.092
26.74	4.17	256.237	26.74	4.22	258.646	26.74	5.53	248.684	26.74	5.14	242.749
28.38	4.01	261.293	28.38	4.00	256.180	28.38	5.88	250.645	28.38	5.33	238.631
30.02	4.36	255.765	30.02	4.04	265.576	30.02	5.77	248.955	30.02	5.43	240.478
31.66	4.04	255.434	31.66	3.90	272.460	31.66	5.50	251.003	31.66	4.96	238.477
33.30	4.29	251.330	33.30	4.11	267.160	33.30	5.61	248.024	33.30	5.31	240.822
34.94	4.10	251.087	34.94	3.96	263.046	34.94	5.19	246.773	34.94	4.84	245.173
36.58	4.32	257.084	36.58	3.76	262.372	36.58	5.10	243.880	36.58	4.60	249.200
38.22	4.22	251.650	38.22	3.43	255.326	38.22	5.17	246.085	38.22	4.98	247.203
39.86	4.42	254.002	39.86	4.16	258.060	39.86	4.75	241.149	39.86	5.05	248.406
41.50	4.28	256.040	41.50	3.99	258.894	41.50	4.72	240.779	41.50	4.95	251.998
43.15	4.25	252.419	43.15	3.98	251.132	43.15	4.71	242.007	43.15	4.50	252.661
44.79	4.09	249.412	44.79	3.50	252.380	44.79	4.88	239.036	44.79	3.72	251.789
46.43	4.12	250.454	46.43	3.35	259.725	46.43	4.80	241.596	46.43	4.23	253.109
48.07	4.06	249.574	48.07	3.77	251.849	48.07	4.86	242.127	48.07	2.60	241.787
49.71	3.90	248.557	49.71	2.90	234.636	49.71	4.78	242.555			
51.35	4.05	246.948	51.35	2.86	254.307	51.35	4.71	236.122			
52.99	3.88	251.335	52.99	3.52	243.077	52.99	4.77	243.118			
54.63	3.98	254.737	54.63	3.23	253.000	54.63	3.80	237.916			
56.27	3.57	250.782	56.27	2.90	251.608	56.27	3.28	235.515			
57.91	3.35	249.313	57.91	2.43	254.310	57.91	2.04	246.028			
59.55	3.19	252.534	59.55	2.51	258.778						
61.19	2.36	231.999	61.19	2.14	245.592						

Table B.9. Bed material data at Union Point.

DATE: 27-FEB-98		RIVER CONDITION: GOOD										TYPE SAMPLER: DRAG BUCKET						
STREAM: MISSISSIPPI RIVER		TIME: 08:00 TO 09:00										TYPE SAMPLES: BED MATERIAL						
LOCATION: UNION POINT		TEMP: 9 C @10 FT.										NO. VERTICALS: 4						
GAGE: KNOX LANDING		WEATHER: CLOUDY AND MILD										NO. POINTS: 1						
DISCHARGE: 1,010,854 CFS (DOPPLER)		GAGE READING: 48.60 FT.																
CONVENTIONAL METHOD: 1,028,013 CFS																		
(SAMPLE)																		
FIELD NO.	1																	
DISTANCE (FT.)	1066																	
DEPTH (FT)	66																	
DIA. (MM)	25.40	19.10	12.70	9.52	4.76	3.36	2.00	1.41	1.00	0.50	0.35	0.25	0.177	0.125	0.088	0.074	0.062	PAN
CUM. WT.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.5	31.5	123.6	147.9	149.7	149.9	149.9	150
% HELD	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.3	21.0	82.4	98.6	99.8	99.9	99.9	100.0
% FINER	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.9	99.7	79.0	17.6	1.4	0.2	0.1	0.1	0.0
(SAMPLE)																		
FIELD NO.	2																	
DISTANCE (FT.)	1658																	
DEPTH (FT)	66																	
DIA. (MM)	25.40	19.10	12.70	9.52	4.76	3.36	2.00	1.41	1.00	0.50	0.35	0.25	0.177	0.125	0.088	0.074	0.062	PAN
CUM. WT.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9	7.5	52.8	116.1	124.0	124.7	124.7	124.7	124.8
% HELD	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	6.0	42.3	93.0	99.4	99.9	99.9	99.9	100.0
% FINER	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.3	94.0	57.7	7.0	0.6	0.1	0.1	0.1	0.0
(SAMPLE)																		
FIELD NO.	3																	
DISTANCE (FT.)	2256																	
DEPTH (FT)	66																	
DIA. (MM)	25.40	19.10	12.70	9.52	4.76	3.36	2.00	1.41	1.00	0.50	0.35	0.25	0.177	0.125	0.088	0.074	0.062	PAN
CUM. WT.	0.0	0.0	0.0	6.5	6.5	6.5	6.5	6.5	6.5	9.1	22.6	97.7	144.8	149.3	149.8	149.8	149.8	149.8
% HELD	0.0	0.0	0.0	4.3	4.3	4.3	4.3	4.3	4.3	6.1	15.1	65.2	96.7	99.7	100.0	100.0	100.0	100.0
% FINER	100.0	100.0	100.0	95.7	95.7	95.7	95.7	95.7	95.7	93.9	84.9	34.8	3.3	0.3	0.0	0.0	0.0	0.0
(SAMPLE)																		
FIELD NO.	4																	
DISTANCE (FT.)	2941																	
DEPTH (FT)	56																	
DIA. (MM)	25.40	19.10	12.70	9.52	4.76	3.36	2.00	1.41	1.00	0.50	0.35	0.25	0.177	0.125	0.088	0.074	0.062	PAN
CUM. WT.	0.0	15.8	39.6	58.2	100.0	137.6	236.7	268.7	274.5	338.2	380.5	392.1	393.4	393.5	393.5	393.5	393.6	393.6
% HELD	0.0	4.0	10.1	14.8	25.4	35.0	60.1	68.3	69.7	85.9	96.7	99.6	99.9	100.0	100.0	100.0	100.0	100.0
% FINER	100.0	96.0	89.9	85.2	74.6	65.0	39.9	31.7	30.3	14.1	3.3	0.4	0.1	0.0	0.0	0.0	0.0	0.0
DATE: 23-MAR-98																		
STREAM: MISSISSIPPI RIVER		RIVER CONDITION: CHOPPY										TYPE SAMPLER: DRAG BUCKET						
LOCATION: UNION POINT		TIME: 09:00 TO 11:00										TYPE SAMPLES: BED MATERIAL						
GAGE: UNION POINT		TEMP: 9 C @10 FT.										NO. VERTICALS: 4						
DISCHARGE: 1,063,325 CFS (ADCP)		WEATHER: WINDY AND MILD										NO. POINTS: 1						
		GAGE READING: 52.90 FT.																
CONVENTIONAL METHOD: 1,127,296 CFS																		
(SAMPLE)																		
FIELD NO.	5																	
DISTANCE (FT.)	1020																	
DEPTH (FT)	63																	
DIA. (MM)	25.40	19.10	12.70	9.52	4.76	3.36	2.00	1.41	1.00	0.50	0.35	0.25	0.177	0.125	0.088	0.074	0.062	PAN
CUM. WT.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	11.0	91.2	143.9	149.3	149.7	149.8	150
% HELD	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	7.3	60.8	96.0	99.6	99.9	99.9	100.0
% FINER	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.9	92.7	39.2	4.0	0.4	0.1	0.1	0.0
(SAMPLE)																		
FIELD NO.	6																	
DISTANCE (FT.)	1755																	
DEPTH (FT)	67																	
DIA. (MM)	25.40	19.10	12.70	9.52	4.76	3.36	2.00	1.41	1.00	0.50	0.35	0.25	0.177	0.125	0.088	0.074	0.062	PAN
CUM. WT.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	37.7	123.3	147.6	149.7	149.9	149.9	149.9
% HELD	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	25.2	82.3	98.5	99.9	100.0	100.0	100.0
% FINER	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.7	74.8	17.7	1.5	0.1	0.0	0.0	0.0
(SAMPLE)																		
FIELD NO.	7																	
DISTANCE (FT.)	2274																	
DEPTH (FT)	80																	
DIA. (MM)	25.40	19.10	12.70	9.52	4.76	3.36	2.00	1.41	1.00	0.50	0.35	0.25	0.177	0.125	0.088	0.074	0.062	PAN
CUM. WT.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.6	13.1	83.5	127.9	149.0	149.8	149.8	149.9
% HELD	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.4	8.7	55.7	85.3	99.4	99.9	99.9	100.0
% FINER	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.9	99.6	91.3	44.3	14.7	0.6	0.1	0.1	0.0
(SAMPLE)																		
FIELD NO.	8																	
DISTANCE (FT.)	3091																	
DEPTH (FT)	60																	
DIA. (MM)	25.40	19.10	12.70	9.52	4.76	3.36	2.00	1.41	1.00	0.50	0.35	0.25	0.177	0.125	0.088	0.074	0.062	PAN
CUM. WT.	0.0	0.0	0.0	0.0	0.0	0.0	3.2	9.7	14.9	78.6	133.7	148.3	150.1	150.5	150.6	150.6	150.6	150.7
% HELD	0.0	0.0	0.0	0.0	0.0	0.0	2.1	6.4	9.9	52.2	88.7	98.4	99.6	99.9	99.9	99.9	99.9	100.0
% FINER	100.0	100.0	100.0	100.0	100.0	100.0	97.9	93.6	90.1	47.8	11.3	1.6	0.4	0.1	0.1	0.1	0.1	0.0