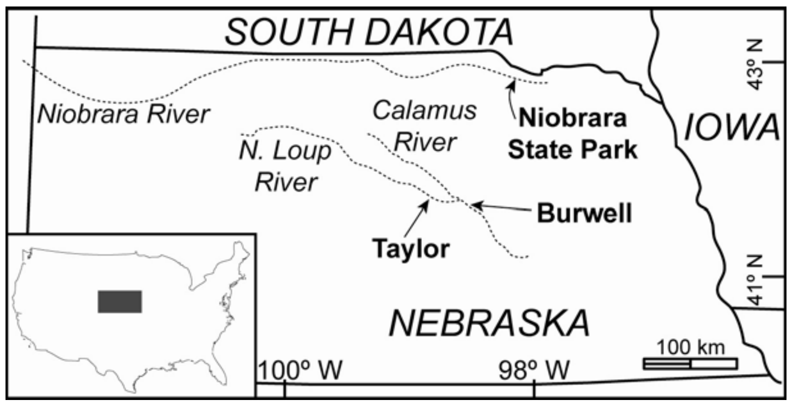
# NIOBRARA, NORTH LOUP, AND CALAMUS RIVER DATA COLLECTION AND ANALYSIS

Three sand-bedded rivers in Nebraska, USA, were sampled for this study, including the Niobrara, North Loup, and Calamus rivers. The Niobrara River originates in east-central Wyoming, flows eastward across northern Nebraska and terminates at the Missouri River at the study area in Niobrara State Park. Sediment sources include Miocene and Pliocene continental deposits in western Nebraska and Cretaceous Pierre Shale and Niobrara Chalk in eastern Nebraska (Watkins and Diffendal 1997). The Niobrara River maintains year-round base flow (Bristow et al. 1999) because it derives most of its discharge from groundwater (Bleed 1989). The mean annual discharge of the Niobrara River from 1955 through 1957, 2009, and 2010 (the only available published discharge data) was 48.5 $m^3/s$ (USGS Water Resources 2014a). Discharges are lowest during the frozen winter months and highest during spring runoff (Skelly and Ethridge 1997). This study was carried out during August 2004 when the river was nearly at bankfull. The Niobrara River has been studied in some detail by Bristow et al. (1999) and Skelly et al. (2003), including a ground-penetrating radar study which provides some information about the geometry of preserved deposits in the subsurface. Within the studied reach, channel-belt width varies from 250–330 m.




Location map of the study areas in Nebraska, USA. Data were collected from Niobrara State Park on the Niobrara River, near Burwell on the Calamus River, and near Taylor on the North Loup River.

The North Loup River is sourced in the Sand Hills of central Nebraska, making it a particularly sandy braided river. The river was studied near the town of Taylor, Nebraska. The mean annual discharge at the study location from 1936 through 2014 was 14 $m^3/s$ (USGS Water Resources, 2014b). As with the Niobrara River, the North Loup River is frozen during the winter months and experiences highest discharges in the spring. At the study location the river is 110 m wide.

The Calamus River is sourced and entirely confined to the Sand Hills of central Nebraska. On the studied reach near the town of Burwell, Nebraska, the Calamus River is primarily a single thread sand-bedded channel with infrequent mid-channel bars. The Calamus River has been interpreted as containing braided reaches (e.g., Bridge et al. 1998) but is unquestionably not braided at this study locality. Sinuosity within the Calamus River ranges from 1.1–2.0 (Smith and Bridge 1985). The mean annual discharge on the Calamus River recorded at the Burwell gauging station from 1940–1996 was 8.5 $m^3/s$ (USGS Water Resources 2014c), recording highest discharges during the spring months. The Calamus River commonly has one (and rarely two) active channel threads per cross-stream transect in the area of study.

Because the Calamus River is a dominantly a single-thread system in the studied reach, a “channel thread” is effectively the active thalweg.

General river statistics for each of the three rivers are summarized in Table 1. Reach-averaged water surface slope was first estimated by measuring the drop in bed elevation along 1–3 km of river length from the appropriated USGS 7.5-minute topographic quadrangle. Water surface elevation was then independently surveyed over 1–1.5 km sections of the studied rivers to confirm the accuracy of the measured slopes from the topographic maps. These field surveys used a theodolite and measuring rod. Every survey point was taken when the basal tip of the survey rod just touched the water surface. We found excellent agreement between the reach-averaged values for water-surface slope measured from the topographic maps and the direct measures of water-surface slope provided by the field surveys.

Table 1. General River Statistics

| River | Measured Slope[a] | Average Maximum Depth (cm) | Average Width (m) | Number of Transects |
|---|---|---|---|---|
| Niobrara | 0.001085 | 91.0 | 293 | 2 |
| North Loup | 0.001516 | 52.4 | 110 | 6 |
| Calamus | 0.001100 | 68.0 | 27 | 10 |

[a]Reach-averaged water-surface slope.
[b]Average maximum thalweg depth per river transect.

## GRAIN-SIZE ANALYSIS

### *Sampling Procedure*

Suspended sediment samples were collected with a wading-type suspended sediment sampler, US DH-48. The sampler is 33 cm long, consists of streamlined aluminum casting, and holds a plastic 0.47-liter sample container. Suspended sediment was collected from several locations on the rivers, including active boils, mid-channel (thalweg), and 10 cm downstream of dune or avalanching bar crests. After collection, all samples were allowed to settle in the sample container, the water was decanted, and the sediment deposited into plastic bags for storage. In some cases the sampler did not catch enough sediment for analysis, so the processes was repeated a maximum of three times.

Suspended-sediment (slackwater) deposits (Lynds and Hajek 2006; Hajek et al. 2010) were sampled from areas in the river with locally near-zero flow velocities. Samples were collected in plastic sample containers by skimming the upper (approximately) 1 cm of sediment from the river bottom. The sediment settled in the container, the water was decanted, and the sediment was placed into plastic bags for storage.

Sediment samples defining the composition of the active channel bed (i.e. bed-material load or active layer) were collected as grab samples from prograding bar crests. Each sample was skimmed from the bed surface into a plastic sample container. The sediment was allowed to settle, the water was decanted, and the sediment was placed into a plastic bag for storage.

### *Sample Preparation*

All samples were dried by air or in a drying oven. Nearly half the samples contained significant amounts of organic material. The organic matter was removed by placing the sample in a beaker with twice the volume of water as sediment, and a 2:1 ratio of water to 30 percent hydrogen peroxide. The beaker with sediment, water, and hydrogen peroxide was placed under a fume hood on a hot plate at 40°C, and allowed to boil until dry. In a few cases this process was repeated twice to remove all the organic material.

All bed-material load and some slackwater samples were divided into two populations sieved at 0.09 mm. Samples were sieved for approximately 15 minutes with a Ro-tap. The coarse-grained (>0.09 mm) and fine-grained (<0.09 mm) fractions were individually weighed and placed in plastic bags.

### *Grain-size Assessment*

Samples were processed for sediment size in the Sedimentary Geology Laboratory at the Massachusetts Institute of Technology. The fine-grained (< 0.09 mm) fraction was analyzed with a Horiba LA-300 laser particle-size analyzer (LPSA), and the coarse-grained material (> 0.09 mm) was analyzed using a Retsch Technology digital image-processing particle-size analyzer (CAMSIZER). The LPSA uses a diode laser to measure grain sizes from 0.001-0.1 mm in diameter and the CAMSIZER uses digital photographic images to measure grain sizes ranging from 0.05-30 mm in diameter. The final grain-size distributions are thus the weighted average of the fine- and coarse-grained components.

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