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Channel Morphology and Bed Sediment Characteristics Before and After Habitat Enhancement Activities in the Uridil Property, Platte River, Nebraska, Water Years 2005–2008

Paul J. Kinzel
U.S. Geological Survey

USGS
science for a changing world

Prepared in cooperation with the Platte River Whooping Crane Maintenance Trust

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Conversion Factors

[Inch/Pound to SI]

Multiply	By	To obtain
	Length	
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
	Area	
square foot (ft^2)	0.09290	square meter (m^2)
	Volume	
cubic foot (ft^3)	0.02832	cubic meter (m^3)
cubic yard (yd^3)	0.7646	cubic meter (m^3)
	Flow rate	
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)
	Mass	
ton, short (2,000 lb)	0.9072	megagram (Mg)
ton, long (2,240 lb)	1.016	megagram (Mg)
	Density	
pound per cubic foot (lb/ft^3)	16.02	kilogram per cubic meter (kg/m^3)

[SI to Inch/Pound]

Multiply	By	To obtain
	Length	
meter (m)	3.281	foot (ft)
kilometer (km)	0.6214	mile (mi)
	Area	
square meter (m^2)	10.76	square foot (ft^2)
	Volume	
cubic meter (m^3)	35.31	cubic foot (ft^3)
	Flow rate	
cubic meter per second (m^3/s)	35.31	cubic foot per second (ft^3/s)
	Mass	
megagram (Mg)	1.102	ton, short (2,000 lb)
	Density	
kilogram per cubic meter (kg/m^3)	0.06242	pound per cubic foot (lb/ft^3)

Vertical coordinate information is referenced to the North American Vertical Datum of 1988 (NAVD 88)

Horizontal coordinate information is referenced to the North American Datum of 1983 (NAD 83)

Channel Morphology and Bed Sediment Characteristics Before and After Habitat Enhancement Activities in the Uridil Property, Platte River, Nebraska, Water Years 2005–2008

By Paul J. Kinzel

Abstract

Fluvial geomorphic data were collected by the United States Geological Survey from July 2005 to June 2008 (a time period within water years 2005 to 2008) to monitor the effects of habitat enhancement activities conducted in the Platte River Whooping Crane Maintenance Trust's Uridil Property, located along the Platte River, Nebraska. The activities involved the removal of vegetation and sand from the tops of high permanent islands and the placement of the sand into the active river channel. This strategy was intended to enhance habitat for migratory water birds by lowering the elevations of the high islands, thereby eliminating a visual obstruction for roosting birds. It was also thought that the bare sand on the lowered island surfaces could serve as potential habitat for nesting water birds. Lastly, the project supplied a local source of sediment to the river to test the hypothesis that this material could contribute to the formation of lower sandbars and potential nesting sites downstream. Topographic surveys on the islands and along river transects were used to quantify the volume of removed sand and track the storage and movement of the introduced sand downstream. Sediment samples were also collected to map the spatial distribution of river bed sediment sizes before and after the management activities. While the project lowered the elevation of high islands, observations of the sand addition indicated the relatively fine-grained sand that was placed in the active river channel was rapidly transported by the flowing water. Topographic measurements made 3 months after the sand addition along transects in the area of sediment addition showed net aggradation over measurements made in 2005. In the year following the sand addition, 2007, elevated river flows from local rain events generally were accompanied by net degradation along transects within the area of sediment addition. In the spring of 2008, a large magnitude flow event of approximately 360 cubic meters per second occurred in the study reach and was accompanied by net aggradation in the managed area. These observations illustrate the high sediment transport capacity of the river channel both at lower flows, when the sand was added, and during higher flow events. This field experiment also serves as a practical example of the dynamic response of a Platte River channel to a relatively small-scale sand augmentation project directed toward enhancing in-channel habitat for avian species.

Introduction

The Platte River in central Nebraska is a prime ecological resource for migratory bird species. Both wading and nesting birds gather among the mix of shallow channels and emergent sandbars. These riverine habitats are also used by three federally listed avian species: the endangered whooping crane (*Grus Americana*) (U.S. Fish and Wildlife Service, 1967), interior least tern (*Sterna antillarum*), and the threatened piping plover (*Charadrius melodus*) (U.S. Fish and Wildlife Service, 1985a,b). In the last century, habitats for the listed species along the central Platte River have been negatively impacted as upstream dams and diversions for agriculture have altered the flow regime in the central Platte River (National Research Council, 2004; U.S. Department of the Interior, 2006). A reduction in the frequency and magnitude of flows necessary for mobilizing and preventing vegetative succession on sandbars has been accompanied by profound changes in the channel morphology. In the 20th century, the river narrowed significantly in response to the altered flow regime (Williams, 1978; Eschner and others, 1983; Johnson, 1997). Narrower river channels are believed to be less suitable with regard to the roosting habitat requirements of the whooping crane (U.S. Department of the Interior, 2006). Similarly, the absence of large magnitude flows and reduction in upstream sediment supply has impaired the creation of high-elevation emergent sandbars in the river channel, effecting the nesting habitat of the interior least tern and piping plover (U.S. Department of the Interior, 2006).

Habitat enhancement and preservation activities for the listed species along the central Platte River have been underway for some time. Vegetation clearing, conducted since the 1980s, has attempted to control vegetation succession on emergent sandbar areas and islands as a means to enhance river roosting habitat for cranes (Currier, 1991). Clearing strategies have included the application of herbicides, burning, mowing, and mechanically discing vegetated surfaces. Discing typically involves using a tractor to pull a trailer with rows of steel discs over a vegetated surface. The intent of the discing process is to disturb the vegetation root system and decrease its stabilizing effects on the sand substrate. These clearing strategies have typically not attempted to deliberately alter the topography of sandbars and islands or intentionally redistribute sand into the active channel.

There has been increasing interest by river managers in implementing strategies to augment the sand supplied to Platte River channels to enhance habitat for the listed avian species. This interest was prompted in part by the findings of the Platte River Final Environmental Impact Statement (U.S. Department of the Interior, 2006). Specifically a temporal analysis of topographic river transects by Murphy and Randle (2001) pointed out the linkage between clear water inputs to the Platte River from hydropower operations and recent (post-1989) scouring of the river bed. Aside from this work, Kinzel and others (1999) showed that the bed sediments of the Platte River were coarser in 1998 than in 1931 and hypothesized that upstream regulation and reduced sediment supplies were responsible for winnowing fine material from the river bed. Taken together, observations of degrading channels and coarser, less mobile, bed materials suggest that the present sediment supply may be influencing the Platte River channel morphology.

Potential strategies to restore river channel habitat for the endangered and threatened species were identified in the Final Environmental Impact Statement prepared for the Platte River. These strategies included: "vegetation clearing and discing on banks and islands to improve sight distance across and along the river and to create roosting and nesting opportunities," "island leveling—lowering elevation of vegetated islands and river banks to improve sight distance and create sandbars," and "moving river sand from islands or banks back into the active river channel to offset ongoing erosion of the channel and support formation of new sandbars" (U.S. Department of the Interior, 2006). Similar strategies were identified in the Adaptive Management Plan component of the Platte River Recovery Implementation Program Document, hereinafter referred to as the Program, as actions that could be undertaken to improve habitat and offset or ameliorate imbalances in the sediment budget (Governance Committee, 2006). The "Flow-Sediment-Mechanical Strategy" also referred to as the "Clear/Level/Pulse" strategy mentioned in the Program document describes a process by which islands are first cleared of vegetation, then leveled to a lower elevation through mechanical means. The material removed by the leveling process would be placed into the active channel for a managed flow release, or pulsed-flow event, to transport downstream. The overarching hypothesis of this approach is that it will "…generate detectable changes in the channel morphology of the Platte River, and habitats for whooping crane, least tern, piping plover, pallid sturgeon, and other species of concern."

Despite the advocacy in these habitat enhancement strategies, no comprehensive large-scale examples of their application along the Platte River were available when the Program document was written. For this reason, as the Platte River Recovery Implementation Program moves forward, pilot investigations and experiments are necessary to determine how best to undertake and monitor a large-scale management program, of which sand augmentation is a component, to ensure that the treatment produces the desired effects both from a physical and biological perspective while at the same time keeping with the Program's goal of avoiding negative third-party effects. The importance of monitoring habitat-management sites was also identified by the National Research Council (NRC) in their review of the needs of the endangered and threatened species in the Platte River basin. The NRC noted that "as with most habitat-management strategies in the central Platte River, there has been no specific monitoring to assess the success of clearing. Unintended effects remain to be investigated." (National Research Council, 2004).

Although not a comprehensive or large-scale example of the "Flow-Sediment-Mechanical" approach, the vegetation clearing habitat enhancement project conducted by the Nebraska Public Power District (NPPD) in their Cottonwood Ranch Property from 2002 to 2004 has some similar components. The project lowered the elevation of several islands and introduced bank and island material into the active channel. The volume of bank material directly introduced to the river in this phase of the Cottonwood Ranch project was estimated by Kinzel and others (2006a) to be approximately 250 cubic meters (m^3). Additional material was indirectly introduced as a consequence of island leveling activities conducted by NPPD. These activities involved pushing island sand to its periphery, increasing the area of the island but lowering its overall elevation. The process made accounting for any sand introduced to the channel more difficult to estimate, but approximately 1,500 to 3,000 m^3 of material was estimated to have been made available for river flows to transport downstream (Kinzel and others, 2006a). Despite these direct and indirect sediment additions, Kinzel and others (2006a) found no statistically significant evidence of greater incidences of increased mean channel elevations downstream compared to upstream from the managed area.

The management activities in the Cottonwood Ranch Property provided some empirical data necessary to evaluate the response of the river channel to habitat enhancement activities, specifically riparian vegetation clearing and sediment additions. A key difference between the management at the Cottonwood Ranch and that proposed by the Program is that although a pulse-flow release was considered by the U.S. Fish and Wildlife Service (USFWS), the agency which manages the environmental water account for the Platte River, a pulse flow was not released during the time period of the management activities and monitoring in the Cottonwood

Ranch Property. The study described herein, conducted by the U.S. Geological Survey (USGS) in cooperation with the Platte River Whooping Crane Maintenance Trust (PRWCMT), is the result of an effort to build upon the observations collected and the monitoring methodology developed for the Cottonwood Ranch Property by directly adding a larger quantity of sand to the river at the Uridil Property and monitoring the fate and transport of that material downstream. Although a pulsed-flow event was not released during the management and monitoring activities at the Uridil Property, naturally elevated river flows from local rain events occurred in the final 2 years of the study. These elevated flows provided an opportunity to monitor the effects of higher magnitude discharges on the channel morphology of a recently managed river reach.

Purpose and Scope

This report presents an analysis of channel morphology and bed sediment characteristics based on data collected in the PRWCMT Uridil Property during water years 2005 to 2008. The report is intended to provide the data necessary to detect the physical response of the river channel to a management strategy designed to enhance in-channel habitat for migratory water birds. This strategy also includes components of an approach suggested in the Platte River Environmental Impact Statement document and in the Platte River Recovery Implementation Program document intended to enhance habitat for endangered and threatened species in the Platte River basin. This report also addresses a primary objective of the USGS Platte River Priority Ecosystem Program: Evaluating the effects of management strategies on individual species and their habitats. The data used in the analysis provided in this report are provided in the appendixes and include transect plots, tables of bed sediment grain-size distributions, and ground photographs.

Acknowledgments

This study was supported through a the proposal written by the PRWCMT to the Nebraska Environmental Trust (NET). The NET project proposal was developed by Robert Henszey formerly of the PRWCMT. Kenny Dinan, Jeff Runge, and Kirk Schroeder (USFWS, Grand Island, Nebr.) provided technical assistance in the project design and execution phases. Assistance with field data collection was provided by Ashley Heckman, Brandy Logan, Richard McDonald, Jonathan Nelson, Francisco Simões, and Andrew Wilcox (USGS, Golden, Colo.), and Jason Alexander, Brent Hall, Brian Imig, and Matt Moser (USGS, Lincoln, Nebr.). Ashley Heckman (USGS, Golden, Colo.) provided laboratory analysis of the bed sediment samples. The recording stage gage on the site, USGS station 06770375 Platte River at Prosser, Nebr., and the upstream and downstream streamflow-gaging stations: USGS stations 06770200 Platte River at Kearney, Nebr. and 06770500 Platte River at Grand Island, Nebr. were maintained by the USGS office in North Platte, Nebr. The author would like to thank Sharon Gloe and Barbara and Jarron Suck for kindly providing access to the portions of the Platte River located on their properties.

Study Area

The PRWCMT's Uridil Property is located in Hall County, Nebraska. The Uridil Property lies along a reach of the Platte River between the town of Shelton to the west and the Wood River to the east (fig. 1). The Platte River through this area includes three braids or channels (north, middle, and south channels). This property and others adjacent to it along the middle channel of the Platte River are popular locations for water birds to congregate. Each spring thousands of sandhill cranes can be observed roosting in this reach (Kinzel and others, 2006b). This is due, in part, to the habitat management activities which have maintained a wide channel through discing operations on the sandbars. The slope of the river valley through the reach, determined from USGS topographic maps produced in 1962 and revised in 1993, is 0.0014.

Geomorphology

Two complete islands and the upstream part of a third island in the PRWCMT's Uridil Property were selected for clearing and leveling. The islands are numbered 1 to 3 from upstream to downstream (fig. 2). The history of island development in the study reach was established by examining 1867 General Land Office (GLO) Cadastral Surveys and serial aerial photography from 1938, 1951, and 2006. The cadastral surveys by the General Land Office (GLO) were used to create maps of Platte River channels in this area. The managed islands were not delineated in the plat map made from surveys conducted between 1859 to 1867 of Township 9 North and 12 West (fig. 3*A*). However, GLO plat maps should be interpreted cautiously because the spatial extent of the managed islands may have been deemed insufficient by the surveyor for cartographic purposes and therefore were omitted from the map. Johnson and Boettcher (1999) thought that some islands were not surveyed by the GLO because the islands had little agricultural value, they were too time consuming to survey, and they were only documented when surveyors crossed the river. Examination of the GLO plat map does, however, show the location of the meander corners or the river banks along the reach.

The managed islands are identifiable in an aerial photograph taken by the Soil Conservation Service on October 24, 1938 (fig. 3*B*). In this photograph, portions of the managed islands are present and appear to have trees similar in size to those on the river banks. It could be inferred that if the islands were inundated in the years leading up to when

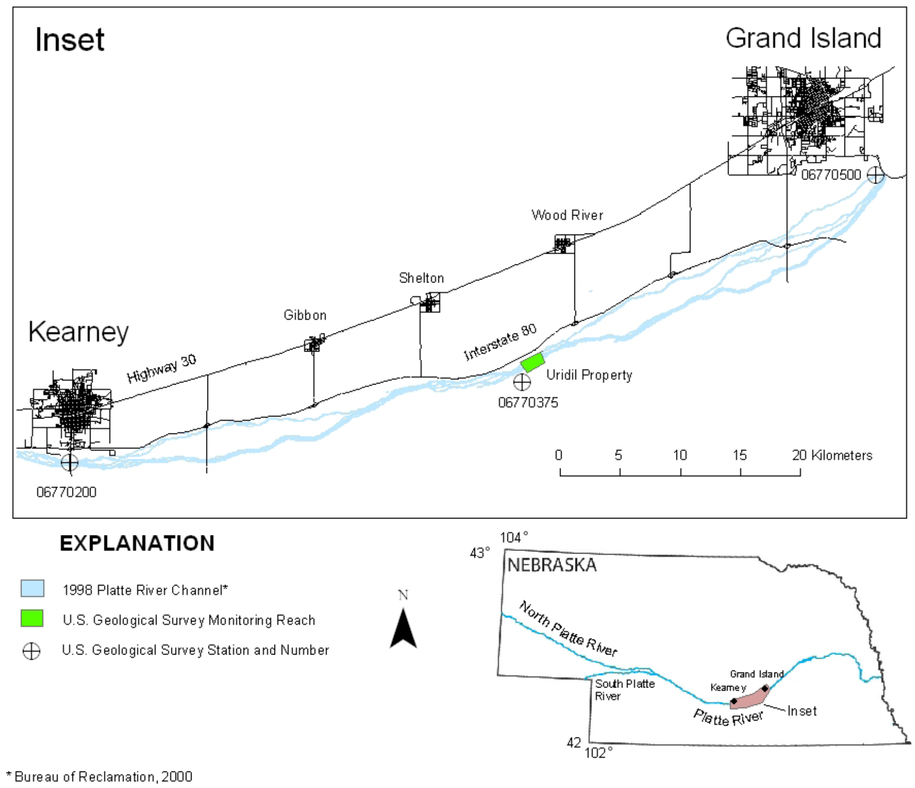


Figure 1. Map showing the location of the Uridil Property study site along the central Platte River, Nebr.

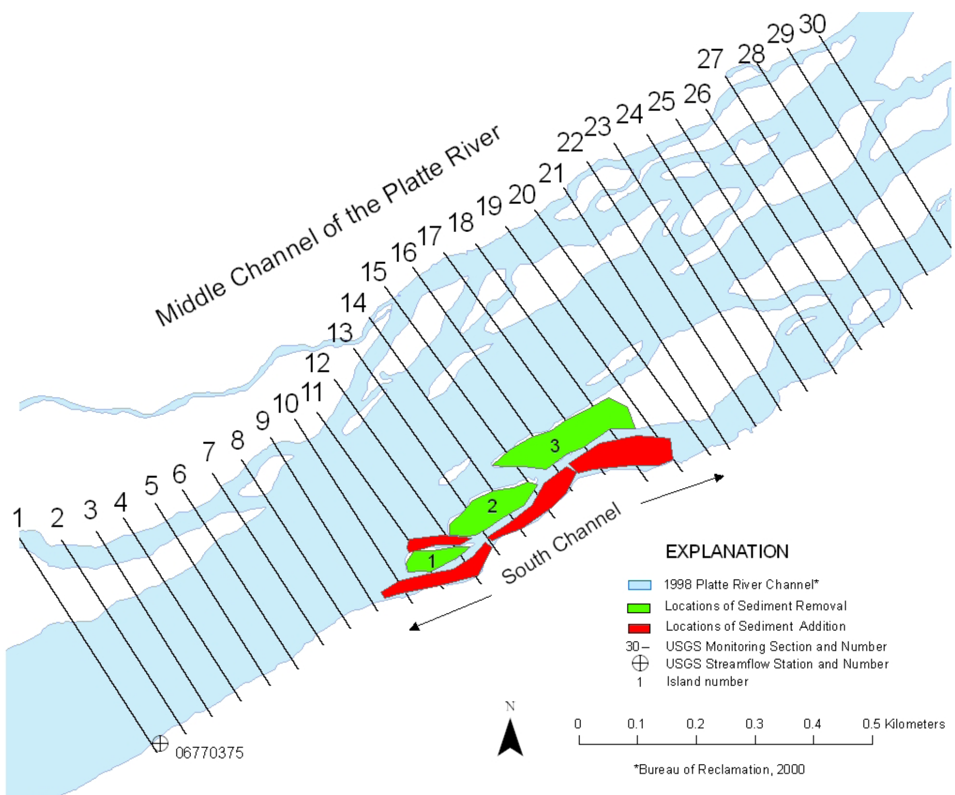


Figure 2. Map of the Uridil Property study site showing the location of monitoring transects and locations of sediment removal and addition. Flow is from lower left to upper right.

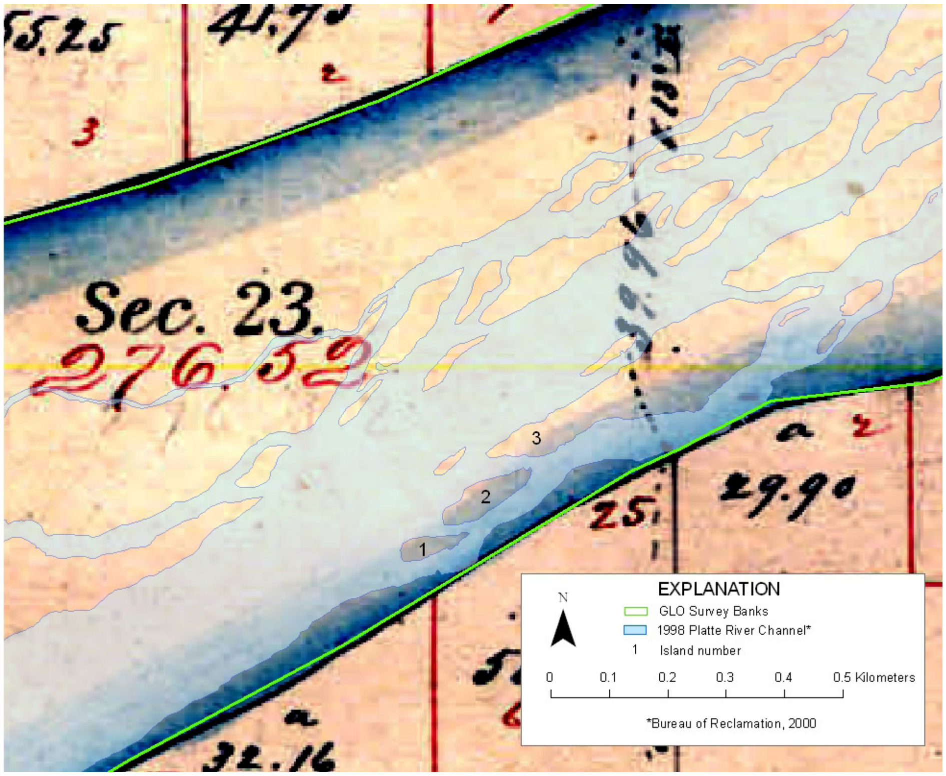


Figure 3*A*. Map created by the General Land Office circa 1867 using surveys from 1859 to 1867.

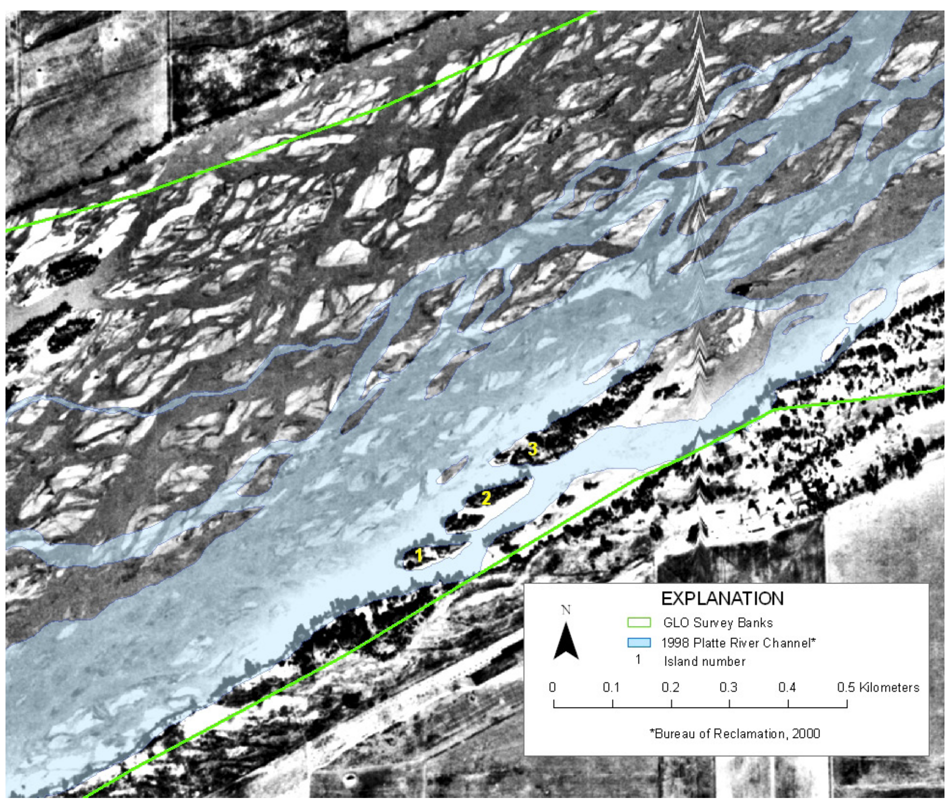


Figure 3*B*. Black and white aerial photograph of the Uridil Property taken October 24, 1938 by the Soil Conservation Service. Distortion in image is a result of warping the image during the georeferencing process.

the 1938 photograph was taken, these flows did not prevent vegetative succession on the islands. The shape and position of the south bank of the middle river channel in 1938 is similar to that delineated by the GLO surveys, suggesting that the islands were not connected to the river bank in 1867, although this does not rule out the possibility that they were connected sometime before this.

In the aerial photograph taken of the study site on April 27, 1951, the higher portions of the islands vegetated in 1938 are also vegetated in 1951 (fig. 3*C*). However, many sandbars that appeared bare and unvegetated in the 1938 photography are vegetated in the 1951 photography. This is especially true along the north side of the channel where these vegetated sandbars have begun to accrete to the river bank. The size of island 3 in particular appears to have increased from 1938 to 1951 as a sandbar accreted to the downstream end of the island.

Aerial imagery collected between July 16 to 23, 2006 shows the extent of lateral accretion and channel narrowing in this reach since 1938 (fig. 3*D*). A sandbar that was present along the south bank in 1938 and 1951 between islands 2 and 3 forms the south bank of the river in 2006. The distance between high banks in the study reach has been reduced by approximately 50 percent from 1938 to 2006, approximately 880 m to 426 m respectively. Most of the bank to bank width in the 1938 photograph was relatively unvegetated, indicating that few islands were present and most of the channel was likely made up of low elevation sandbars that would be expected to be mobile or active if inundated. Even though the 2006 photograph was taken after the islands in this study were cleared of vegetation and the sediment removed, the channel is obstructed in other parts of the reach by the presence of high and stable vegetated islands. These islands surfaces would be inundated and mobilized only under high magnitude flow events. Successive years of low magnitude flows leading up to the 2006 photograph accentuated the low elevation channels in this reach, providing preferential flow paths to route water and sediment at these flows.

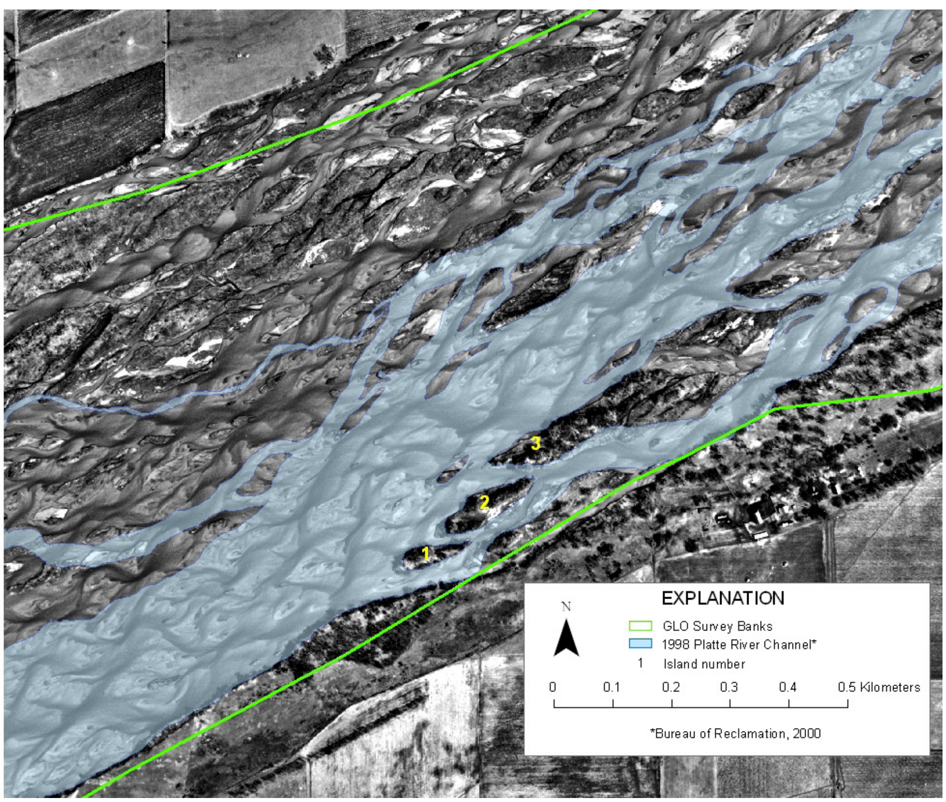


Figure 3*C*. Black and white aerial photograph of the Uridil Property taken April 27, 1951.

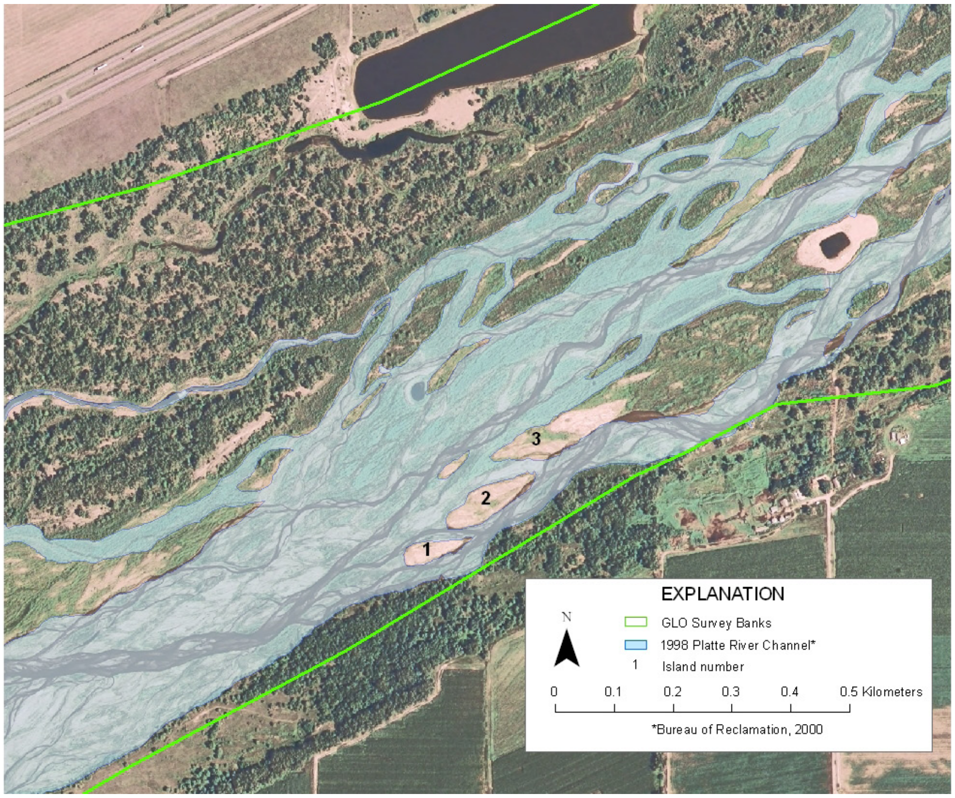


Figure 3*D*. Natural color photograph of the Uridil Property taken between July 16 to July 23, 2006.

Hydrology

Upstream from the study site, flow in the Platte River is regulated by upstream diversions and impoundments (Williams, 1978; National Research Council, 2004; U.S. Department of the Interior, 2006). The study site is located between two USGS streamflow-gaging stations. The USGS streamflow gaging station 06770200 Platte River near Kearney, Nebr. (contributing drainage area 136,078 km^2) is located approximately 39 km upstream from the study area and USGS streamflow-gaging station 06770500 Platte River near Grand Island, Nebr. (contributing drainage area 137,114 km^2) is located approximately 34 km downstream (fig. 1). The mean daily streamflows from the Grand Island gage over the period of the study and the mean of the daily mean discharge at the Grand Island gage from 1941 to 2008 (*http://waterdata.usgs.gov/ne/nwis/dv/?site_no=06770500&agency_cd=USGS&referred_module=sw*) are shown in figure 4. In addition to the streamflow-gaging stations a recording stage gage (USGS station 06770375 Platte River at Prosser, Nebr.) is located at the upstream end of the study reach (figs. 1, 2). Mean daily stage values recorded at this gage during the study are shown in figure 4.

In the first year of the study, July 1, 2005 to June 30, 2006, the total annual flow was approximately 22 percent of the average total annual flow from 1941 to 2008 and no major peak flows occurred. From July 1, 2006 to June 30, 2007 two major peak flows occurred, February 23, 2007 at 206 m^3/s and April 26, 2007 at 183 m^3/s. These magnitudes fall between peak discharges with a 2 and 5 year reoccurrence interval (Soenksen and others, 1999). The total annual flow in this year was 57 percent of the average total annual flow. In the final year of the study, 2007 to 2008, a flow of a larger magnitude than those observed in 2007 occurred in the study reach (fig. 4). These elevated flows were caused by rain events (Kinzel, 2008). The maximum provisional flow measured at the Grand Island gage was approximately 360 m^3/s. This magnitude falls between peak discharges with a 5 and 10-year reoccurrence interval, 306 and 391 m^3/s, respectively (Soenksen and others, 1999). The total annual flow from July 1, 2007 to June 30, 2008 was 76 percent of the average total annual flow.

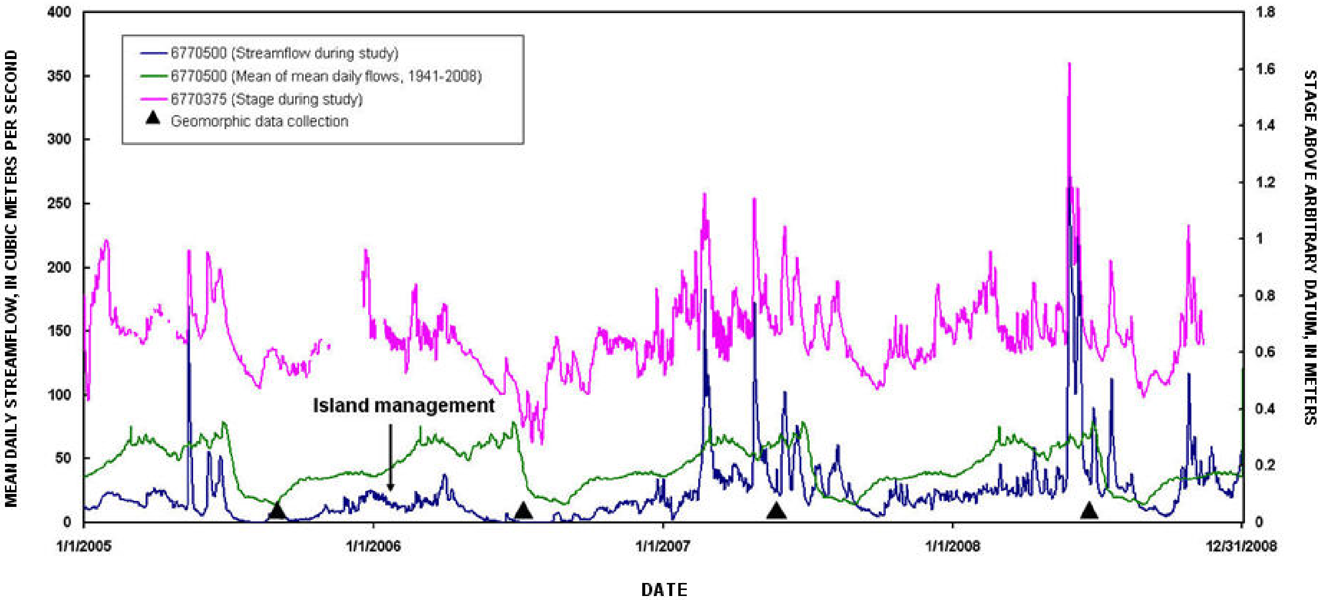


Figure 4. Hydrograph showing the mean daily streamflow during the study and the mean of the mean daily flows between 1941 to 2008 at USGS 06770500, Platte River near Grand Island, Nebr., the mean daily stage during the study at USGS 06770375, Platte River near Prosser, Nebr., and the dates of geomorphic data collection and island management in the study reach.

Management Activities

The elevations of the managed islands were designed so that the islands would both remain above the water surface (emergent) at a flow of 34 m^3/s, an anticipated high flow during the tern and plover nesting season, and would be below the water surface at a flow of 85 m^3/s, an anticipated high spring peak flow. It was thought that a peak flow of this magnitude, either from a high natural spring flow or an artificial pulsed-flow event, would overtop and have the potential to scour vegetation seedlings on the island surfaces. The scouring action and erosion provided by these higher events was thought to be capable of maintaining the island surfaces free from vegetation and preserving them as suitable tern and plover nesting habitat. The volume of sediment removed from the islands was estimated in the project proposal (Platte River Whooping Crane Maintenance Trust, 2003) by taking the individual areas of the three islands and multiplying by an estimated elevation that each island was to be lowered. It was estimated that 27,378 m^3 of sediment was to be removed from the islands.

On February 3, 2004 a permit application was submitted by the PRWCMT to the U.S. Army Corps of Engineers to discharge sediment under Section 404 of the Clean Water Act and concurrently to the Nebraska Department of Environmental Quality for a Water Quality Certification under Section 401 of the Clean Water Act. Approval to proceed with the project was given on April 23, 2004. However, changes in the scope and personnel involved in the project delayed selection of a contractor and initiation of work until February 1, 2006. The contractor began the process of clearing the vegetation on the three islands in February of 2006 (fig. 2). The vegetation was removed using a bulldozer to scrape the vegetation and top soil from the islands. The contractor then proceeded from upstream to downstream using a bulldozer (see cover photograph) to scrape the majority of the sand from the island tops south into the adjacent river channel. This part of the study reach is referred to as the south channel (fig. 2) and should not be confused with the south channel of the Platte River which is a separate braid of the river. The island sand was spread evenly into the flowing water to avoid damming the channel and to permit the water to mobilize the sediment. Observations made by the author during this process indicated that even in relatively small depths of flowing water (less than one-half meter) sand mounds deposited in the channel by the bulldozer were easily eroded by the flowing water and the material was transported downstream in a matter of a few minutes. The contractor completed work on March 6, 2006 and submitted an invoice that indicated that 14 days (119.5 hours) were spent clearing, leveling, and reshaping the islands (Kenny Dinan, USFWS, written communication, January 20, 2009). In the time period following the management and up to the final topographic survey completed for this report (March 2006 to June 2008), the managed islands were not disced (Kenny Dinan, USFWS, written communication, January 20, 2009).

Methods

Channel Morphology

Thirty transects spanning the entire width of the middle channel of the Platte River (fig. 2) were established in the study reach in 2005. The transects were spaced approximately every 55 m and were distributed to obtain measurements of channel morphology upstream from, within, and downstream from the area where island clearing and leveling activities were to occur. Ten transects were placed immediately upstream from the islands, 10 across the islands, and 10 immediately downstream (fig. 2). The horizontal coordinates of the transect end points, Universal Transverse Mercator (UTM) coordinate system in the North American Datum of 1983, were defined in the office using a digital aerial orthophotograph of the study area. The horizontal coordinates were then uploaded into global positioning system (GPS) data controllers for use in the field.

A survey-grade global positioning system (GPS) was operated in real-time kinematic mode (RTK) to transmit corrections from a fixed GPS receiver (base station) located over an established concrete benchmark to roving GPS receivers. The manufacturer reported precisions of an RTK GPS measurement are described as centimeter (cm) level (Trimble Navigation Ltd, 1998). In practice the precisions of RTK measurements were found to be approximately +/- 2 cm in the horizontal and +/- 3 cm in the vertical based on periodic checks against fixed monuments during the surveys. The base station for the topographic surveys used coordinate values obtained from a survey collected in 1998 as part of a contract to the United States Bureau of Reclamation (Druyvestein, Johnson & Anderson, 1998). Surveyors operating the roving GPS receivers in RTK mode could precisely navigate to the location of the transect end points using output from a handheld data collector. After a transect endpoint was located on one bank, surveyors could then follow and position themselves interactively along an imaginary line connecting that transect endpoint to the corresponding endpoint of the transect on the other bank. While traversing the transect lines, surveyors were instructed to measure a topographic point every few meters in addition to the locations of major changes in elevation gradient (for example, the top and bottom of a river bank), and locations where the water surface intersected a landform (river bank, sandbar, or island). Ellipsoidal heights measured with the GPS were converted to orthometric heights relative to the North American Vertical Datum of 1988 (NAVD88) using GEOID 99 (Smith and Roman, 2001). In addition to points collected along the transects crossing the islands, topographic points were also collected in distributed locations on the island surfaces before and after the management activities. Taken together these points helped to estimate the quantity of material removed from these surfaces. River channel topographic surveys were not conducted downstream from transect 18 (fig. 2) in 2008 due to a change in landowner permissions for survey access.

In the office, survey data from the data collectors were downloaded to an office computer and the locations of the points surveyed along a transect were related to the horizontal coordinates of the left bank transect endpoint using a Euclidian distance equation (the left bank of the river is defined as the bank on the left side of an observer facing down river). The surveyed elevations were then linearly interpolated to obtain a set of points for each transect spaced at 1-m increments. This procedure is identical to that described by Kinzel and others (2006a). Figure 5 illustrates the elevations along transect 14 surveyed before and after the management activities. Graphs that include surveys along all of the transects collected during all of the site visits are included in Appendix 1.

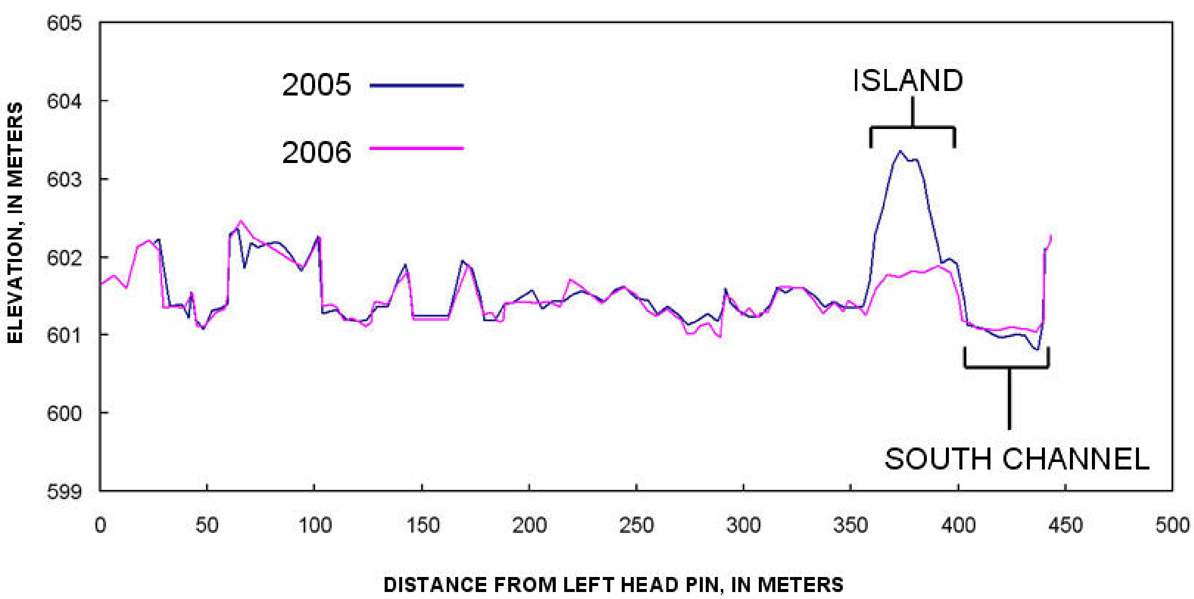


Figure 5. Topographic surveys collected along transect 14 before (2005) and after (2006) island management.

The interpolated transect elevations were used to compute a mean elevation for segments along the transects, including the entire transect (left bank to right bank), the managed islands, and the south channel. For example, two points on the interpolated transect were used to define the extent of the island surface. The mean elevation was computed by taking the average of the interpolated points that were between those two points. Similarly, points were identified along the interpolated transects that defined the entire active channel (left to right bank) and the south channel, a segment between the islands that were managed and the right bank of the river.

Annual area changes between segments on the transects were computed by subtracting the elevation at each interpolated 1-m position from its corresponding position in a subsequent year. If the elevation value for the subsequent measurement was greater than the previous year's measurement an increase in elevation was recorded, and if it was less than the previous year a decrease in elevation was recorded. A net change in area was approximated for each transect by multiplying the net change in elevation at each point by the 1-m distance between the mid-points and summing the changes between all of the points along the transect segment.

Detailed topographic surveys were conducted along channel transects before and after the island leveling (fig. 2). These transects were supplemented with additional points collected along the island surfaces and were used in the ArcGIS™ software (ESRI Redlands, Calif.) to create surfaces for each survey. The software estimated the volume of sediment removed from the islands by differencing these surfaces.

Island and Bed Sediment Sampling

Sediment was sampled from the islands in the channel and from the bed of the river before and after the management activities to document the variability and spatial distribution of sediment grain sizes in the study reach. Sediment was sampled at regular intervals in 2005, approximately every 22 m, along every other river transect using a 'can on a stick' bed sediment-sampling device (Edwards and Glysson, 1999). The location of the sediment samples were recorded with the GPS surveying equipment. In 2006 a subset, 173, of the 250 locations where sediment samples were obtained in 2005 were resampled. The samples collected in 2006 were obtained in the lower elevation areas of the transects as opposed to the samples collected in 2005 which also included samples on higher elevation island surfaces along the transects. Because these higher islands surfaces were not overtopped by water and subjected to fluvial processes or to management activities in the intervening period, they were not expected to provide additional information and thus were not resampled in 2006.

Sediment was sampled by plunging the bed-sediment sampler into the river bed, exposed sandbar, or high island surface and removing the top 5 centimeters of sand. If vegetation and top soil were present on the high islands, the top few centimeters of this material was removed before the sediment was sampled at those locations. Each sediment sample was placed in a separate sample bag and labeled with the date, time, transect number, and sample number. The sediment samples were numbered in increasing order from the right to the left bank The samples were processed at the USGS Geomorphology and Sediment Transport Laboratory (Golden, Colo.) to determine their grain-size distribution. Grain-size analysis involved mechanically agitating the sample through a series of sieve stacks at ½ phi intervals (a phi unit is defined as the negative base 2 logarithm of the grain diameter in millimeters). The cumulative mass of the sample was noted at each interval and plotted as a cumulative size-distribution curve. The sizes for which 16, 50, and 84 percent of the sample by mass were finer than were computed by interpolation of the cumulative size-distribution curves. These parameters are denoted as D_{16}, D_{50}, and D_{84} respectively. The size parameters of each sample and their sampling locations within the channel are provided in Appendix 2.

Surveyed GPS coordinates for each of the 173 bed-sediment sample locations were used to map the spatial distribution of in-channel bed sediment characteristics before (2005) and after (2006) the management treatment. A geographic information system (GIS) layer delineating the river channel and islands developed from the 1998 imagery (Bureau of Reclamation, 2000) was used to define the boundary of an inverse-distance weighted spatial interpolation of the sample parameters. Maps were created showing the D_{50} of samples collected from the river bed in 2005 were subtracted from the D_{50} of samples collected from the river bed in 2006.

Statistical Analysis

A non-parametric technique (the Wilcoxon signed-rank test) was used to detect the significance of pair-wise differences between the interpolated elevations from the annual topographic surveys along various transect segments. This technique was also used to detect the significance of pair-wise differences between the 2005 and 2006 bed-sediment samples. The Wilcoxon signed-rank test is often used as an alternative to the paired student's t-test because it does not require assumptions about the distribution of the measurements (TIBCO Software Inc., 2008). The test evaluates if the null hypothesis, that the samples follow the same distribution, can be rejected provided a given level of significance. If the p value computed by the test is less than the significance level (alpha), the alternative hypothesis, that the samples follow different distributions, can be accepted. The tests used a significance level of 5 percent or 0.05. The Spotfire S+ statistical software package version 8.1 for Windows™ (TIBCO Sofware Inc.) was used to conduct the Wilcoxon signed-rank testing.

Ground Photography

To document changes in the managed islands and the adjacent river channel, ground photographs were taken along the right bank of the river with either a 35-mm single action reflex camera and slide film or a 3.3-megapixel digital camera. Three photographs were taken near each end point, one with the photographer facing upstream, one facing across the channel along the transect, and the third facing downstream. The slide film was developed onto slides that were scanned into digital images at a resolution of 200 dots per inch. Panorama photographs were taken from the right bank at transect 13 looking upstream at two of the three managed islands in 2005 before the management activities and in 2006 following the management activities (figs. 6*A,B*). The collection of ground photographs taken during the study period are provided in Appendix 3. The file name of each photograph indicates the year, transect number, and direction the photograph was taken. Photographs taken upstream are identified (us), along transects (xs), and downstream (ds).

A

B

Figure 6. Panoramic images created from ground photographs taken from the right bank near transect 13. The photographs were taken looking upstream at islands 1 and 2. (*A*) Before the management activities on July 26, 2005 and (*B*) following the management activities on May 20, 2006.

Analysis of Channel Morphology

As the islands prior to leveling were not of uniform height, and the heights used in the preliminary volume computation represented a maximum height on the island, the volume identified for removal in the project proposal (Platte River Whooping Crane Maintenance Trust, 2003) was an overestimate. The ArcGIS™ software calculated the volume of material removed from the islands to be closer to 14,100 m^3, almost half the volume identified in the project proposal. Assuming a bulk density of sand of 1.59 g/cm^3 this volume represents a mass of 22,400 Mg.

Plots of mean elevations along various segments of the transects were made to illustrate the mean-bed elevations for the annual surveys and their standard deviations (fig. 7). For the annual site visits (2005 to 2008) all of the points surveyed between the left and right banks along transects 1 and 30 were used to compute a mean elevation for the transects in this reach (entire channel) (fig. 7*A*). In the reach of the river between transects 11 and 20, the mean elevations on the managed islands are plotted for 2005 to 2008 (fig. 7*B*). The mean elevation of the points surveyed between the island and the right bank (south channel) along transects 11 through 30 are also plotted (fig. 7*C*). Figure 7*A* shows that the reach upstream of the islands (transects 1 to 10) has relatively small standard deviations and as the transects transition downstream and across the managed islands, the standard deviations increase in magnitude. The profiles shown in figure 7*B* indicate the change in the mean elevations on the islands as a result of the management activities. The mean elevation at transect 11 on the island decreased over 1 m from the management. However, it is the only transect with a post-management mean that falls outside the standard deviations of the pre-management measurements. The majority of transects between 11 and 23 in the south channel (13 out of 20) showed an increase in mean elevation in the surveys conducted from 2005 to 2006 (fig. 7*C*), which coincide with the time period of sediment addition, but these changes also fall within the standard deviations of the measurements.

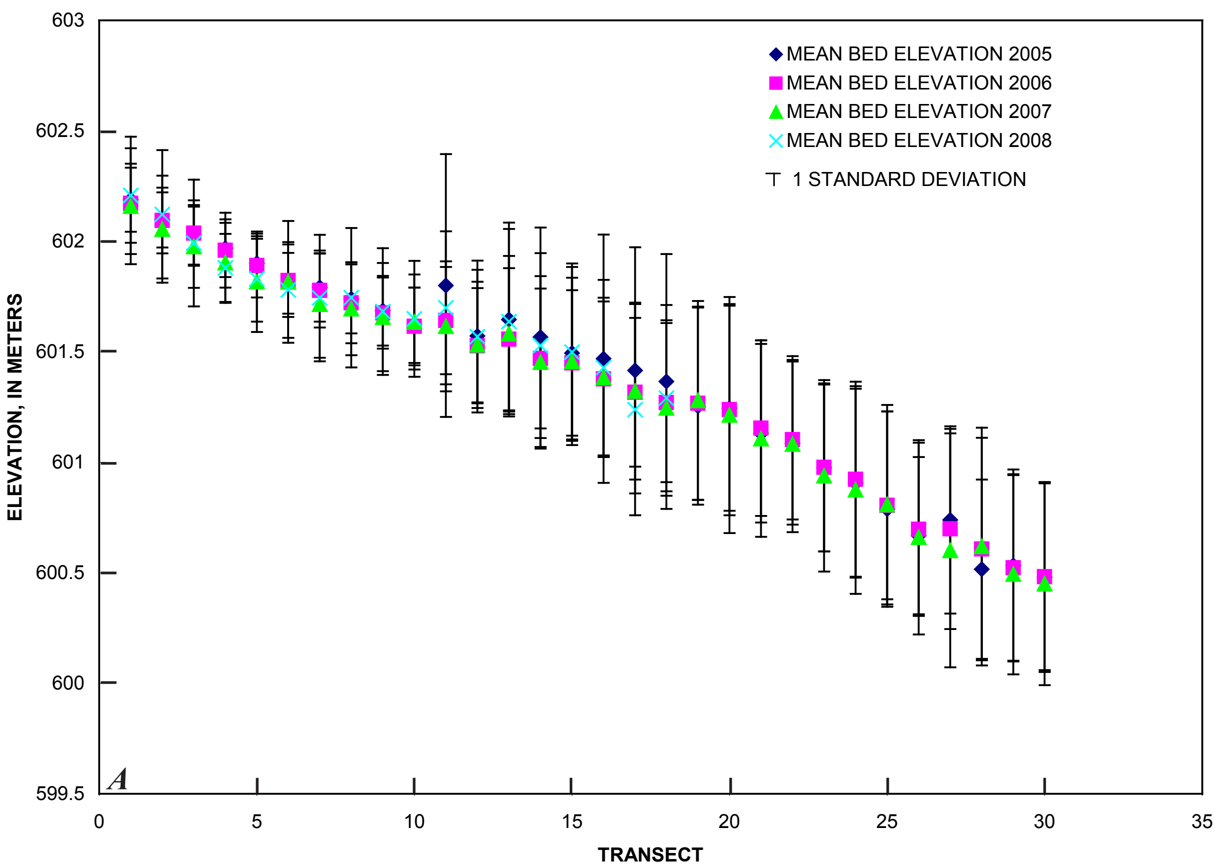
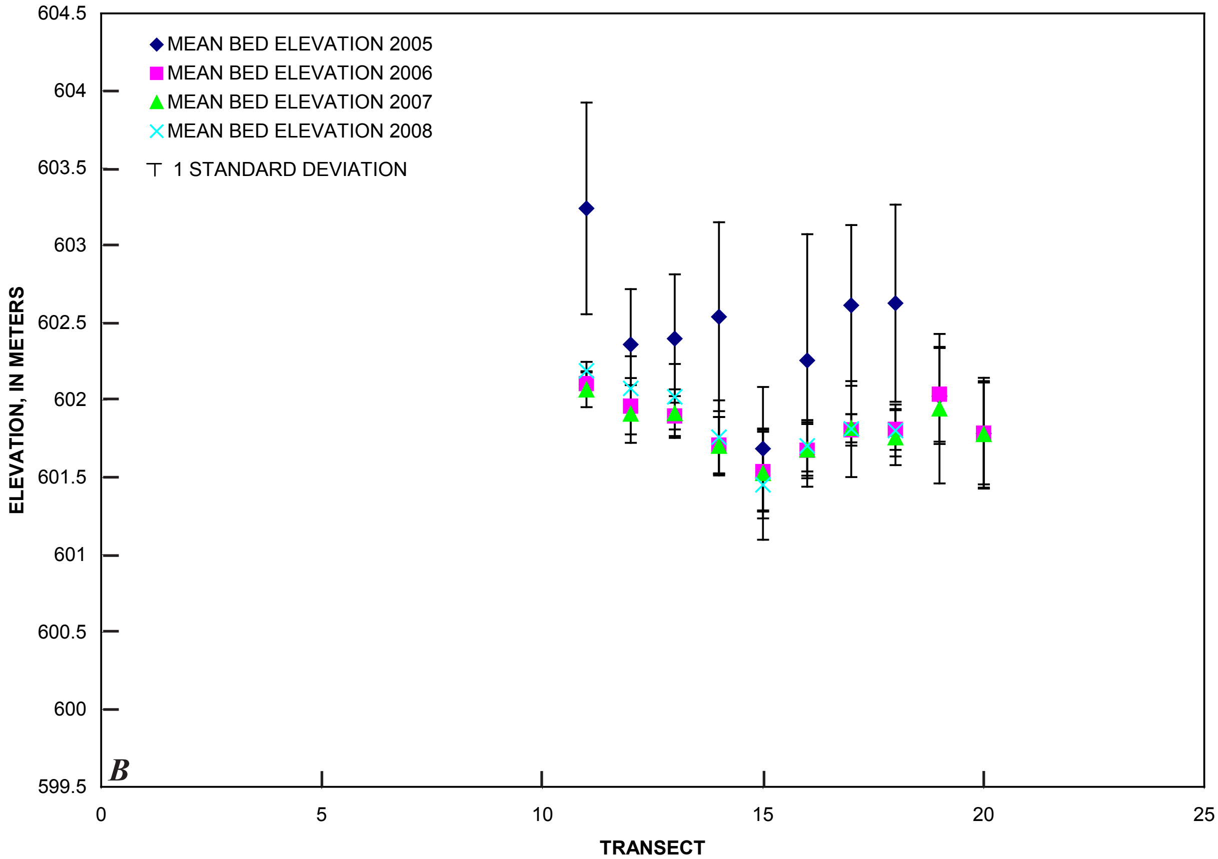


Figure 7. Longitudinal mean bed elevation upstream from, within, and downstream from the management area prior to (2005) and following the management (2006 to 2008) for (*A*) the entire channel, (*B*) the managed islands, and (*C*) the south channel.


604.5
604
603.5
603
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602
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601
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599.5
ELEVATION, IN METERS
MEAN BED ELEVATION 2005
MEAN BED ELEVATION 2006
MEAN BED ELEVATION 2007
MEAN BED ELEVATION 2008
1 STANDARD DEVIATION
B
0
5
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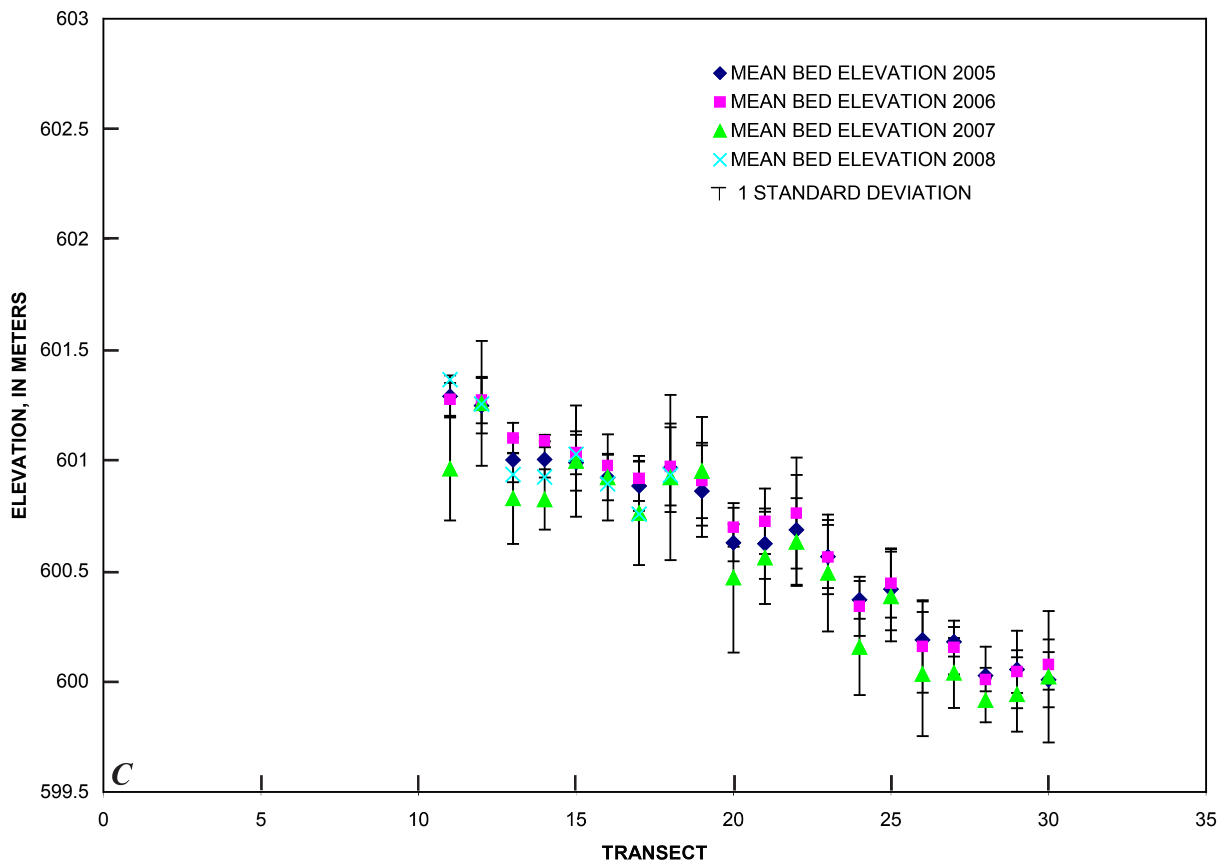
15
20
25
TRANSECT


603
602.5
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600.5
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ELEVATION, IN METERS
MEAN BED ELEVATION 2005
MEAN BED ELEVATION 2006
MEAN BED ELEVATION 2007
MEAN BED ELEVATION 2008
1 STANDARD DEVIATION
C
0
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30
35
TRANSECT

Because of the large variation in elevations surveyed across the islands and the channels compared to the magnitude of change caused by the management activities, using the standard deviation alone to determine statistical significance is not particularly diagnostic. The interpolated transects along the study area were also examined to compute the net changes in area (aggradation plus degradation) between the transects along the entire channel, the islands, and the south channel (fig. 8). Figure 8*A* shows the net change in channel area for the entire channel. In the year between 2005 and 2006 along the area where island management activities were performed (transects 11 to 18) net degradation was measured as the material on the island surfaces was removed and the elevation reduced. In the same time period, a waterfowl pond was excavated in an island along transect 17 (independent of this project) by a downstream landowner. Net degradation along transect 17 was detected from the excavation and net aggradation was measured along transect 18 where the excavated material was deposited. A majority of the transects surveyed across the entire channel showed net degradation from 2006 to 2007. A continuous interval of net aggradation was detected from transect 7 to 16 from 2007 to 2008 which overlaps the area where the island management activities were previously performed and includes the time period with the highest peak flow measured during the study, 360 m^3/s. The profiles in figure 8*B* traverse the island channel segment. As in figure 8*A*, the island management reduced the mean channel elevation from 2005 to 2006. From 2006 to 2007 magnitudes of aggradation and degradation are nearly balanced across the island and from 2007 to 2008 some net aggradation was measured at the upstream end of the islands. Figure 8*C* shows the net gradation profiles computed in the south channel. From 2005 to 2006 a small quantity of aggradation was measured in the area of sediment addition (transects 12 to 19) which extends downstream to transect 22. In the year between 2006 to 2007 a majority of the transects in the south channel underwent degradation while from 2007 to 2008 a small amount of aggradation was detected from transects 11 to 15.

While figures 7 and 8 allow the magnitude of large changes in channel elevation to be visualized, the statistical significance of these and smaller magnitude changes are not readily apparent. The Wilcoxon signed-rank test was used to test the statistical significance of the changes that were identified in figures 7 and 8 (table 1). Of special interest is a determination if the net aggradation along transects near the area of sediment addition in figure 8*C* is statistically significant. The Wilcoxon signed-rank test indicated that the distributions along transects 13 to 16 were significantly different from 2005 and 2006 as were the transects 19, 21, and 22.

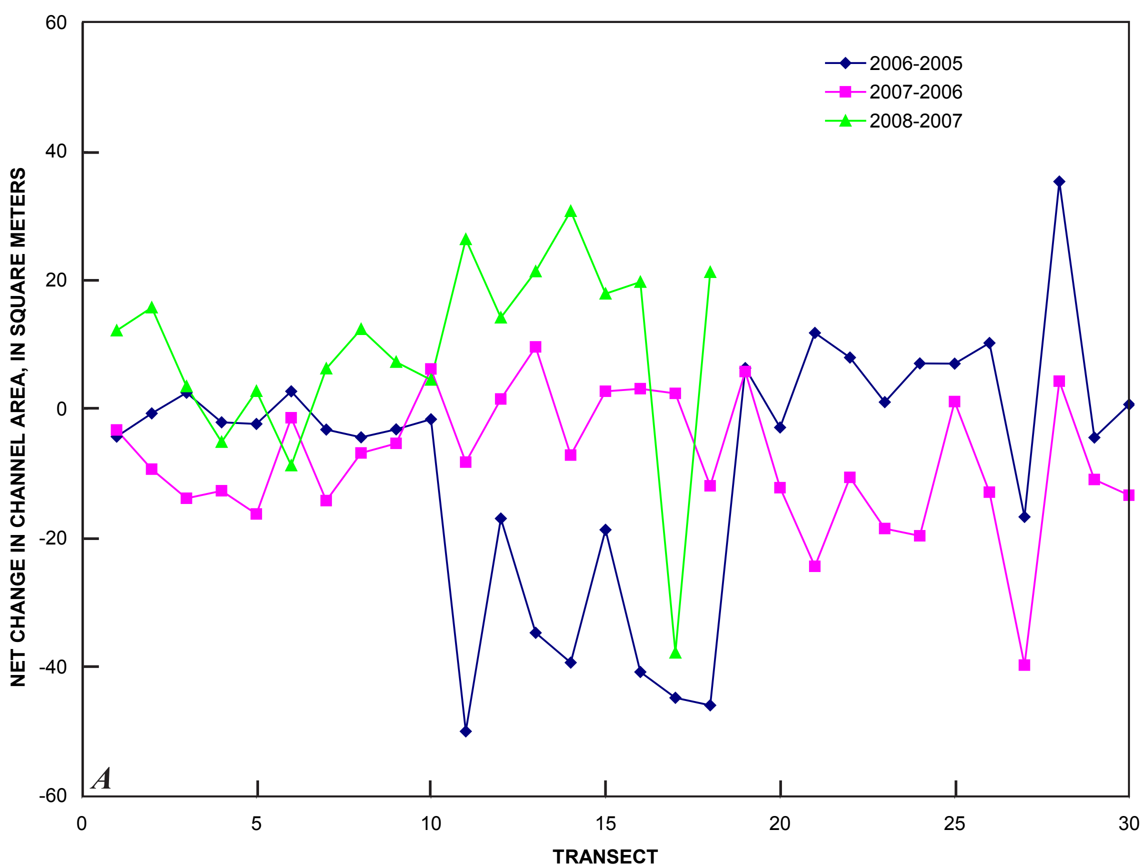
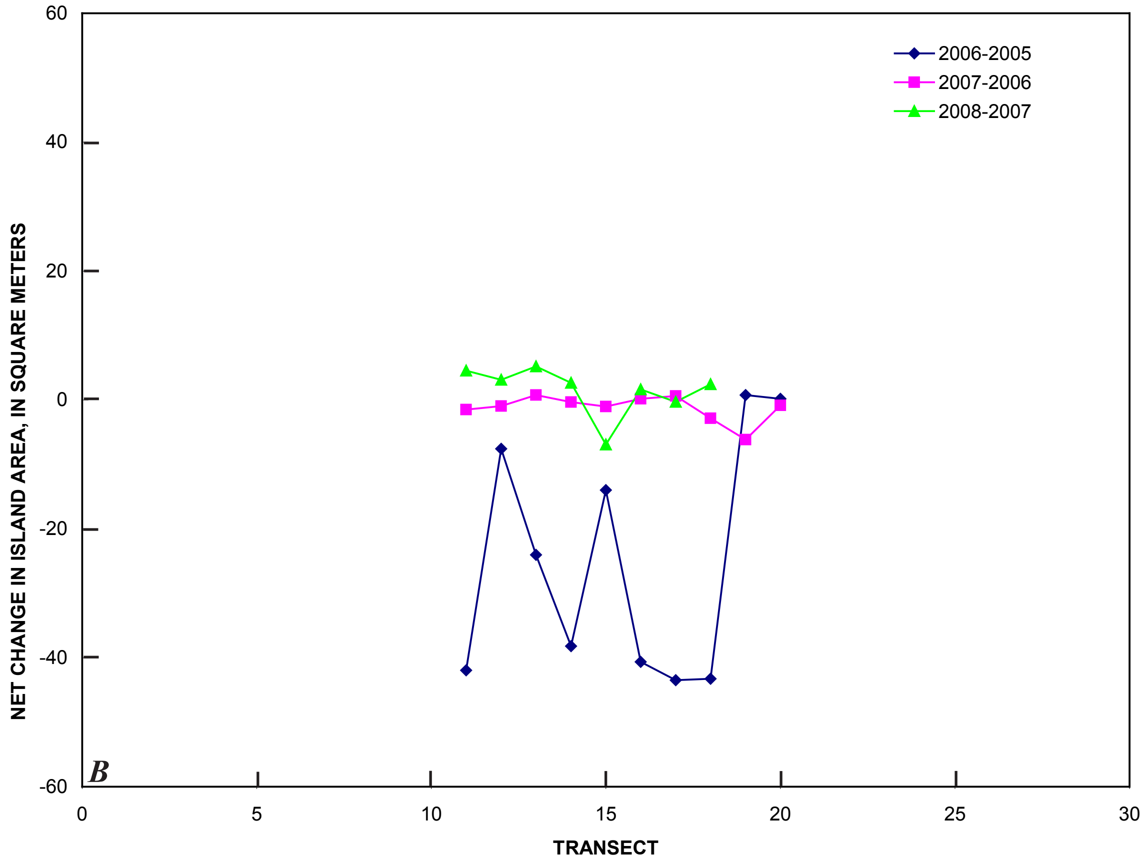
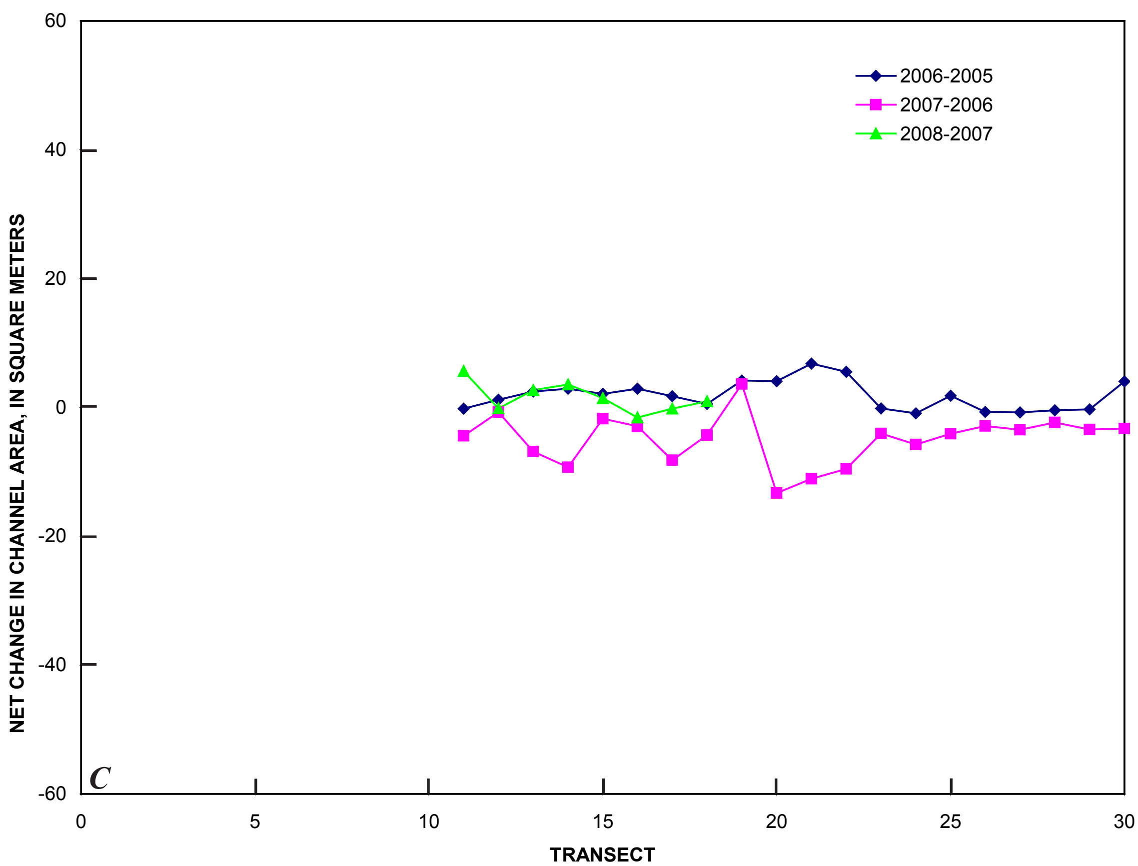


Figure 8. Net change in area between annual transect surveys (*A*) entire channel, (*B*) managed islands, and (*C*) south channel.



60
40
20
0
-20
-40
-60
NET CHANGE IN ISLAND AREA, IN SQUARE METERS
0
5
10
15
20
25
30
TRANSECT
2006-2005
2007-2006
2008-2007
B



60
40
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-20
-40
-60
NET CHANGE IN CHANNEL AREA, IN SQUARE METERS
0
5
10
15
20
25
30
TRANSECT
2006-2005
2007-2006
2008-2007
C

Table 1. Results of Wilcoxon signed-rank test for annual transect surveys. Significant p-values are less than 0.05. [NA, not applicable]

Entire Channel	p-values by year		
Transect	2005–2006	2006–2007	2007–2008
1	0.32	0.01	0.01
2	0.12	0.02	0.01
3	0.00	0.00	0.28
4	0.60	0.00	0.00
5	0.24	0.00	0.01
6	0.01	0.00	0.02
7	0.78	0.00	0.02
8	0.41	0.08	0.00
9	0.50	0.34	0.02
10	0.58	0.00	0.03
11	0.00	0.01	0.00
12	0.00	0.00	0.00
13	0.00	0.00	0.00
14	0.00	0.59	0.00
15	0.00	0.00	0.00
16	0.00	0.00	0.00
17	0.00	0.05	0.40
18	0.00	0.42	0.00
19	0.00	0.00	NA
20	0.67	0.99	NA
21	0.00	0.00	NA
22	0.00	0.65	NA
23	0.14	0.01	NA
24	0.00	0.00	NA
25	0.00	0.32	NA
26	0.00	0.03	NA
27	0.00	0.01	NA
28	0.00	0.00	NA
29	0.46	0.06	NA
30	0.02	0.99	NA

Table 1. Results of Wilcoxon signed-rank test for annual transect surveys. Significant p-values are less than 0.05. [NA, not applicable].—Continued

Managed Islands	p-values by year		
Transect	**2005–2006**	**2006–2007**	**2007–2008**
11	0.00	0.00	0.00
12	0.00	0.00	0.00
13	0.00	0.04	0.00
14	0.00	0.21	0.00
15	0.00	0.14	0.01
16	0.00	0.88	0.02
17	0.00	0.01	0.00
18	0.00	0.00	0.00
19	0.05	0.01	NA
20	0.39	0.95	NA

South Channel	p-values by year		
Transect	**2005–2006**	**2006–2007**	**2007–2008**
11	0.00	0.02	0.36
12	0.18	0.91	0.62
13	0.00	0.00	0.11
14	0.00	0.00	0.01
15	0.02	0.89	0.90
16	0.00	0.05	0.30
17	0.07	0.00	0.85
18	0.78	0.51	0.56
19	0.00	0.00	NA
20	0.00	0.00	NA
21	0.00	0.00	NA
22	0.00	0.03	NA
23	0.66	0.08	NA
24	0.42	0.00	NA
25	0.05	0.00	NA
26	0.73	0.00	NA
27	0.17	0.01	NA
28	0.57	0.00	NA
29	0.64	0.00	NA
30	0.97	0.21	NA

Analysis of Bed Sediment Characteristics

Examination of the maps of bed-sediment median grain size, D_{50}, illustrate that there was a large range in the D_{50} parameter throughout the reach (figs. 9*a* and *b*). The mean D_{50} in 2005 across the reach was 0.69 mm with a standard deviation of 0.37 mm; those collected in 2006 had a mean of 0.68 mm with a standard deviation of 0.59 mm. Figure 9*C* illustrates the spatially interpolated differences. A small amount of fining is seen near the areas of sediment addition (fig. 2). However, other areas in the study reach away from the augmentation underwent similar or even greater magnitudes of fining (fig. 9*C*). The samples collected on all the islands in the reach prior to the management (2005) had an average D_{50} of 0.34 mm and a standard deviation of 0.15 mm, while the samples collected on the islands that were leveled had an average D_{50} of 0.32 mm and a standard deviation of 0.12 mm. The percentage of silt and clay in the island samples ranged between 0.17 percent of the total by mass to 16.63 percent with an average of 4.58 percent and a standard deviation of 5.22 percent.

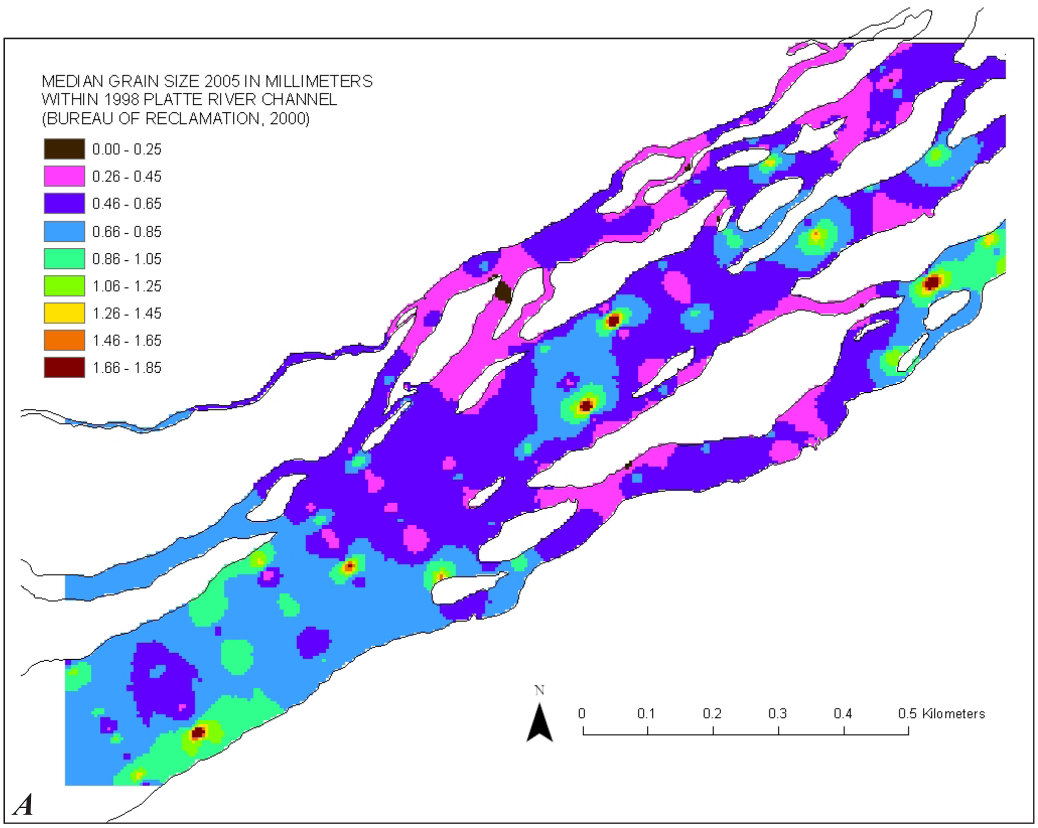
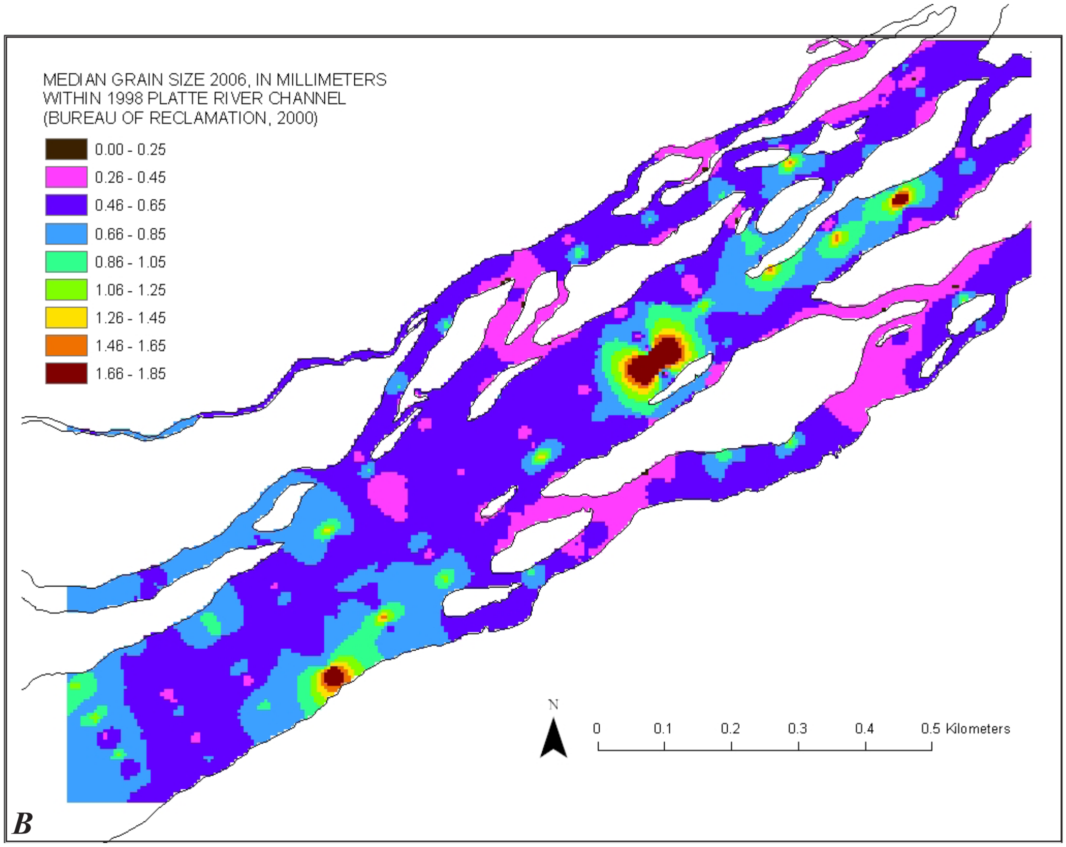
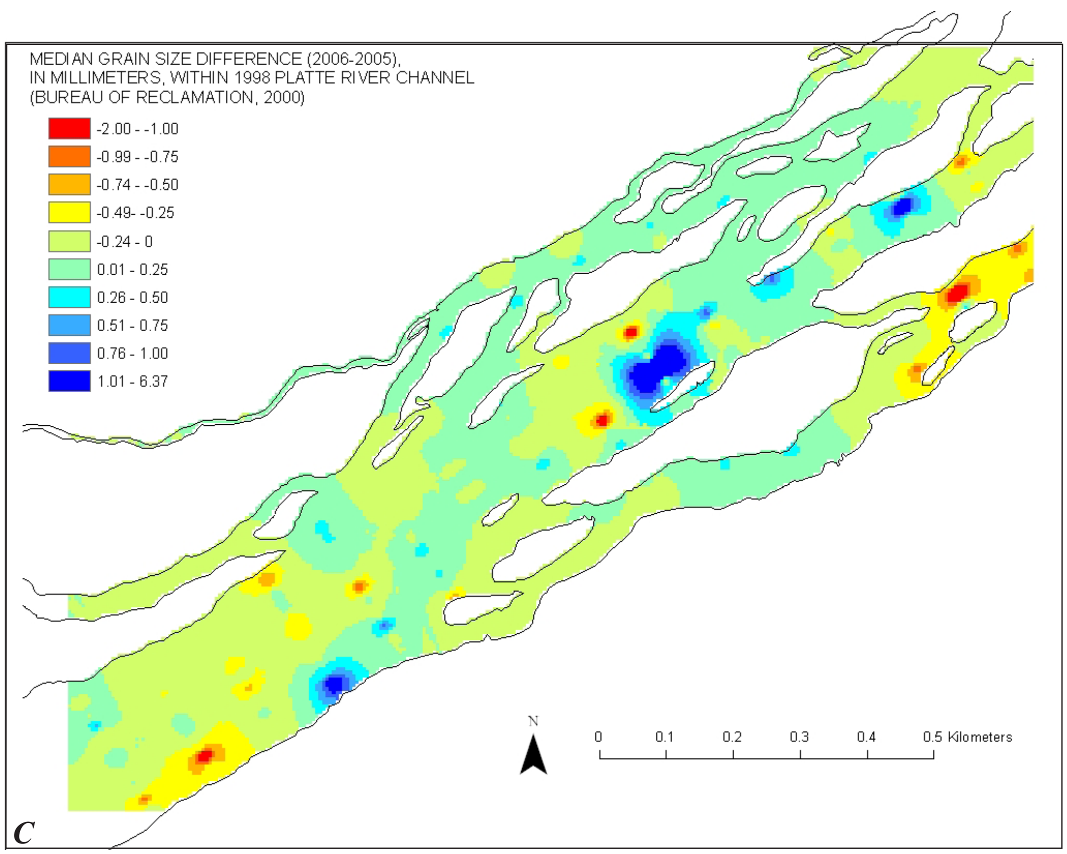


Figure 9. Interpolated median grain size (D_{50}) surface generated from river bed samples (*A*) collected July 2005 and (*B*) May 2006, and (*C*) interpolated difference in bed sediment median grain size (D_{50}) between samples collected in 2005 and those collected in 2006. The 2005 sample results were subtracted from the 2006 sample results; therefore a negative value indicates the area sampled became finer from 2005 to 2006 and a positive value indicates the area sampled became coarser.


MEDIAN GRAIN SIZE 2006, IN MILLIMETERS
WITHIN 1998 PLATTE RIVER CHANNEL
(BUREAU OF RECLAMATION, 2000)
0.00 - 0.25
0.26 - 0.45
0.46 - 0.65
0.66 - 0.85
0.86 - 1.05
1.06 - 1.25
1.26 - 1.45
1.46 - 1.65
1.66 - 1.85
N
0
0.1
0.2
0.3
0.4
0.5 Kilometers
B


MEDIAN GRAIN SIZE DIFFERENCE (2006-2005),
IN MILLIMETERS, WITHIN 1998 PLATTE RIVER CHANNEL
(BUREAU OF RECLAMATION, 2000)
-2.00 - -1.00
-0.99 - -0.75
-0.74 - -0.50
-0.49- -0.25
-0.24 - 0
0.01 - 0.25
0.26 - 0.50
0.51 - 0.75
0.76 - 1.00
1.01 - 6.37
N
0
0.1
0.2
0.3
0.4
0.5 Kilometers
C

Samples collected along transect 11 were used to illustrate the variability in grain sizes across a transect and on a managed island. Figure 10 shows the grain-size distribution of samples collected along transect 11 in 2005. The size distributions of the 13 samples obtained in the river channel were averaged to compute a mean grain-size distribution. The D_{50} of this average distribution was 0.49 mm compared with a maximum D_{50} of 1.5 mm and minimum D_{50} of 0.25 mm. The D_{50} of the sample obtained from the island along transect 11 was 0.22 mm.

The Wilcoxon signed-rank test was also used to determine if the size parameters computed for sediment samples collected in 2005 followed the same distribution as those collected in 2006. Table 2 shows the results of the analysis for 3 size parameters collected in different areas of the study reach. Samples collected in the entire reach, input, managed, and output reaches, and the reach along the south channel were tested. The D_{16} of the samples collected in the entire reach in 2006 were determined to be of a different distribution that was finer than that sampled in 2005. The D_{16} and D_{50} sizes of the input reach samples collected in 2005 were also finer than those measured in 2006 and determined to be statistically significant. The managed or output reaches did not show significant changes in the sediment sizes considered. The south channel indicated that the D_{84} showed a significant increase from 2005 to 2006 (table 2).

Table 2. Results of Wilcoxon signed-rank test for the size parameters in the 2005 and 2006 sediment samples. [D_{16}, size for which 16 percent of the sample by mass is finer; D_{50}, size for which 50 percent of the sample by mass is finer; D_{84}, size for which 84 percent of the sample by mass is finer]

Stratification	p-values by parameter			n
	D_{16}	D_{50}	D_{84}	
All samples	0.03	0.16	0.70	173
Input	0.03	0.04	0.18	57
Managed	0.96	0.99	0.58	79
Output	0.06	0.65	1.00	37
S. channel	0.12	0.11	0.04	24

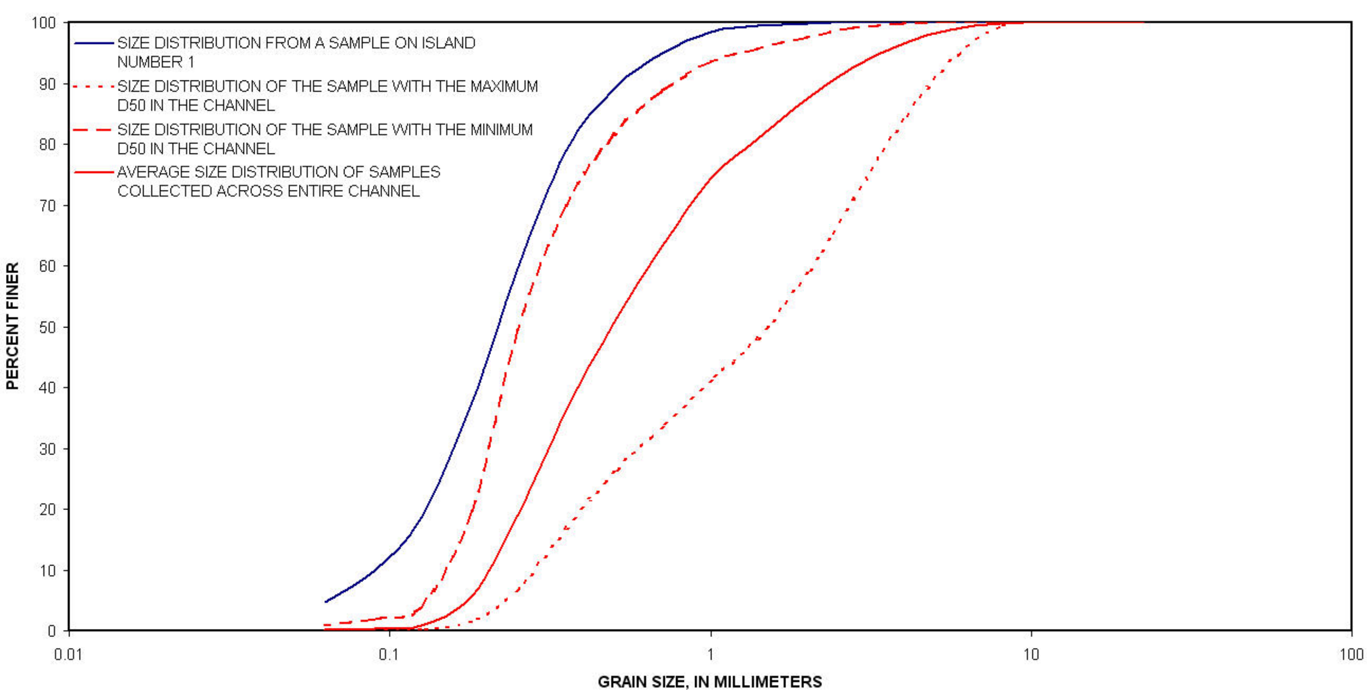


Figure 10. Grain-size distribution of sediment samples collected along transect 11 in the Uridil Property in 2005.

Inferences from Habitat Enhancement Activities

The grain-size distribution of island sediment sampled in the study reach was finer that that which was present on the river bed. When introduced to the river, these relatively fine-grained sands were easily transported down river by suspension while the coarser fraction was made available to contribute to the elevation of the river bed. Statistical analysis of bed elevations in the area of sediment addition provided evidence that elevated bed levels were significantly raised and aggradation occurred in the time period of the management activities, providing a causal linkage. However, it does not eliminate the possibility that the changes in mean bed elevation measured in the south channel in this time period were the result of natural fluvial processes. Elevated river flows in the final 2 years of the study also occurred over the same period of statistically significant but opposite changes. Net degradation along the majority of transects in the entire reach segment occurred in 2007 while in 2008 net aggradation was observed in the majority of the transects surveyed. These differential responses could be attributed to the variation in flow magnitudes and (or) the magnitude of upstream sediment supply.

Bed elevation adjustments in natural river channels are forced by the supply rate and caliber of sediment loads imposed on them. Adjustments are also influenced by the effects of flow regime (magnitude, duration, and rate of change) which interacts with the sediment supply influencing the resultant sediment storage or evacuation in a natural channel. Controlled experiments in laboratory channels have been used to examine the effects of sediment supply on channel elevation (Soni and others, 1980; Germanoski and Shumm, 1993; Madej and others, 2009). These approaches are instructive but simplify the effect of reach-scale hydraulics which are driven by topographic complexity. Flume studies also have difficulty simulating long time scales over which natural flow regimes influence sediment storage. Acquiring this insight from field data sets also is problematic given the inability to either accurately measure or manipulate key variables. However, because some level of topographic monitoring will be required at sediment augmentation sites for permitting purposes, standardizing the monitoring methodology and analysis techniques will facilitate inter-comparison of the empirical results. Results from the study described in this report should stimulate efforts toward this objective.

More temporal intensive sediment monitoring which would include both bed-load, bed-sediment, and suspended-sediment sampling during an augmentation experiment would provide more detailed information and perhaps a better estimate of sediment residence time. These data could contribute toward a better understanding of the effect of shear stress on local bed-load and suspended-load transport and how the addition of fine-grained sand influences the caliber of bed sediment in the channel over shorter time scales furthering the development of computer models that simulate these processes.

If island sediment is to be used to augment natural supplies and alter channel elevations, an understanding of the size distribution of the added material is essential. The deposition history, fluvial or eolian, can produce varying size distributions which influence both the persistence of added material and potential for bed armoring. In addition, the supplies of island sediment are finite and may be locally exhausted during a multi-year sediment-augmentation program; therefore, sustained addition of sediment is needed if the goal.

The U.S. Fish and Wildlife Service's spring 2006, 2007, and 2008 airboat surveys did not observe tern and plover nests on any of the islands modified as part of this project (Jeff Runge, USFWS, oral communication, 2008). Growth of phragmites (common reed) on the islands following clearing required subsequent management in 2008 using both herbicides and mechanical discing. The addition of coarser substrate to the islands has also been identified as a means that could be used in the future to provide suitable nesting habitat for terns and plovers (Kenny Dinan, USFWS, written communication, 2008).

Summary and Conclusions

This report presents an analysis of channel morphology and bed sediment characteristics based on data collected in the Platte River Whooping Crane Maintenance Trust (PRWCMT) Uridil Property during water years 2005 to 2008. The report is intended to provide the data necessary to detect the physical response of the river channel to a management strategy designed to enhance in-channel habitat for migratory water birds. This strategy also includes components of an approach outlined by the Platte River Final Environmental Impact Statement and the Platte River Recovery Implementation Program intended to benefit endangered and threatened species in the Platte River basin.

Repeat topographic surveys along the study reach indicate that the sand that was mechanically introduced into the south channel as a result of this project had a relatively short residence time. Increases in mean-bed elevation and net aggradation detected 3 months after sediment addition were not observed 15 months later. The changes in bed elevation in the south channel from natural flows were of comparable magnitude to the changes in bed elevation that could be attributed to the effect of the mechanical sediment addition. This fact highlights the need for sustained addition of sediment to channels if the goal of sediment addition is to raise and maintain bed elevations. Subtraction of median grain sizes from samples collected in 2005 from those collected in 2006 indicate a subtle fining of bed sediment near the sediment-addition site. However, fining of bed-sediment samples during this time period was not found to be unique to the areas of sediment addition or statistically significant.

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