Geomorphic Analysis of the Main Channel of the Golf Club of Kansas Site in Lenexa, Kansas

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This report describes the geomorphic condition and stability of the main stream channel draining the Golf Club of Kansas Site in Lenexa, Kansas. It is prepared for Olsson Associates by Dr. Robert T. Pavlowsky of the Ozarks Environmental and Water Resources Institute at Missouri State University. The information provided in this report was provided by on-line sources, Olsson Associates, and fieldwork at the site by Pavlowsky and three staff on April 11-12, 2007. This report provides data and professional opinion to support the restoration planning and channel design for the site.

Watershed History and Characteristics

The drainage area above the restoration site has been influenced by a long history of row crop agriculture and a more recent trend of urban/suburban development including significant highway road drainage (Figure 1). The Golf Club of Kansas Site itself has been subjected to a long period of limestone mining and processing with obvious pits, rock dumps, and sandy limestone screenings or tailings scattered about the site. Less disturbed valley floor areas to the east of the site (Pictures 1 and 4) appear to have a higher terrace in which the Ladoga soil series is found about 8-10' above the channel bed (Picture 2) and a middle terrace in which the Kennebec soil series is found about 4-6' above the channel bed (Picture 3). These alluvial materials are composed of silt loams with varying amounts of clay and sand (Figure 2).

Test pit logs by Bair Excavating using a back hoe show that the valley floor along the stream contains fill to a depth 5 to 14 feet composed variable amounts of limestone screenings, silty clay, and weathered limestone rock fragments. The water table ranges in depth from 7 to 11 feet along the upper two thirds of the site from station 14+00 to 28+00 ft (Figure 3). Overall, there is little, if any, natural topography or soils remaining in the valley within the project area with the exception of a limited riparian corridor area from station 21+00 upstream to the site boundary. This area is used as a reference reach to determine channel dimensions and slope for restoration designs.

Downstream Channel Conditions and Photo Log

The following channel locations and descriptions are referenced from upstream to downstream according to the survey stationing reported by Olsson Associates (Figure 3):

>30+00 ft: Adjacent property that is relatively undisturbed (Pictures 1 to 4)

30+00 to 26+00 ft: Somewhat disturbed area around the 13th green (Pictures 5 to 7)

26+00 to 20+50 ft: Reference reach with relatively intact riparian corridor (Pictures 8 to 14)

20+50 to 18+75 ft: Moderately disturbed reach

18+75 ft: Sediment control or drop structure #1 with 3-4 feet of fill behin it (Picture 15)

18-75 to 14+80 ft: Braided channel due to introduction of sandy limestone screenings from dump sites (Pictures 16 to 17).

14+80 ft: Low water bridge (Picture 18)

14+50 to 13+50 ft: Sediment control or drop structure #2 with 3 to 5 ft of fill behind it (Picture 19)

13+50 to 7+85 ft: Trapezoidal rip-rap channel with 1-3 ft diameter rock. Water begins to pool behind next drop struction at 10+00 (Pictures 20 to 21)

7+85 ft: Sediment control or drop structure # 3 with <<1 ft of fill behind it (Picture 22)

7+85 to 7+00 ft: drop structure slope

7+00 to 5+50 ft: channel in fill materials, not large rip-rap like above.

5+50 ft: Sediment control or drop structure # 4 with 1-3 ft of fill behind it (Picture 23)

5+00 to 1+50 ft: gravel and sand channel from drop structure #4 to main road culvert (Pictures 24 to 25)

0+00 ft: End of stationing downstream of main road (Picture 26)

Reference Reach Analysis

Since the majority of the channel length on the site was disturbed far beyond its natural form, it was decided that a reference reach approach would be used to determine the size and shape of the new channel. Twelve cross-sections at riffle crests from an on-site reach which had an intact riparian corridor and two cross-sections from the upstream natural area were examined in order to estimate dominant channel dimensions (Figure 3). A longitudinal profile of the bed thalweg, bankfull stage, and top of bank was used to determine slope (Figure 4). The MSU profile correlated very well with the survey performed by Olsson Associates with the reference reach having a mean slope of around 1.3 to 1.5%. Riffle beds had an average slope of around 4%.

The average bankfull channel cross-section dimensions for riffle crests for the reference reach and upstream natural area is 19 feet wide by 1.6 ft thalweg depth (Table 1). Bedrock control might narrow the channel relative to bankfull depth indicators. The average dimensions of the bankfull channel, excluding narrow cross-sections, only changes slightly to 21 ft wide and 1.8 ft deep. Given that there is little difference between the cross-section dimensions collected in the reference reach and the upstream natural area, these channel dimensions are considered to be good estimates of the dominant channel under present discharge and sediment regimes.

Pebble counts of bed material diameter were made at all the riffles for which cross-sections were measured (n=30 counts per riffle). The bed material gradations for the reference reach averaged 29 mm for the D16, 63 mm for the D50, 112 mm for the D84, and 224 mm for the maximum mobile clast (Table 2). Using the riffle slope of 4%, calculated shear stresses are capable of transporting riffle "pebbles" at bankfull flow stage (Tables 1 and 2). Even at the mean reach slope of 1.3%, the D50 of the riffle substrate is generally mobile.

The size distribution of bar tail sediments ("Rosgen cores") is much finer than the riffle bed substrate with the majority or 80% of the sediment in the very fine gravel size (2-4 mm) for the three bar samples evaluated for this study. Channel designs should assume that ample loads of very fine to medium gravel sediment will be delivered to the site from upstream and local sources. The delivery of limestone screenings from old dumps or fill loations by sheet wash and erosion to the channel presently adds excessive loads of sand to the channel. It is expected that sand loads will decrease greatly after construction is completed.

Conclusions

1. Most of the site is disturbed and there is much evidence that present channel location and form is not in a natural state downstream of station 19+00.

2. The upper portion of the restoration reach from 20+50 to 27+50 is suitable for use as a reference reach.

3. Reference reach slope averages about 1.3% and increases to 4% at riffle beds.

4. Dominant channel dimensions for the reference reach at riffle crests are 20 ft wide and 1.7 ft thalweg depth.

5. Pebble counts of riffle bed substrate diameter yield a median or D50 of 63 mm (very coarse gravel) with the maximum mobile clast size in the large cobble size (around 200 mm).

6. Complete pebble counts of grab samples collected by shovel from longitudinal bar tail deposits indicate that transport is dominated by very fine and fine gravel (<8 mm). This suggests that the bed is armored to some extent relative to the dominant sediment load of the stream. This makes sense given that riffle substrate size and shear stress appear to be in balance with riffle forms in apparent quasi-equilibrium with present conditions in most cases.

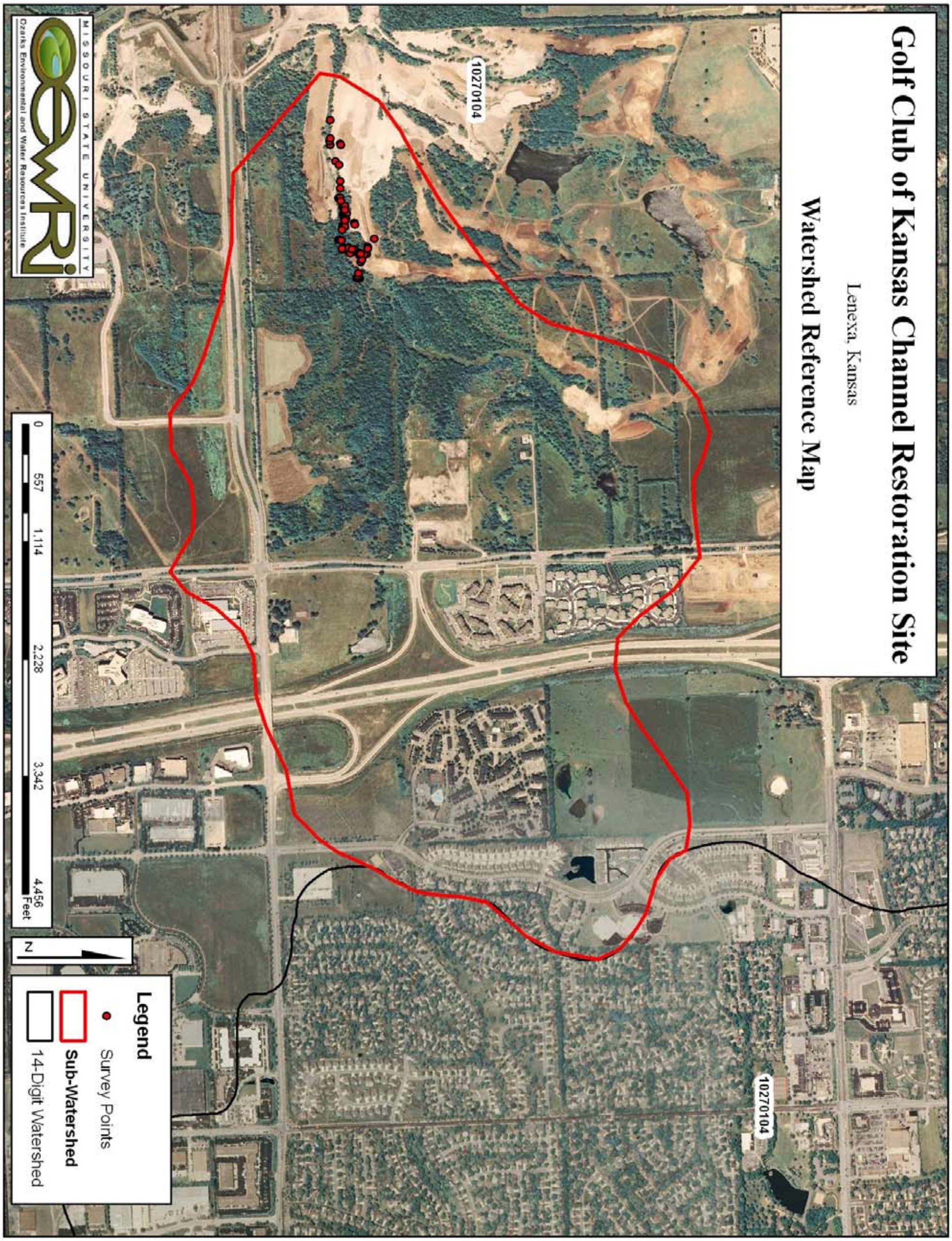


Figure 1. Channel restoration survey site watershed reference map

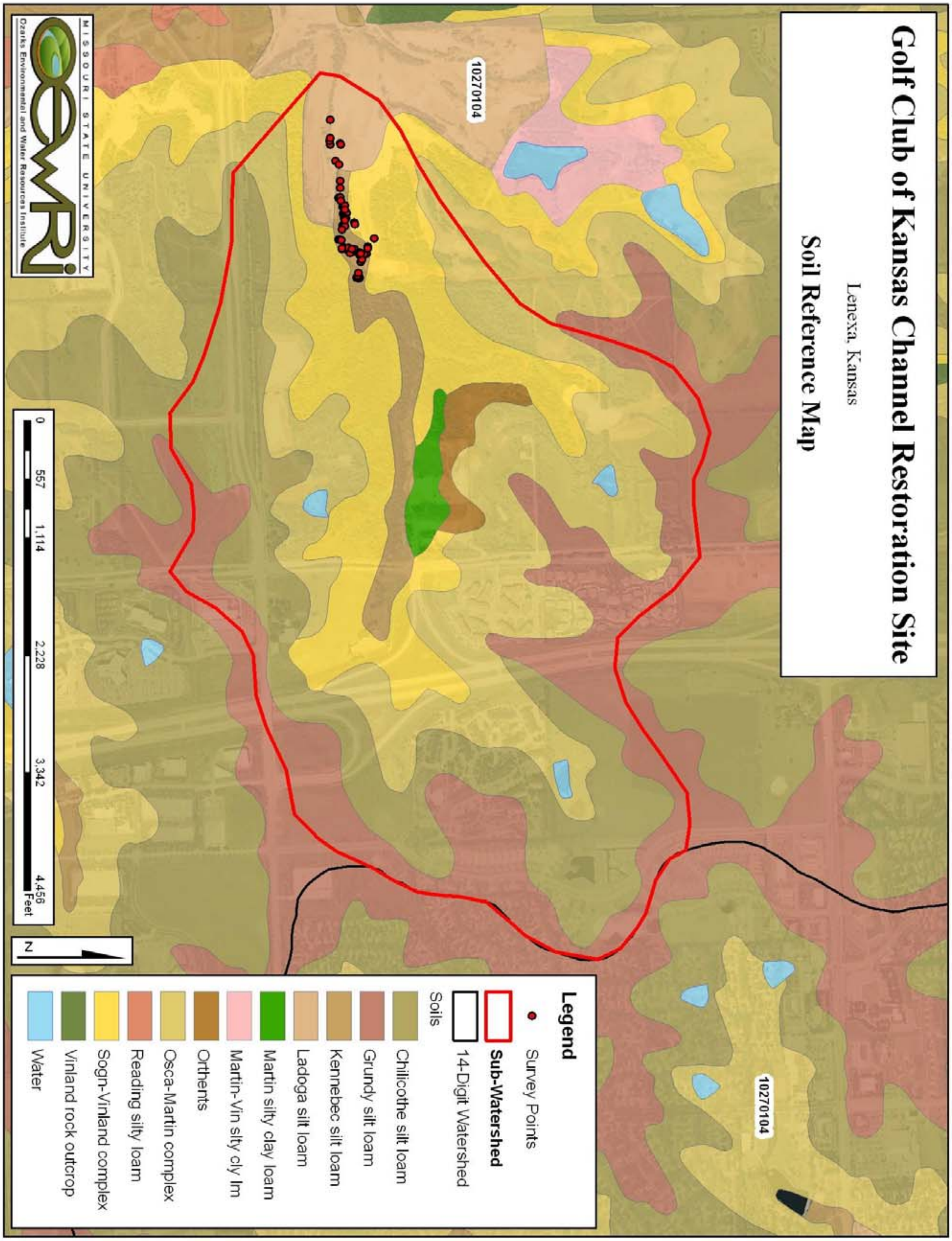


Figure 2. Channel restoration site soil reference map

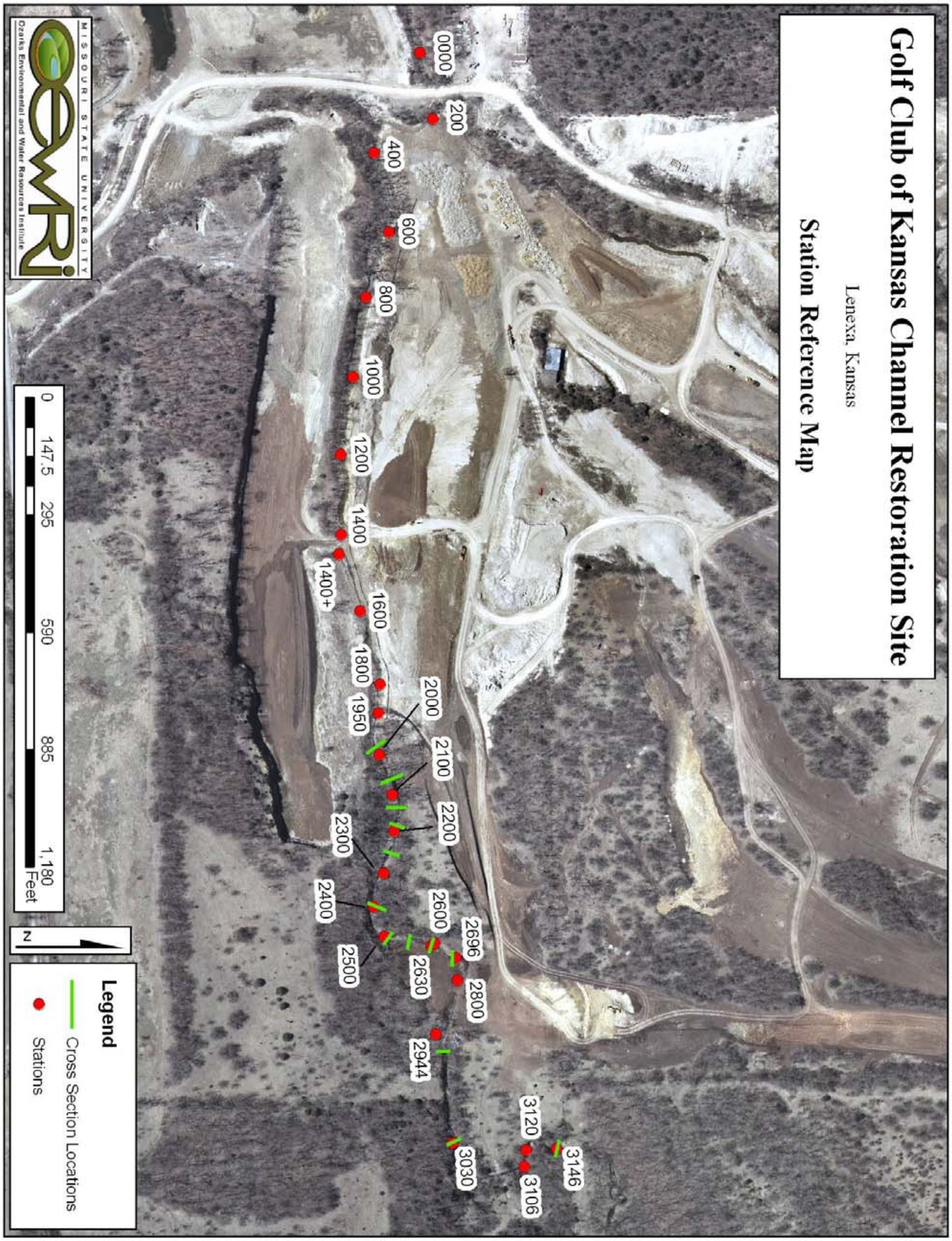


Figure 3. Channel restoration site station reference map

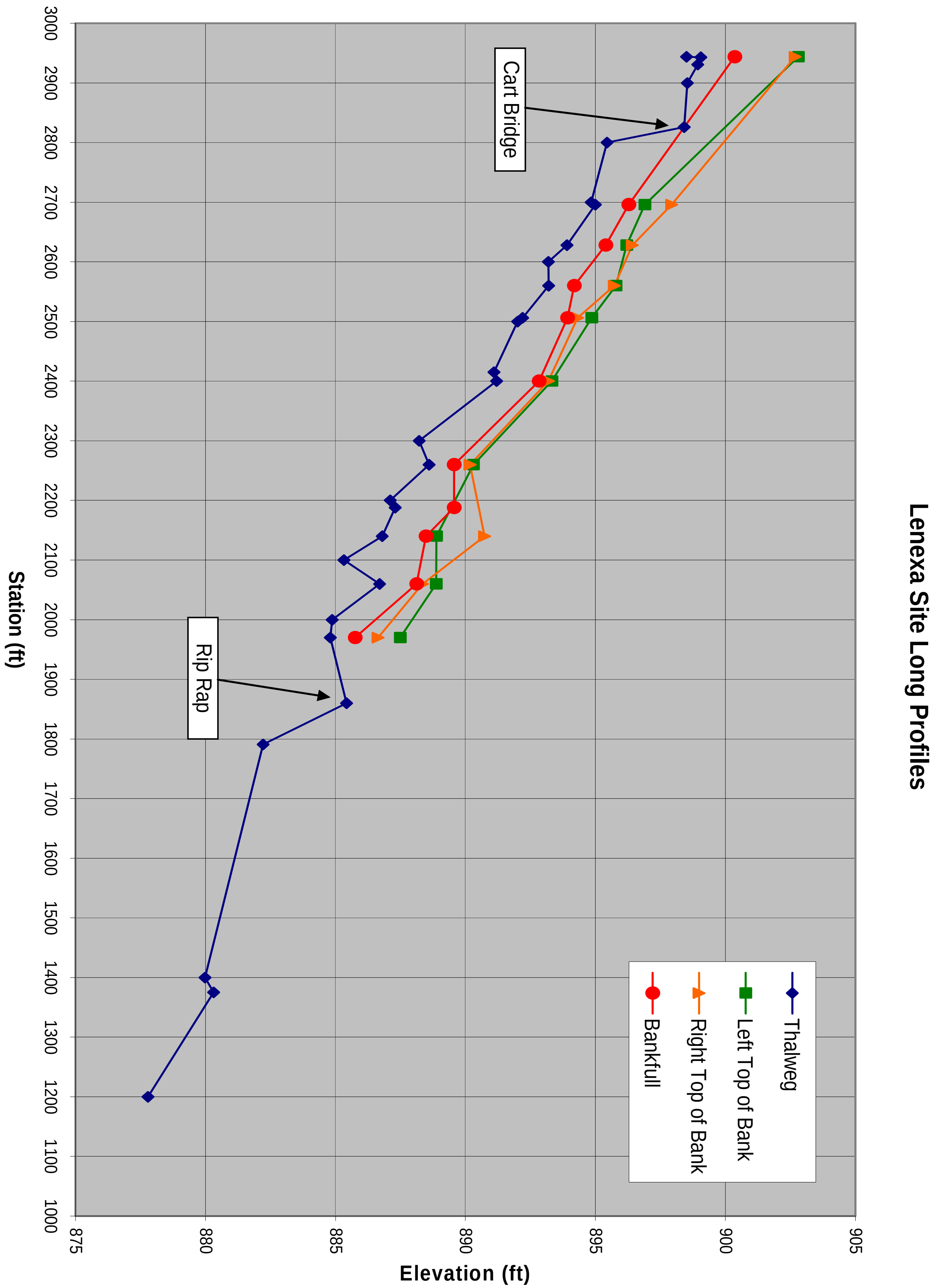


Figure 4. Longitudinal profile for the reference reach.

Table 1. Cottonwood Canyon Cross-Section Data

Sec ID Station	Width feet	D (max) feet	D (mean) feet	R feet	A $feet^2$	Wp feet	Slope ft/ft	Mannings "n"	Mean V ft/s	Q ft^3/s
1970	14.65	1.72	1.24	1.18	18.19	15.44	0.04	0.035	9.49	172.57
2060	22.04	1.62	1.07	1.03	23.66	22.89	0.04	0.035	8.70	205.90
2140	23.53	1.91	1.10	1.08	25.88	23.97	0.04	0.035	8.96	231.79
2188	18.86	1.09	0.38	0.37	7.21	19.31	0.04	0.035	4.44	32.04
2260	20.7	1.15	0.66	0.65	13.65	20.86	0.04	0.035	6.44	87.85
2400	23.88	1.66	0.96	0.93	22.9	24.62	0.04	0.035	8.12	185.88
2415	14.89	1.63	0.99	0.93	14.72	15.84	0.04	0.035	8.11	119.41
2506	19.03	1.97	1.42	1.33	27.03	20.29	0.04	0.035	10.29	278.10
2560	16.63	1.44	0.81	0.77	13.4	17.43	0.04	0.035	7.16	95.91
2628	17.41	1.35	0.86	0.85	15.02	17.69	0.04	0.035	7.64	114.79
2696	14.89	1.18	0.84	0.82	12.51	15.25	0.04	0.035	7.47	93.46
2944	19.69	1.63	1.36	1.27	26.77	21.15	0.04	0.035	9.95	266.28
3030	14.86	1.58	1.07	1.02	15.97	15.69	0.0074	0.035	3.71	59.17
3146	19.94	1.75	1.20	1.15	23.91	20.71	0.0123	0.035	5.19	124.12
mean (all)	18.64	1.55	1.00	0.96	18.63	19.37	0.0357	0.04	7.55	147.66
mean (selected)	21.35	1.76	1.19	1.13	25.03	22.27	0.0354	0.04	8.53	215.34

Table 2. Cottonwood Canyon Sediment Transport Data

Sec ID Station	Shear (lbs/ft^2)	Critical Dia (mm)[1]	Critical Dia (mm)[2]	D16 mm	D50 mm	D84 mm	Dmax mm
1970	2.94	240	336	40	65	130	186
2060	2.58	209	305	30	60	120	208
2140	2.69	219	315	26	75	100	206
2188	0.93	72	144	30	55	80	258
2260	1.63	130	218	30	60	90	210
2400	2.32	188	282	2	28	80	190
2415	2.32	187	282				
2506	3.33	273	368	20	65	120	220
2560	1.92	154	246	50	100	140	206
2628	2.12	171	264	5	45	138	260
2696	2.05	165	258	40	70	109	246
2944	3.16	259	354	45	75	129	270
3030	0.47	36	87				
3146	0.89	69	139				
mean (all)	2.10	169	257	29	63	112	224
mean (selected)	2.49	203	294	25	61	110	219

1. From Leopold, Wolman, and Miller, 1964
2. Colorado Streams from Rosgen, 1996

Picture 1. Looking upstream at distance 3146 ft.

Picture 2. Cutbank at distance 3120 (Ladoga Soil Series)

Picture 3. Cutbank at distance 3106 (Kennebec Soil Series)

Picture 4. Looking downstream at distance 3030

Picture 5. Looking downstream at distance 2944

Picture 6. Looking downstream at distance 2800

Picture 7. Looking downstream at distance 2696

Picture 8. Looking downstream at distance 2600

Picture 9. Looking downstream at distance 2500

Picture 10. Looking downstream at distance 2400

Picture 11. Looking downstream at distance 2300

Picture 12. Looking downstream at distance 2200

Picture 13. Looking downstream at distance 2100

Picture 14. Looking downstream at distance 2000

Picture 15. Looking downstream at distance 1950

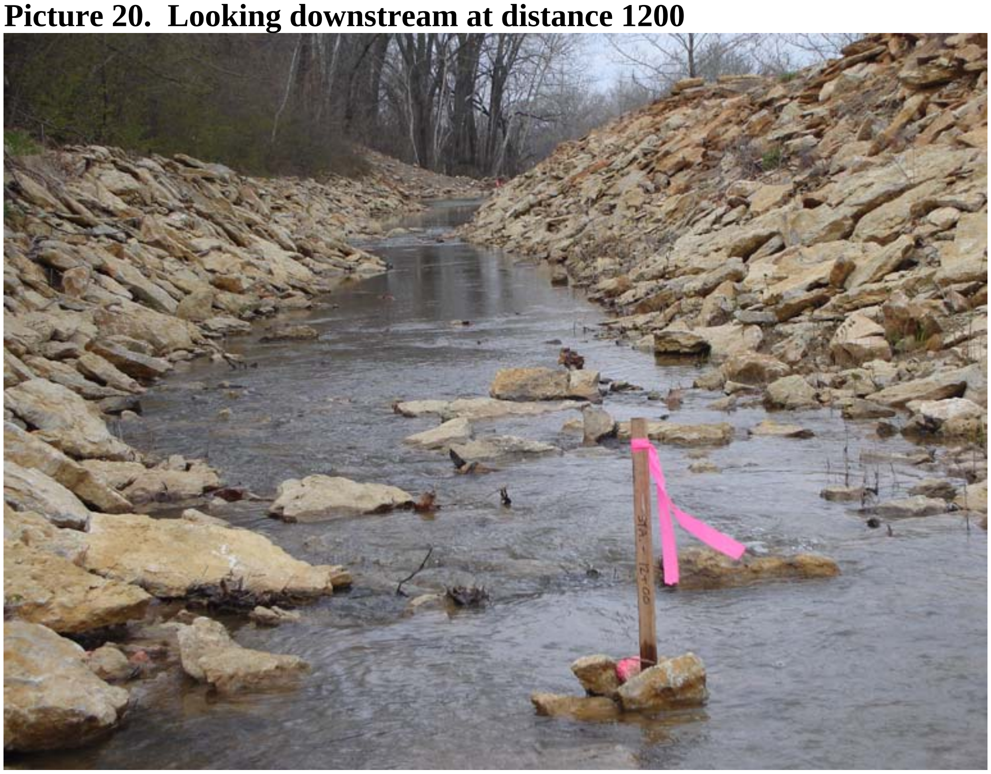
Picture 16. Looking downstream at distance 1800

Picture 17. Looking downstream at distance 1600

Picture 18. Looking downstream at distance 1400+

Picture 19. Looking downstream at distance 1400

Picture 20. Looking downstream at distance 1200



Picture 21. Looking downstream at distance 1000

Picture 22. Looking downstream at distance 800

Picture 23. Looking downstream at distance 600

Picture 24. Looking downstream at distance 400

Picture 25. Looking downstream at distance 200

Picture 26. Looking downstream at distance 0