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Study 3, Job 4
Area F212

MISSISSIPPI RIVER SURVEY REPORT
BRAINERD FISHERIES MANAGEMENT AREA
CROW WING COUNTY, MINNESOTA

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Introduction

A survey of the approximately 480 miles of the upper Mississippi River from the headwaters to the Coon Rapids Dam on the northwest side of the Twin Cities Metropolitan Area was conducted by the Minnesota Department of Natural Resources in 2007 and 2008. The seven MNDNR Fisheries offices with management areas along the upper Mississippi surveyed the fish community, main channel depths, water chemistry, and other features in 2007. In 2008, sampling focused on surveying representative riffle cross sections, water surface slope, and riverbed substrate, usually within or near a fish community sampling site. The 2008 sampling was the first characterization of the channel morphology of the upper Mississippi River ever done by the MNDNR. This document represents a report for the channel morphology surveying by the Brainerd Area Fisheries Office in Crow Wing County. A report on the 2007 sampling was produced in 2008 (Baird 2008).

Study Area

The Brainerd Fisheries Office management area on the Mississippi River generally corresponds with the boundaries of Crow Wing County. However, no sampling was done by the Brainerd Office upstream of Highway 6 to Aitkin County in eastern Crow Wing County. The Little Falls Fisheries Office management area generally begins at the confluence with the Crow Wing River.

Hydrology

A USGS gage is located on the downstream side of the Brainerd Dam (station number 05242300). This gage has a period of record from 24 April 1987 through the present. The drainage area is 7,320 square miles. The average discharge is 3,600 cfs. The maximum daily discharge for this site was 17,400 cfs in April 2001 and the minimum discharge was 348 cfs in July 1988. Bankfull discharge (1.5 year recurrence interval) is about 8,900 cfs.

Methods

A channel morphology survey was done in each of the five similar reaches within Crow Wing County downstream to the Crow Wing River as identified in Baird (2008; Figure 1, Appendix A). Each survey site was located within or near a fish community survey site sampled in 2007. Site number used for the channel morphology correspond with 2007 fish community sampling site numbers. A representative riffle cross-section and water surface slope were surveyed in each of the five reaches using standard stream channel surveying techniques (Harrelson et. al 1994) modified for a large river. A laser level was used to measure relative elevation and distances were measured with a tape measure for near shore portions of cross sections that could be waded. Where depth was to great to wade, depth of the cross section was measured using a Garmin 178C GPS/sounder mounted on a boat. The GPS sounder recorded location and water depth at two-second intervals while the boat was driven at slow speed across the cross section. The GPS track log was then imported into ESRI ARCgis ArcView 9 and depths were corrected for transducer depth (usually about 0.8 ft). Distances across the channel and depth were then extracted from the GPS points using the Locate Features Along Routes tool in ArcView. The laser level/tape measure and GPS/sounder cross sectional surveys were then combined to create a complete cross section of the riverbed elevation. Slope of the water surface was measured over approximately 1,800 to 5,700 ft of thalweg distance. Water surface elevation was measured with the laser level and locations were recorded with the Garmin 178C

GPS/sounder. Thalweg distances between water elevation points were measured in ARCgis with recent aerial images (2008 FSA). A reach scale particle count was done to characterize the streambed material at each site. Particles were classified into the major groups of silt, sand, gravel, cobble, or boulder visually or using a long probe (PCV pipe with endcap) to detect the particle types in deeper water. Channel survey data were entered into Rivermorph 4.0.1, which was then used to calculate channel parameters. Bankfull velocity and discharge were estimated with Manning's equation. Channel roughness (n) was estimated by channel type (Rosgen 1994). Floodprone widths were estimated from 1:24,000 USGS topographic maps.

Reaches 30 and 31 are influenced by the Brainerd Dam and therefore are not natural river channels. At site 31-22 only the GPS/depthfinder was used to measure depths and the water surface slope was not measured. Banks above water shown in the cross section figure for site 31-22 are estimated for illustration purposes.

Water Chemistry

Water samples were collected from three sites in Crow Wing County on August 27, 2008 from the same three sites sampled in August 2007. Samples were analyzed by the MDA. Samples were collected at the Highway 6 bridge, at the Half-Moon Landing, and at the Highway 371 bridge.

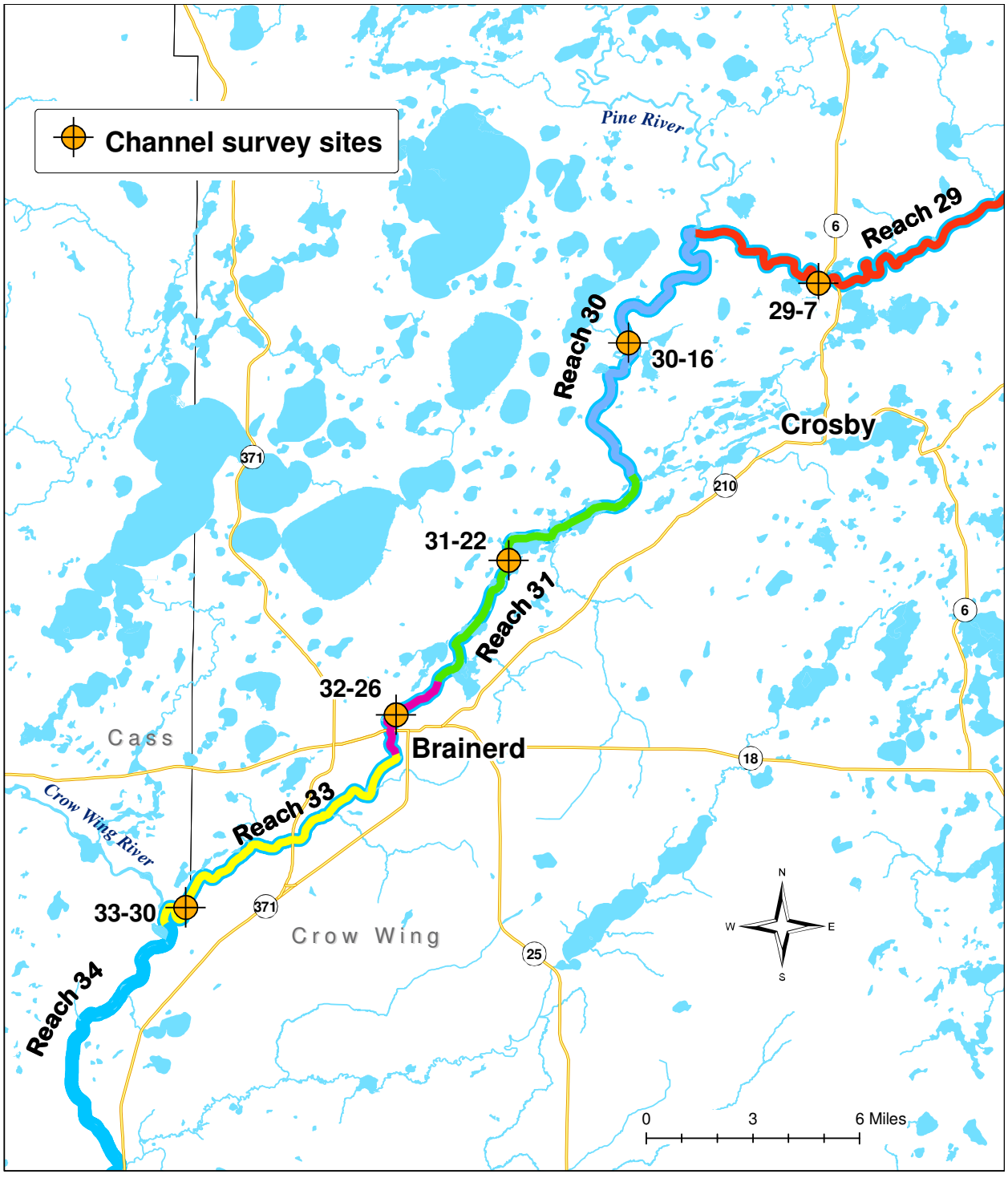

Figure 1. Location of the five channel survey sites on the Mississippi River within Crow Wing County, Minnesota in September 2008. Survey sites are labeled as reach-site number. These site numbers correspond with electrofishing site numbers from the 2007 fish community survey.

Results and Discussion

Water Chemistry

The water chemistry of the Mississippi River in Crow Wing County was characteristic of fairly hard water (Table 3). The three water samples were similar across the measured parameters in both years, except total phosphorus and chloride which were elevated in the sample collected downstream of Brainerd in 2007. The flow of the Mississippi was quite low when the samples were collected in 2007 thus the Brainerd sewage treatment plan discharge contributed a greater portion of the flow at the Highway 371 sampling site than it would under higher flows.

Table 3. Water chemistry from three sites on the Mississippi River in Crow Wing County, Minnesota. Water samples were collected on August 27, 2007 when the mean daily flow in Brainerd was 394 cfs and August 27, 2008 when the mean daily flow in Brainerd was 646 cfs.

		Location		
	Year	Highway 6	Half Moon Landing	Highway 371
Total phosphorus (ppm)	2007	0.040	0.034	0.117
	2008	0.038	0.031	0.042
Chlorophyll a (ppb)	2007	9.2	11.8	8.9
	2008	5.5	4.4	2.5
Chlorophyll a (ppb) corrected for pheophytin	2008	2.3	1.2	0.8
Total alkalinity (ppm)	2007	153	150	155
	2008	149	147	147
pH	2007	8.32	8.36	7.93
	2008	8.10	8.15	7.97
Total dissolved solids (ppm)	2007	204	196	204
	2008	176	176	176
Specific conductivity (umhos)	2007	309	302	313
	2008	322	316	318
Chloride (ppm)	2007	5.7	5.5	10.4
	2008	5.1	5.0	6.6

Channel Morphology

The survey site in reach 29 was slightly entrenched with a moderately high width to depth ratio resulting in a C4c- channel classification (Table 4). The left bank was against the valley wall while about 800 ft of flood prone area was present on the right bank (Figures 2, 3, and 9). The bed particles were a mix of silt, sand, gravel, with a few boulders with gravel as the median particle size. The water surface slope was low at 0.00012. This reach had the tightest average radius of curvature at 390 ft. The surveyed cross section in reach 29 appears to be representative of most of the reach. Some relatively small areas with more abundant large cobble and boulder are present within the reach.

The survey sites in reaches 30 and 31 are impounded by the Brainerd Dam and so were not classified because they are not free-flowing channels (Table 4). At both sites wild rice and other aquatic vegetation was abundant in the shallow water along the banks (Figures 4-6). In reach 30, the water elevation was close to the estimated bankfull elevation (Figure 10). A wide floodprone area resulted in the highest entrenchment ratio. The actual flood prone elevation is likely much lower than the estimated twice maximum bankfull depth as the bankfull elevation is influenced by the Brainerd Dam. Reach 30 had the greatest meander belt width and meander wavelength of the five reaches. The lowest measured water surface slope was at site 30-16 (0.00008). The upper approximately one to two miles of reach 30, immediately below the confluence with the Pine River, tends to be more riverine than the remainder of reach. How much of the upper portion of the reach that is more riverine and how much is influenced by the Brainerd Dam depends on the river discharge. A low discharge, the free flowing section extends further, up to about 2 miles below the Pine River, than at high discharge.

Reach 31 is the main portion of the Brainerd Dam reservoir. Some of reach 31 has much more extensive backwater areas than the surveyed cross section, which included a small section of backwater on the left bank (Figures 6 and 11). In some areas of this reach, impounded backwaters are up to about 0.5 miles wide. At French Rapids the channel is much narrower (~ 250 ft) with a limited flood prone area. While not measured, water surface slope in reach 31 is likely even lower than that found in reach 30. In reach 31, the water elevation was estimated to be similar to the bankfull elevation (Figure 11). The actual flood prone elevation is likely much lower than the estimated twice maximum bankfull depth as the bankfull elevation is influenced by the Brainerd Dam.

The two reaches below the Brainerd Dam were slightly entrenched and had very high width to depth ratios resulting in D5 (reach 32) and D4 (reach 33) classifications (Table 4, Figures 7, 8, 12, and 13). There are about 10 islands with multiple channels in the reach below the Brainerd Dam. The surveyed portion of the reach 32 was almost entirely a sand bed. The lower approximately 1 mile of reach 32 where four bridges cross the river has a higher gradient, narrower channel, coarser bed particles, and portions have a limited flood prone area compared to the section above the bridges.

While the survey site in reach 33 was classified as a D channel, islands and multiple channels were less common in this reach than immediately below the Brainerd Dam. The survey portion of reach 33 was predominately sand and gravel with some cobble. Site 33-30 has the greatest water surface slope (0.00015) of the five sites, but this slope was still relatively low. The surveyed cross section in reach 32 was done in a section with a relatively wide channel compared with the entire reach. Some portions of this reach have a narrower channel and may approach a C channel width to depth ratio.

Table 4. Channel characteristics of the Mississippi River at the four survey sites in Crow Wing Co. Distances are in ft unless otherwise indicated in the table. Reaches 30 and 31 are impounded by the Brainerd Dam and are not free-flowing channels.

	Reach-Site				
	29-7	30-16	31-22	32-26	33-30
Classification	C 4c-			D 5	D 4
Bankfull width	234	313	157	534	474
Mean depth at bankfull	9.9	8.8	11.1	9.7	9.3
Bankfull maximum depth	15.8	11.5	21.8	14.1	13.3
Bankfull cross sectional area (sq ft)	2,307	2,740	1,736	5,153	4,383
Width:Depth Ratio	23.7	35.8	14.2	55.3	51.2
Floodprone width	809	1,750	760	1,400	1,160
Entrenchment ratio	3.5	5.6	4.8	2.6	2.5
Bankfull wetted perimeter	239	319	167	539	477
Bankfull hydralic radius	9.7	8.6	10.4	9.6	9.2
Movable particle from Shields Curve (mm)	5	3		4.9	5.9
Shear stress (lbs/sq ft)	0.07	0.04		0.07	0.09
Water surface slope (ft/ft)	0.00012	0.00008		0.00012	0.00015
Bankfull discharge (cfs)	8,975			11,440	11,660
Bankfull velocity (fps)	3.9			2.2	2.7
Roughness coeff. (n)	0.019			0.033	0.03
% Silt	12%			1%	1%
% Sand	17%			94%	39%
% Gravel	44%			5%	39%
% Cobble	24%			0%	19%
% Boulder	3%			0%	2%
Sinuosity	1.2	1.2	1.1	1.1	1.1
Meander belt width	1,800	3,000	1,500	730	1,800
Radius of curvature	390	1,000	780	1,900	840
Meander length	3,600	5,500	4,000	2,900	2,700
Drainage area (sq mi)	6,015	6,845	6,985	7,003	7,050
Date surveyed	9/17/2008	9/22/2008	9/22/2008	9/23/2008	9/24/2008

Figure 2. Images of channel survey site 29-7 at the cross section location. Left image is looking at the left bank and right image is looking at the right bank.

Figure 3. Images of channel survey site 29-7 looking upstream (left image) and downstream (right image) from the right bank at the cross section location.

Figure 4. Image of the left bank at channel survey site 30-16 at the cross section location.

Figure 5. Images of channel survey site 30-16 looking downstream (left image) and upstream (right image) from the left bank at the cross section location.

Figure 6. Images of channel survey site 31-22 looking downstream at the left bank (left image) and downstream at the right bank (right image) through the cross section survey location.

Figure 7. Images of channel survey site 32-26 looking at the right bank at the cross section survey location (left) and upstream from the left bank at the cross section survey location (right).

Figure 8. Images of channel survey site 33-30 looking upstream (left) and downstream (right) through the cross section survey location.

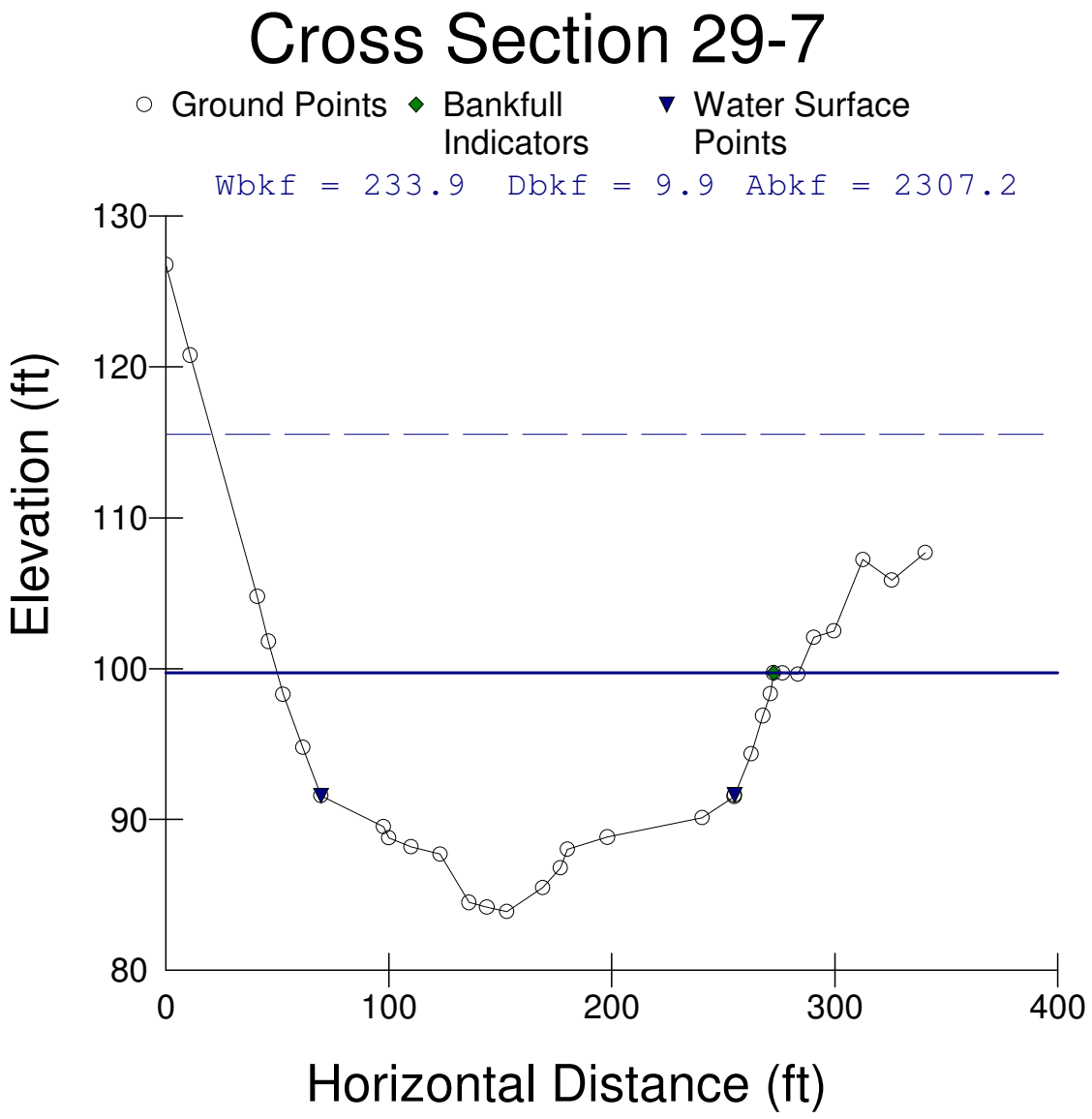

Figure 9. Cross section channel dimensions at survey site 29-7. Solid horizontal line indicates the estimated water elevation at bankfull flow. Dashed horizontal line indicates the estimated flood prone area (twice maximum bankfull depth).

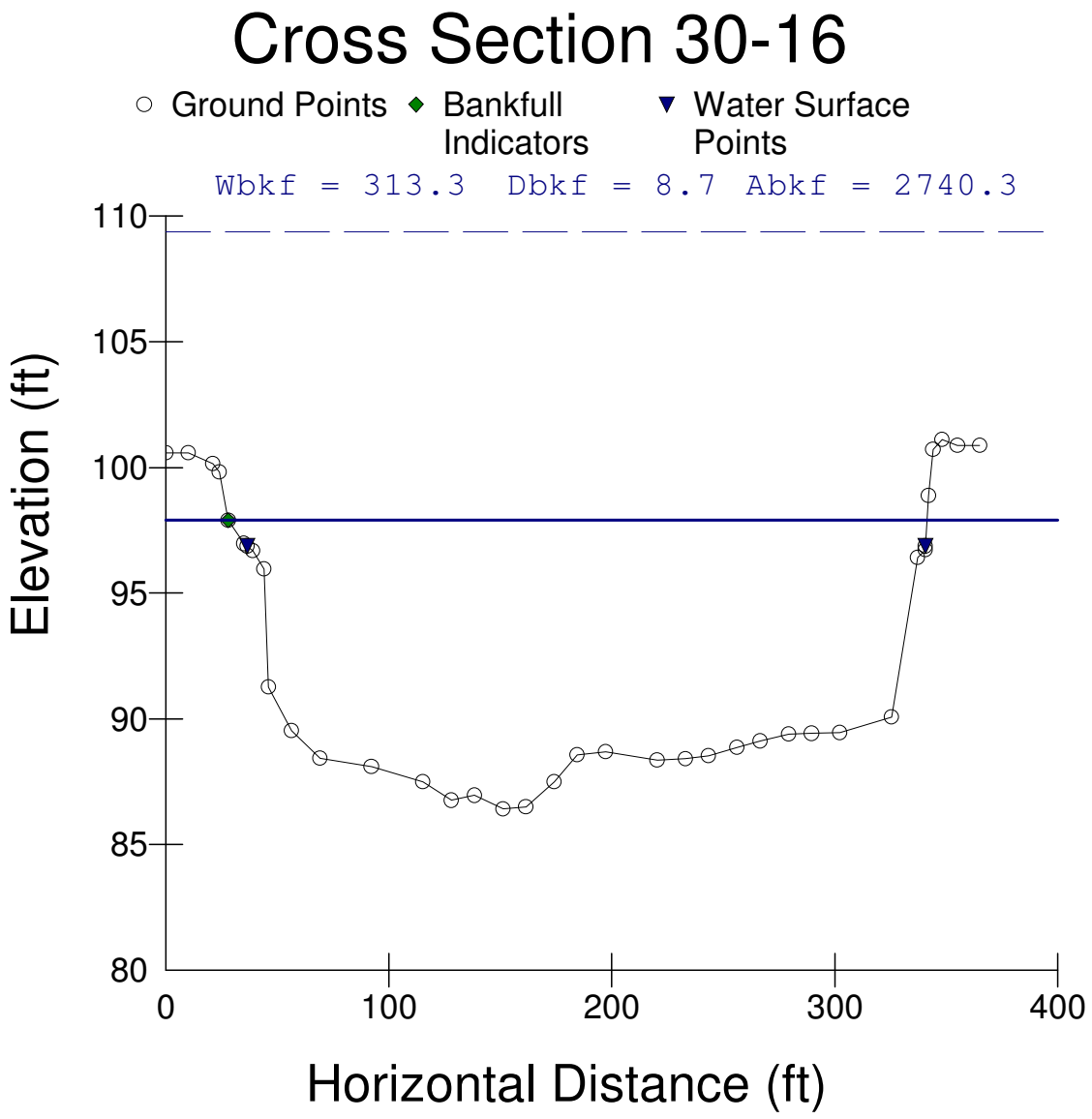

Figure 10. Cross section channel dimensions at survey site 30-16. Solid horizontal line indicates the estimated water elevation at bankfull flow. Dashed horizontal line indicates the estimated flood prone area (twice maximum bankfull depth).

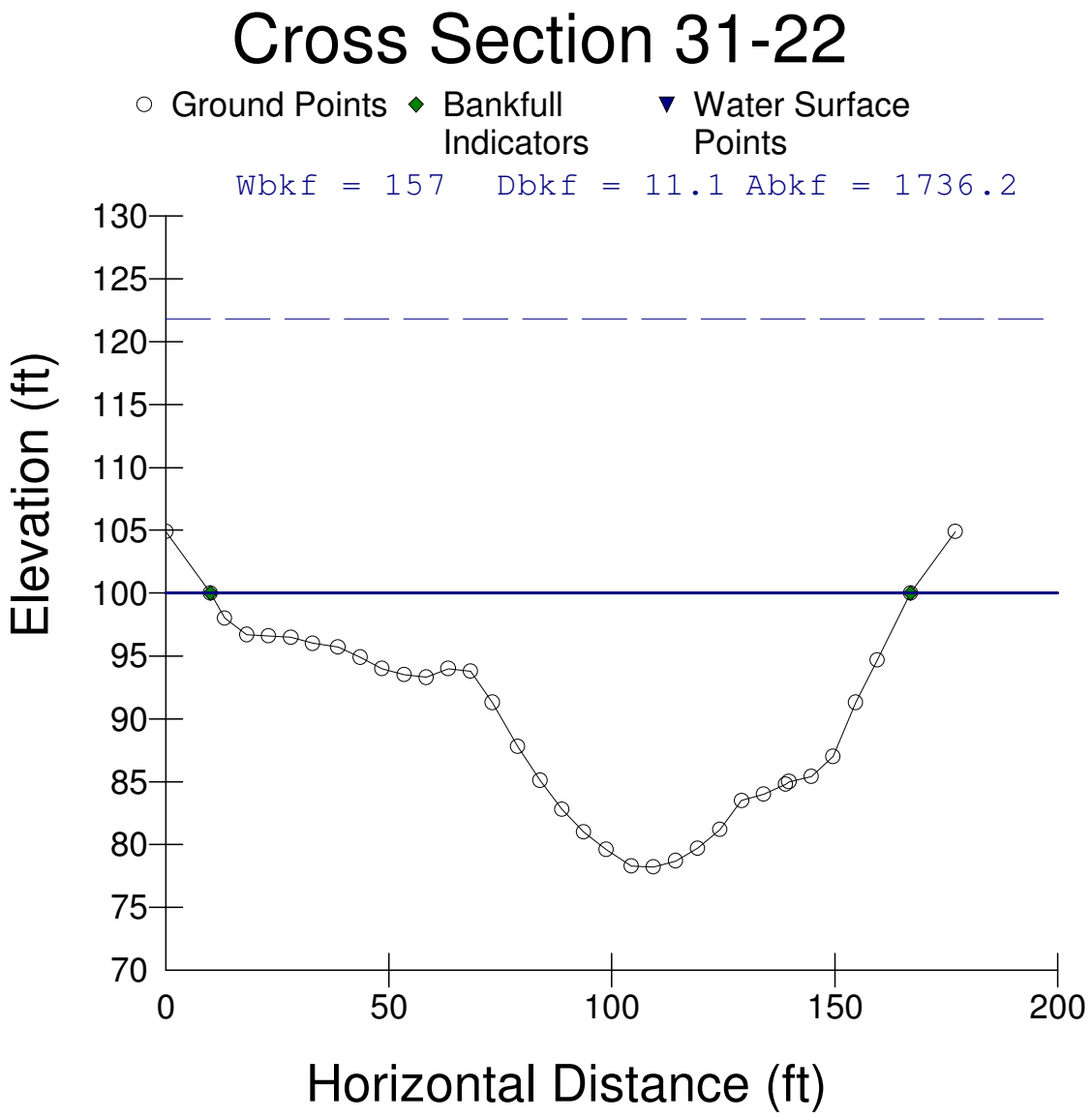

Figure 11. Cross section channel dimensions at survey site 31-22. Solid horizontal line indicates the estimated water elevation at bankfull flow. Dashed horizontal line indicates the estimated flood prone area (twice maximum bankfull depth). Bank elevations above the water surface/estimated bankfull elevation are estimated.

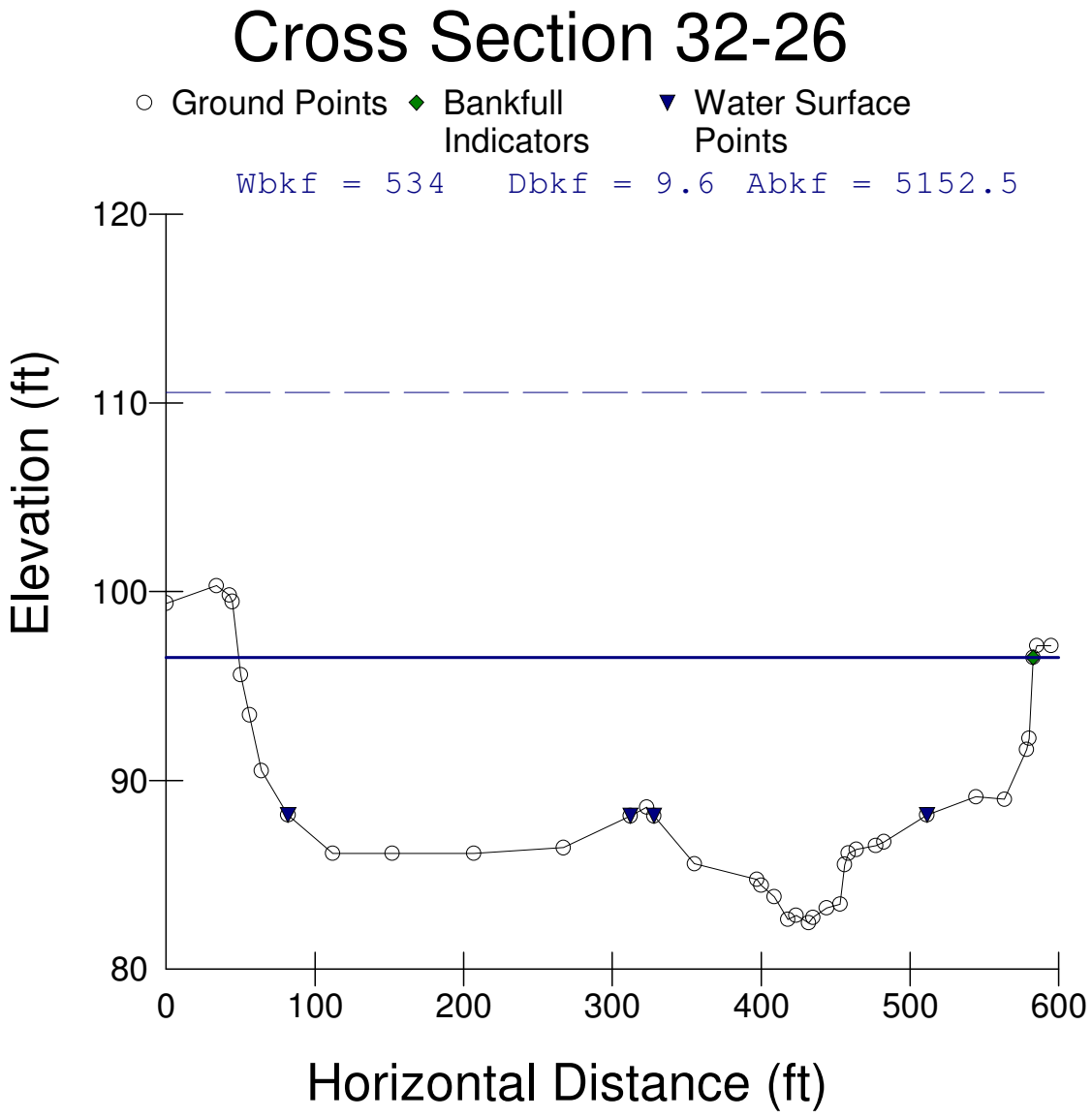

Figure 12. Cross section channel dimensions at survey site 32-26. Solid horizontal line indicates the estimated water elevation at bankfull flow. Dashed horizontal line indicates the estimated flood prone area (twice maximum bankfull depth).

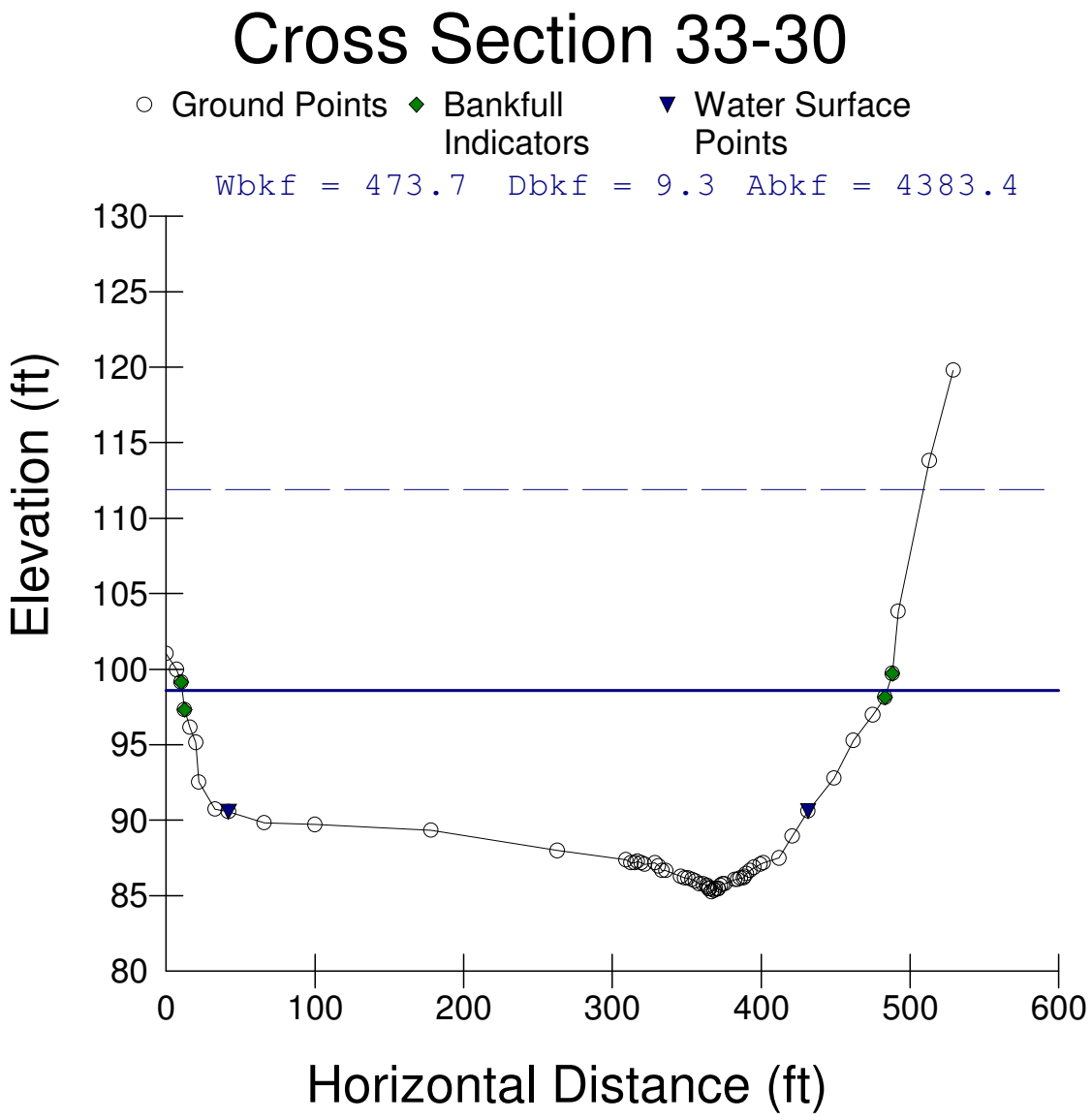

Figure 13. Cross section channel dimensions at survey site 33-30. Solid horizontal line indicates the estimated water elevation at bankfull flow. Dashed horizontal line indicates the estimated flood prone area (twice maximum bankfull depth).

References

Baird, O. E. 2008. Mississippi River survey report, Brainerd fisheries management area, Crow Wing County, Minnesota. Minnesota Dept. of Natural Resources.

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Rosgen, D. L. 1994. A classification of natural rivers. Catena 22:169-199.