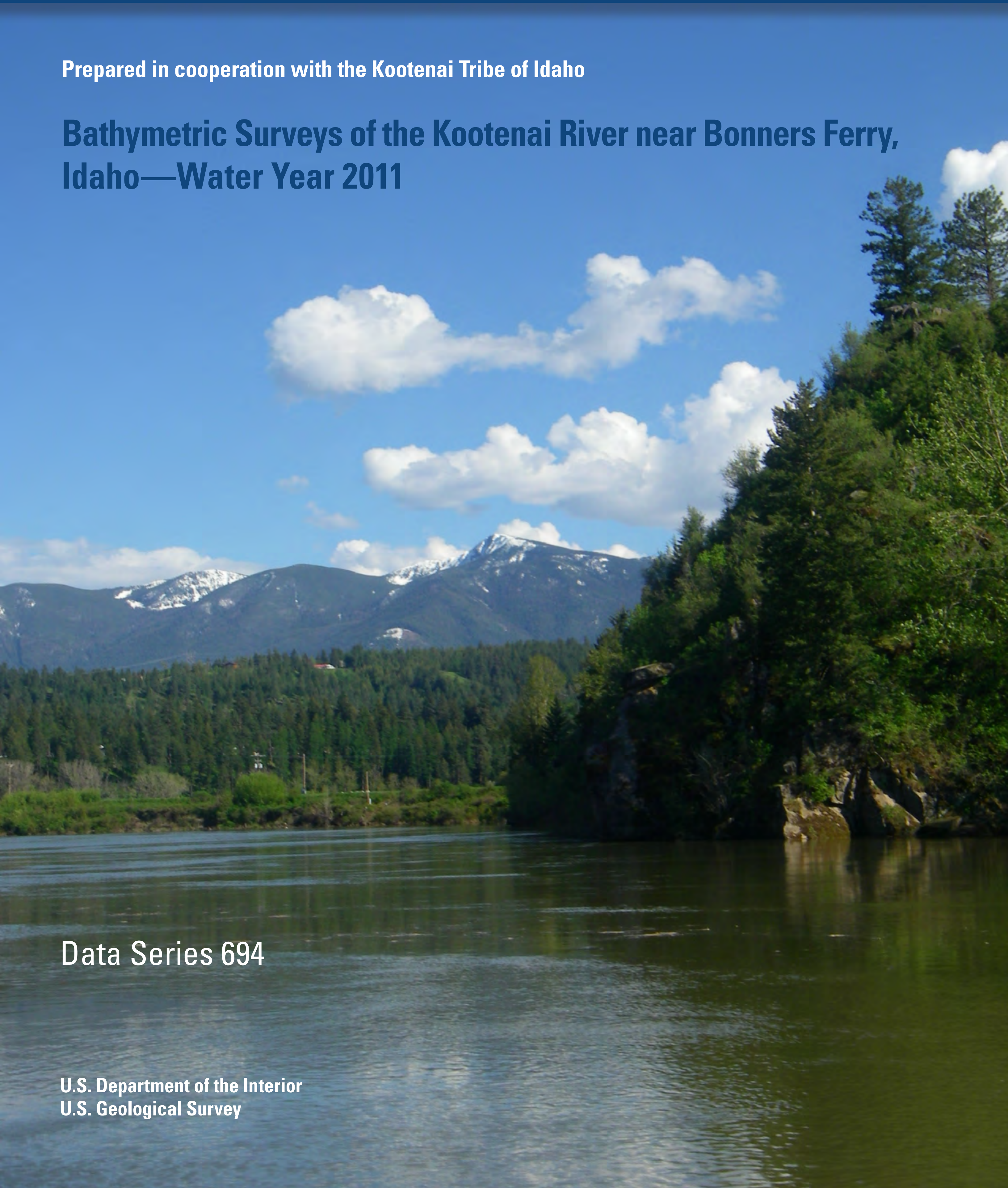
Prepared in cooperation with the Kootenai Tribe of Idaho

Bathymetric Surveys of the Kootenai River near Bonners Ferry, Idaho—Water Year 2011



Data Series 694

U.S. Department of the Interior
U.S. Geological Survey

Front cover: Ambush Rock (foreground) and Clifty Mountain (background) photographed from the Kootenai River, Idaho. Photograph taken June 2011 by Ryan L. Fosness, U.S. Geological Survey.

Back cover: Tree root wads used to protect the levees along the Kootenai River near River Mile 134, Idaho. Photograph taken June 2011 by Ryan L. Fosness, U.S. Geological Survey.

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By Ryan L. Fosness

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U.S. Department of the Interior
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U.S. Department of the Interior
SALLY JEWELL, Secretary

U.S. Geological Survey
Suzette M. Kimball, Acting Director

U.S. Geological Survey, Reston, Virginia: 2013

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Suggested citation:
Fosness, R.L., 2013, Bathymetric surveys of the Kootenai River near Bonners Ferry, Idaho, water year 2011: U.S. Geological Survey Data Series 694, 26 p.

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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)

Bathymetric Surveys of the Kootenai River near Bonners Ferry, Idaho—Water Year 2011

By Ryan L. Fosness

Abstract

In 2009, the Kootenai Tribe of Idaho released and implemented the Kootenai River Habitat Restoration Master Plan. This plan aimed to restore, enhance, and maintain the Kootenai River habitat and landscape to support and sustain habitat conditions for aquatic species and animal populations. In support of these restoration efforts, the U.S. Geological Survey, in cooperation with the Kootenai Tribe of Idaho, conducted high-resolution multibeam echosounder bathymetric surveys in May, June, and July 2011, as a baseline bathymetric monitoring survey on the Kootenai River near Bonners Ferry, Idaho. Three channel patterns or reaches exist in the study area—braided, meander, and a transitional zone connecting the braided and meander reaches. Bathymetric data were collected at three study areas in 2011 to provide: (1) surveys in unmapped portions of the meander reach; (2) monitoring of the presence and extent of sand along planned lines within a section of the meander reach; and (3) monitoring aggradation and degradation of the channel bed at specific cross sections within the braided reach and transitional zone. The bathymetric data will be used to update and verify flow models, calibrate and verify sediment transport modeling efforts, and aid in the biological assessment in support of the Kootenai River Habitat Restoration Master Plan. The data and planned lines for each study reach were produced in ASCII XYZ format supported by most geospatial software.

Introduction

Anthropogenic influence to the Kootenai River (or Kootenay for the Canadian areas) is evident upstream of, within, and downstream of the federally designated critical-habitat reach of the Kootenai River population of white sturgeon (*Acipenser transmontanus*). The Kootenai River white sturgeon critical habitat is a 18 mi long reach extending from river mile (RM) 159.7, downstream of the Moyie River, to RM 141.7 in the meander reach downstream of Shorty's Island (Federal Register, 2008).

Historical references indicate that dikes were built on natural levees early in the 20th century to protect agricultural areas in the Kootenai River floodplain from flooding (Turney-High, 1969; Boundary County Historical Society, 1987; Redwing Naturalists, 1996). Changes to the natural river environment have led to detrimental conditions in the critical habitat reach. Additionally, the construction and operation of Libby Dam, put into service in 1972, substantially altered Kootenai River streamflow and water quality, and created a habitat unsuitable to sustain natural recruitment of the Kootenai River white sturgeon (U.S. Fish and Wildlife Service, 2006). Research by the Idaho Department of Fish and Game on sturgeon populations determined that there was a lack of juvenile sturgeon in all but four 1-year classes during a 16-year period (Partridge, 1983).

In 1994, the U.S. Fish and Wildlife Service (USFWS) listed the Kootenai River population of white sturgeon as an endangered species under the provisions of the Endangered Species Act of 1973, as amended. The population was listed as endangered because of decreasing numbers and a lack of juvenile recruitment that was first noted in the mid-1960s (Federal Register, 1994; U.S. Fish and Wildlife Service, 1999). Many researchers attributed these decreasing numbers and lack of recruitment to the degradation of white sturgeon habitat, particularly the habitat used for spawning (Paragamian and others, 2001, 2002; Kock and others, 2006).

In 2006, the USFWS published a biological opinion that proposed habitat improvements designed to meet the criteria outlined in the Kootenai River white sturgeon recovery plan (U.S. Fish and Wildlife Service, 2006). One proposed improvement was, "a flow regime that limits sediment deposition and maintains appropriate rocky substrate for sturgeon egg adhesion, incubation, escape cover, and free embryo development…" (Federal Register, 2008, p. 39,513 and 39,522).

In 2009, the Kootenai Tribe of Idaho released and implemented the Kootenai River Habitat Restoration Master Plan (hereinafter referred to as the "Master Plan"). The goal of the Master Plan is to restore, enhance, and maintain the Kootenai River habitat and landscape so that it supports and sustains habitat conditions for aquatic species and animal populations (Kootenai Tribe of Idaho, 2009). In support of these restoration efforts, the U.S. Geological Survey (USGS), in cooperation with the Kootenai Tribe of Idaho conducted bathymetric surveys of the Kootenai River during May, June, and July 2011, as a baseline monitoring survey within the braided and meander reaches of the Kootenai River near Bonners Ferry, Idaho. Bathymetric surveys on the Kootenai River provide: (1) surveys of unmapped portions of the meander reach; (2) surveys in the areas near Shorty's Island and Myrtle Creek to support efforts for a potential substrate enhancement project; and (3) surveys within the braided reach at selected monitoring cross sections. Each of the surveys support short- and long-term adaptive management and monitoring as part of the Master Plan.

This document presents the bathymetric data from each of the three surveys on the Kootenai River for water year 2011. A description of the study areas, data-collection methods, and quality-control and quality-assurance procedures are discussed to describe the data-collection efforts.

Description of Study Area

The Kootenai River is the second largest contributor to the Columbia River in terms of discharge volume (fig. 1). From its headwaters in the Rocky, Salish, and Purcell Mountains, the Kootenai River flows to the south through northwestern Montana. Turning west until reaching the base of the Cabinet Mountains, the river then flows north through the Kootenai Valley of northern Idaho. From there, the river reaches its terminus at Kootenay Lake in British Columbia, Canada, at the base of the Selkirk Mountains. In 1972, the U.S. Army Corps of Engineers managed the construction of Libby Dam on the upper Kootenai River near Libby, Montana, creating Lake Koocanusa.

The study area described in this report lies within those parts of the Kootenai River within the State of Idaho (fig. 2) including the critical habitat. Three distinct channel patterns (hereinafter referred to as "reaches") are in the study area: (1) A braided channel, consisting primarily of a gravel and cobble substrate, extending from RM 159.7 near the confluence of the Moyie River downstream to RM 152.9 near Bonners Ferry; (2) a meandering channel, primarily consisting of sand and lacustrine clay, extending from RM 152.9 downstream approximately 78 mi to the confluence of the Kootenai River with Kootenay Lake in British Columbia at RM 74.6; and (3) a small section of the river referred to as a "transitional zone" connecting the braided and the meander reaches. Typically, the transitional zone occurs between RM 156.9 and RM 151.9 depending on the extent of the backwater from Kootenay Lake (Federal Register, 2008).

Bathymetric Data Collection Areas for Water Year 2011

Bathymetric data were collected within an 11-mi reach of previously unmapped areas in the meander reach to obtain high-resolution bathymetric data. The extent of the surveys was from RM 134 to 142 (fig. 3*A*) and RM 149 to 152 (fig. 3*B*).

Bathymetric data were collected in the Shorty's Island and Myrtle Creek substrate enhancement study area in the meander reach. The extent of these surveys was near RM 143.5 and 142.9 near Shorty's Island and at RM 146 near the Myrtle Creek confluence with the Kootenai River (fig. 4). The data-collection efforts described in this report are part of a long-term monitoring program to identify the spatial and temporal distribution of sand in the stream channel. This baseline survey was initiated to survey both the short- and long-term distribution of sediment in the study area. The planned survey lines were created as both cross sections and longitudinal lines intended to be surveyed bi-annually as part of the long-term monitoring program.

Bathymetric data were collected within the braided reach as part of a long-term monitoring program. The extent of these surveys was near RM 152.2 near Ambush Rock upstream to approximately RM 159.1 downstream of the confluence of the Moyie River with the Kootenai River (fig. 5). The bathymetric data were collected at 17 cross sections to monitor aggradation and degradation of the channel bed to support on-going river restoration efforts in the braided reach.

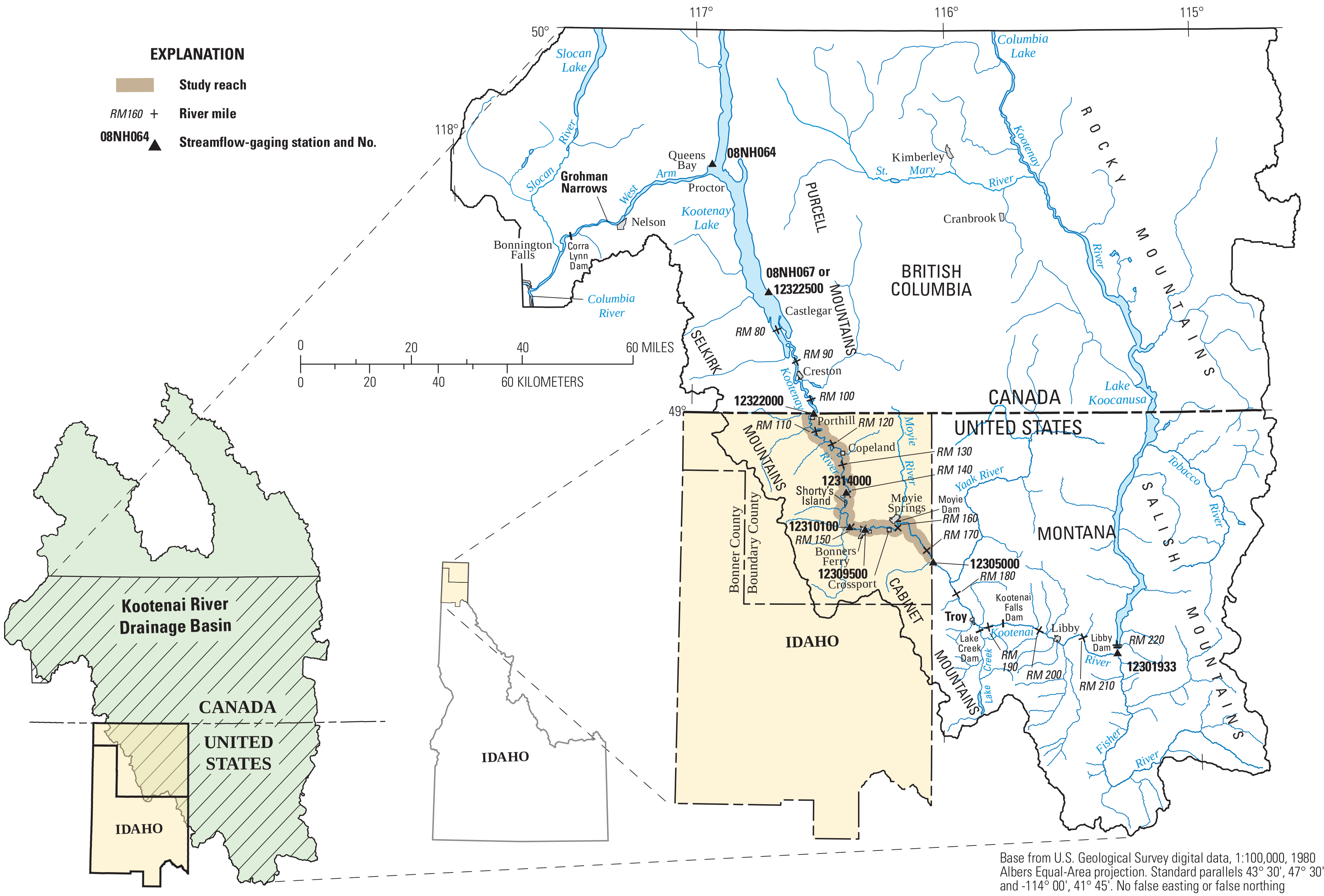
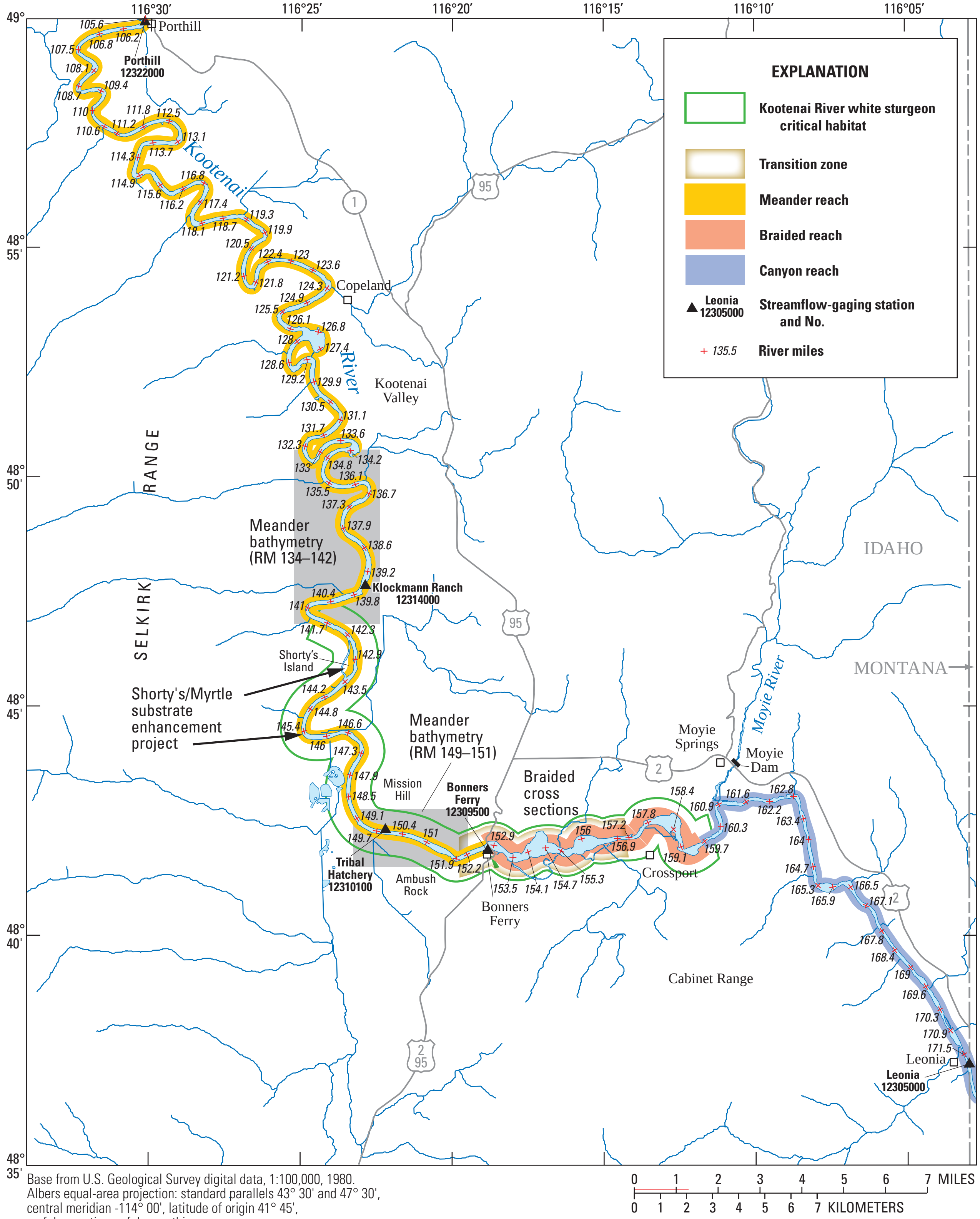
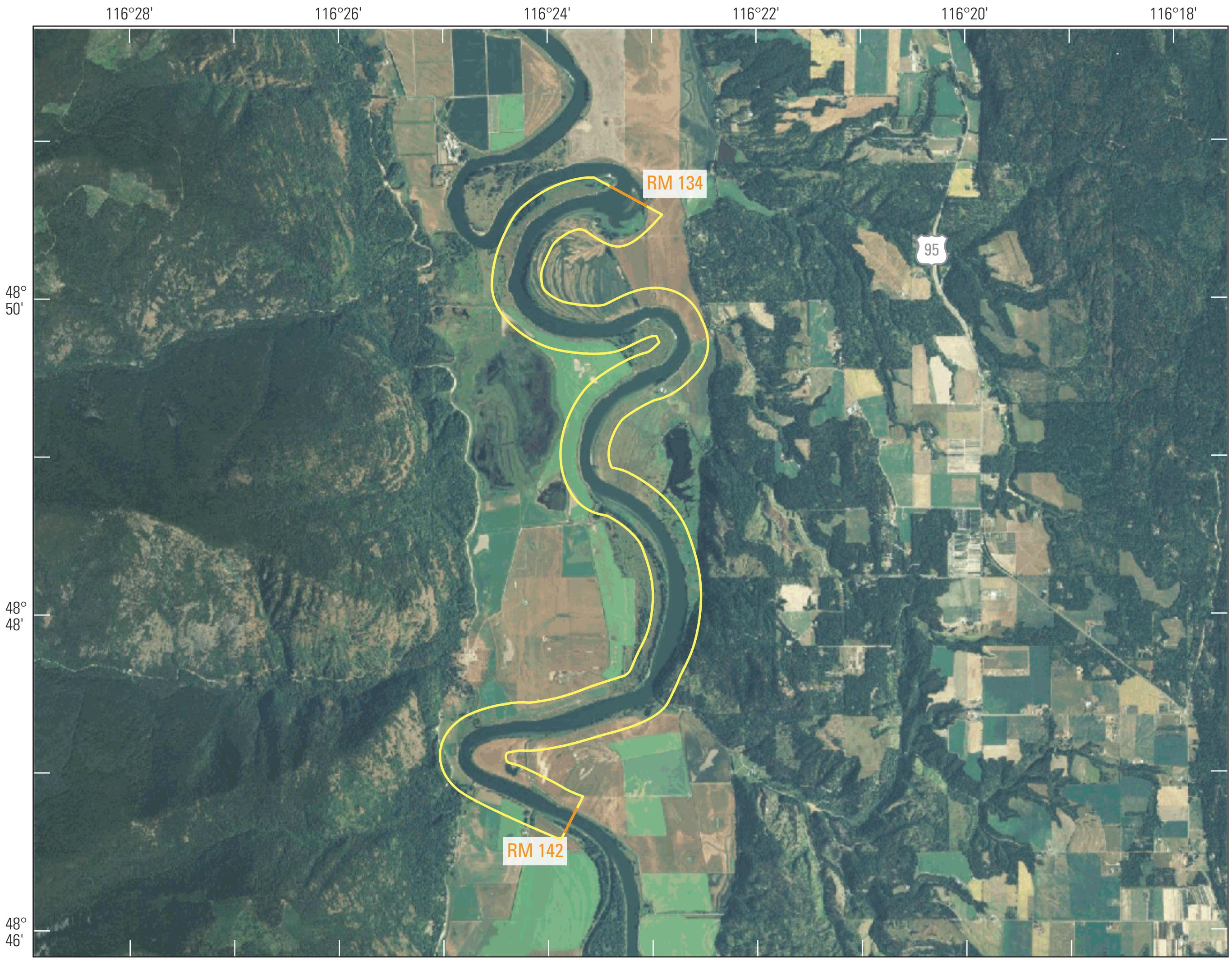


Figure 1. Location of study area in the Kootenai River drainage basin, northern Idaho.



Base from U.S. Geological Survey digital data, 1:100,000, 1980.
Albers equal-area projection: standard parallels 43° 30′ and 47° 30′,
central meridian -114° 00′, latitude of origin 41° 45′,
no false easting or false northing.

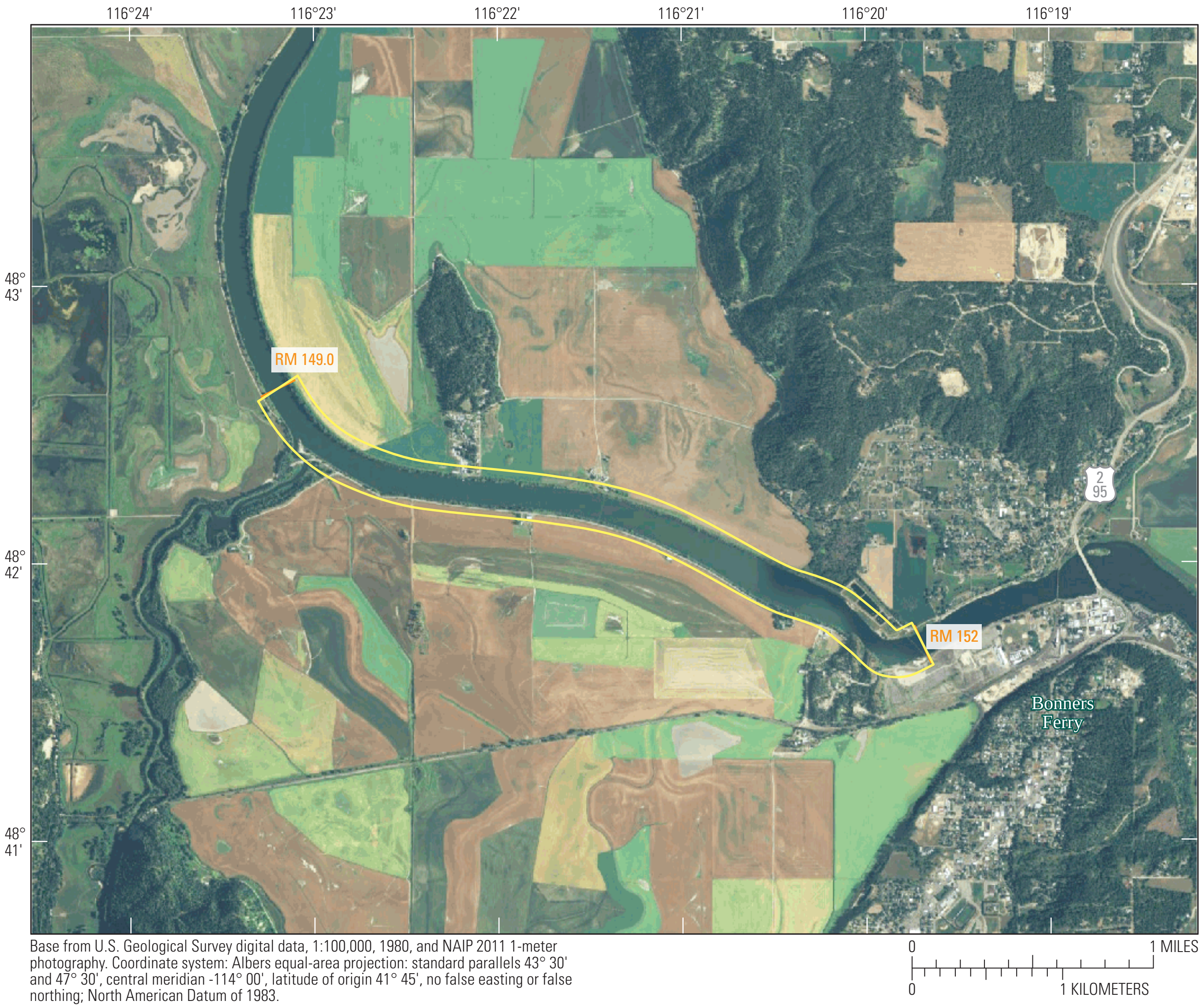
Figure 2. Location of the Kootenai River white sturgeon critical habitat in the study reach, near Bonners Ferry, Idaho.



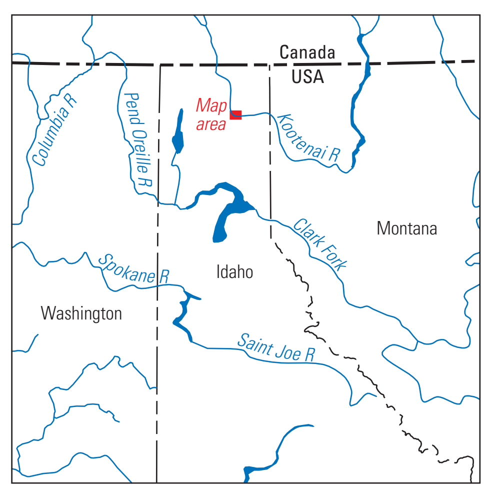
Base from U.S. Geological Survey digital data, 1:100,000, 1980, and NAIP 2011 1-meter photography. Coordinate system: Albers equal-area projection: standard parallels 43° 30' and 47° 30', central meridian -114° 00', latitude of origin 41° 45', no false easting or false northing; North American Datum of 1983.

A. River miles 134–142

Figure 3. Extent of the surveys in unmapped portions of the meander reach, near Bonners Ferry, Idaho, water year 2011.



Base from U.S. Geological Survey digital data, 1:100,000, 1980, and NAIP 2011 1-meter photography. Coordinate system: Albers equal-area projection: standard parallels 43° 30' and 47° 30', central meridian -114° 00', latitude of origin 41° 45', no false easting or false northing; North American Datum of 1983.



B. River miles 149–152

Figure 3.—Continued

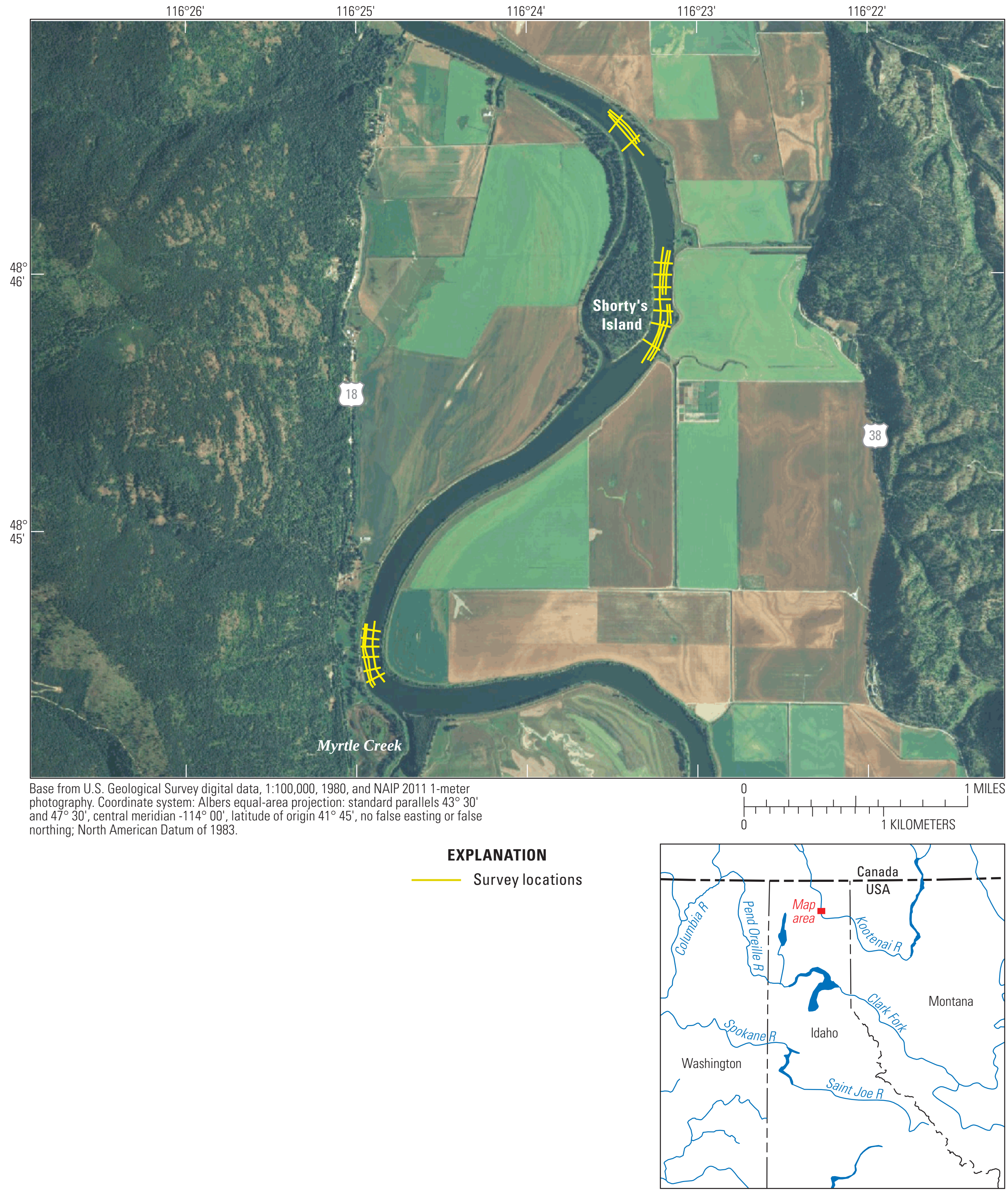


Figure 4. Extent of the Shorty's Island and Myrtle Creek substrate enhancement study area, near Bonners Ferry, Idaho, water year 2011.

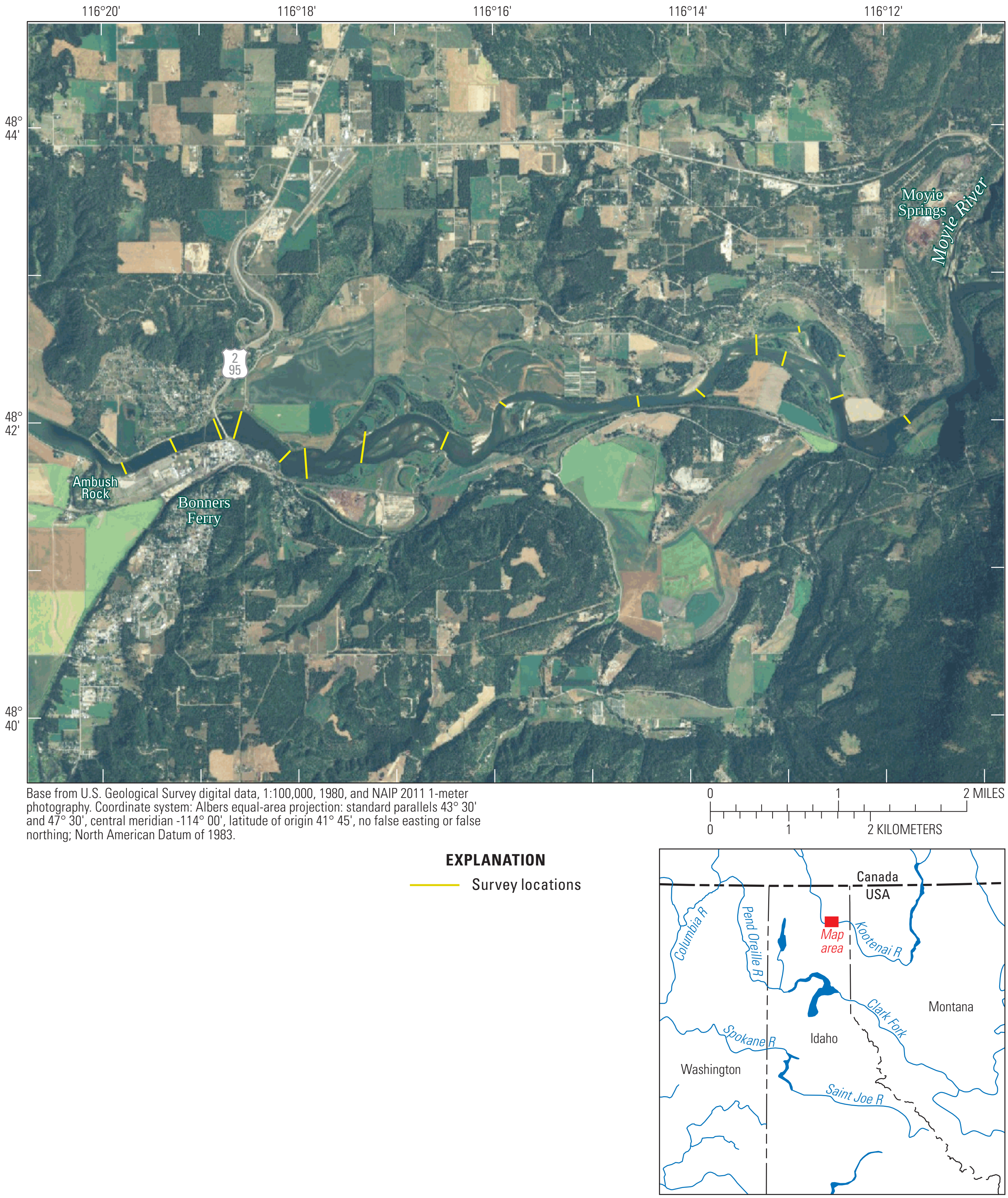


Figure 5. Extent of the braided reach cross-section survey area, near Bonners Ferry, Idaho, water year 2011.

Methods

The bathymetric data were collected using a multibeam echosounder (MBE) system mounted on a USGS-owned and operated 25-foot jet boat research vessel. The echosounding component was a 240 kHz ODOM ES3 multibeam echosounder capable of projecting 120, 240, or 480 beams spanning a max of 120° swath (width of coverage). Figures 6 and 7 show examples of how the multibeam echosounder collects the corrected elevation point coverage across the survey swath. For the surveys on the Kootenai, 240 beams were selected and the port and starboard angles were limited to 50° per side for a total angular coverage of 100°.

A Teledyne TSS DMS-10 dynamic motion reference unit accounted for heave, pitch, and roll of the vessel. Two Digibar Pro sound velocity probes (velocimeters) were used to profile the speed of sound underwater. One velocimeter was mounted and operated real-time near the MBE to account for spatial change in the surface speed of underwater sound. The second velocimeter was used to acquire a depth profile that recorded how the speed of underwater sound varied by depth. A Trimble® R8 GPS receiver mounted over the MBE was radio linked to another GPS receiver set over a survey control point on land to provide real-time horizontal and vertical positioning. A Hemisphere® VS111 dual-GPS system was used for the heading and to output a 1 pulse per second (1PPS) output. The entire MBE system is shown in figures 7 and 8.

An ODOM® Real-Time Appliance (RTA) was used to time stamp the MBE, motion reference unit, real-time velocimeter, RTK-GPS positioning and elevation, and precise heading data to within 1 millisecond based on the 1PPS signal from the Hemisphere® VS111. The RTA output the bathymetric data to two laptops, one for data acquisition and one for data processing. In addition, a Hummingbird® side-scan was used for qualitative purposes to verify and note unique features (trees, sunken cars, sand dunes, clay steps and benches) to the channel bathymetry. A daily field log of the bathymetric surveys was kept to record the equipment used, crew members, referenced survey bench marks, sound velocity profiles, file names, and other ancillary information. An example of the daily log is provided in appendix A. Figure 9 shows an image of each of these components.

The bathymetric data were collected in the field using the HYPACK® software HYSWEEP®. The raw data were then edited using HYPACK®'s MBMAX software. All raw data were initially filtered to exclude the outer 10° of the multibeam swath. These data were out of tolerance (see section, "Quality Assurance") and therefore excluded from the final data. The edited data were reduced to a 3×3-foot cell size as XYZ ASCII data using HYPACK® Combined Uncertainty and Bathymetric Estimator (CUBE). Two hundred and forty beams were used for the survey and overlap of adjacent survey lines was between 75 and 100 percent. However, areas of missing data referred to as holidays occurred within the dataset due to the filtering of macrophytes, editing of erroneous data points, and areas where it was too shallow to allow complete coverage.

Quality Assurance and Quality Control

Quality assurance (QA) and quality control (QC) are critical with MBE surveys to maintain the highest degree of accuracy. Qualitative notes documenting anything that might affect the quality of the data, such as wave action, macrophyte growth, poor GPS quality, and any other observation that could degrade the bathymetric data were recorded in the daily field log.

Quality Assurance

Prior to and during the survey, unique tasks were conducted at specified intervals to prepare the MBE system for bathymetric surveying, but also to describe the total estimated error within the system. Tasks and descriptions are shown in table 1 for the recommended measurement interval for each project and were developed based on requirements from U.S. Army Corps of Engineers (2004), National Oceanic and Atmospheric Administration (2011), and system specific requirements. The order of tasks shown in table 1 is important because each task is dependent on the preceding task. Quality-assurance elements were developed following the input requirements of the Total Propagated Uncertainty (TPU) feature built into HYPACK® software. The TPU required a description of the general, environmental, and sensor settings to best estimate the total error potential in the survey data. A table of the procedures used for this survey is provided in appendixes B and C.

Perhaps the most significant quality-assurance element is the patch test (table 1). A patch test included running a series of MBE survey lines to compensate for physical mounting differences including latency, pitch, roll, and yaw (fig. 10). Two patch tests were conducted before and after the surveys to ensure the MBE system was correctly offset and calibrated (appendixes D and E). A complete description of the patch test process can be found in U.S. Army Corps of Engineers (2004) and National Oceanic and Atmospheric Administration (2011). The offsets from the patch test were applied to the system prior to the surveys on the Kootenai River. A second patch test was conducted after the Kootenai River bathymetric surveys to ensure the system was still properly aligned and no adjustments to the offset coefficients were necessary. Neither of the patch tests were completed on the Kootenai River, due to the poor channel geometry and river currents that are not appropriate for a patch test.

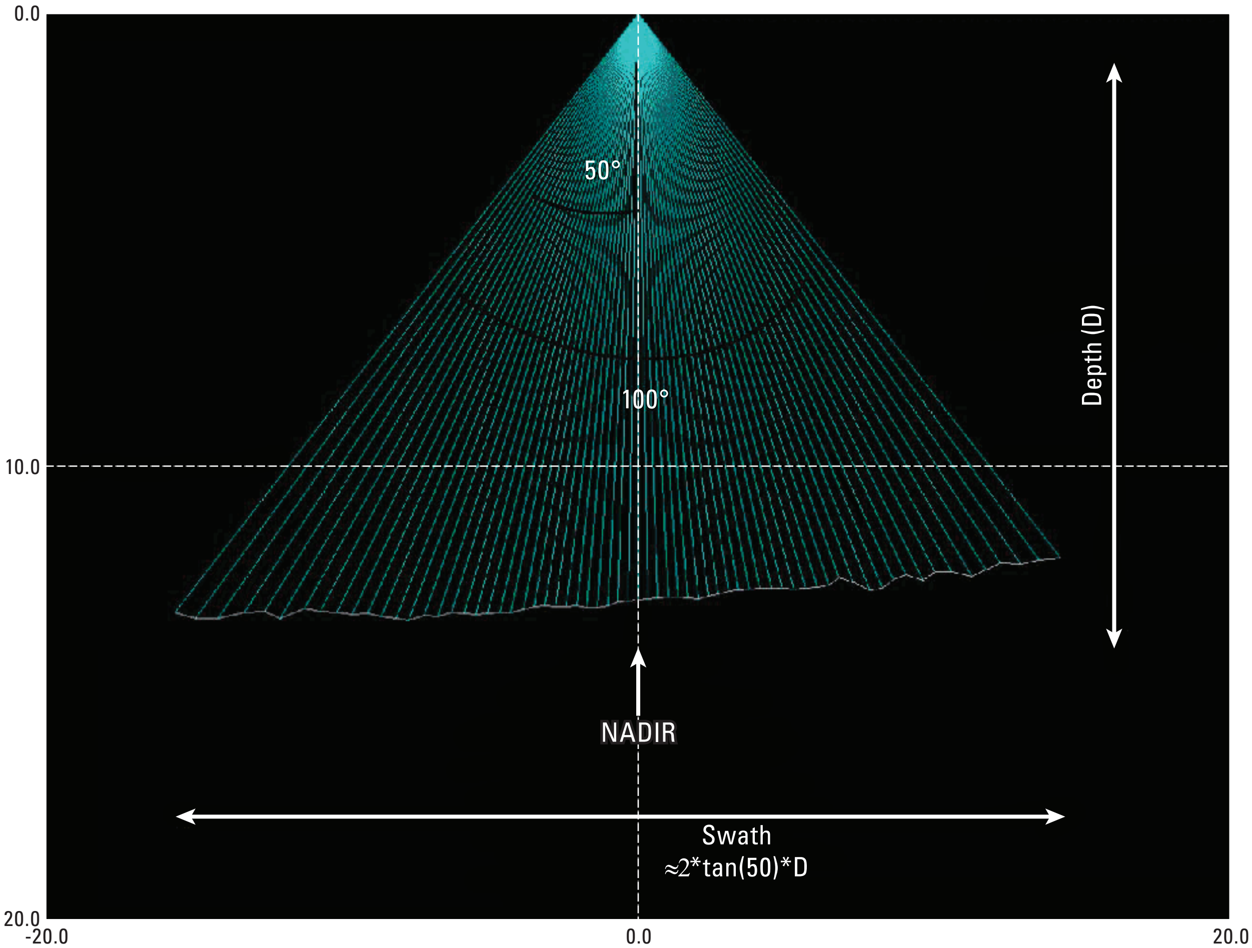


Figure 6. Example of the angular coverage and number of beams for the multibeam echosounder.

Figure 7. Multibeam echosounder components and mount on USGS research vessel.

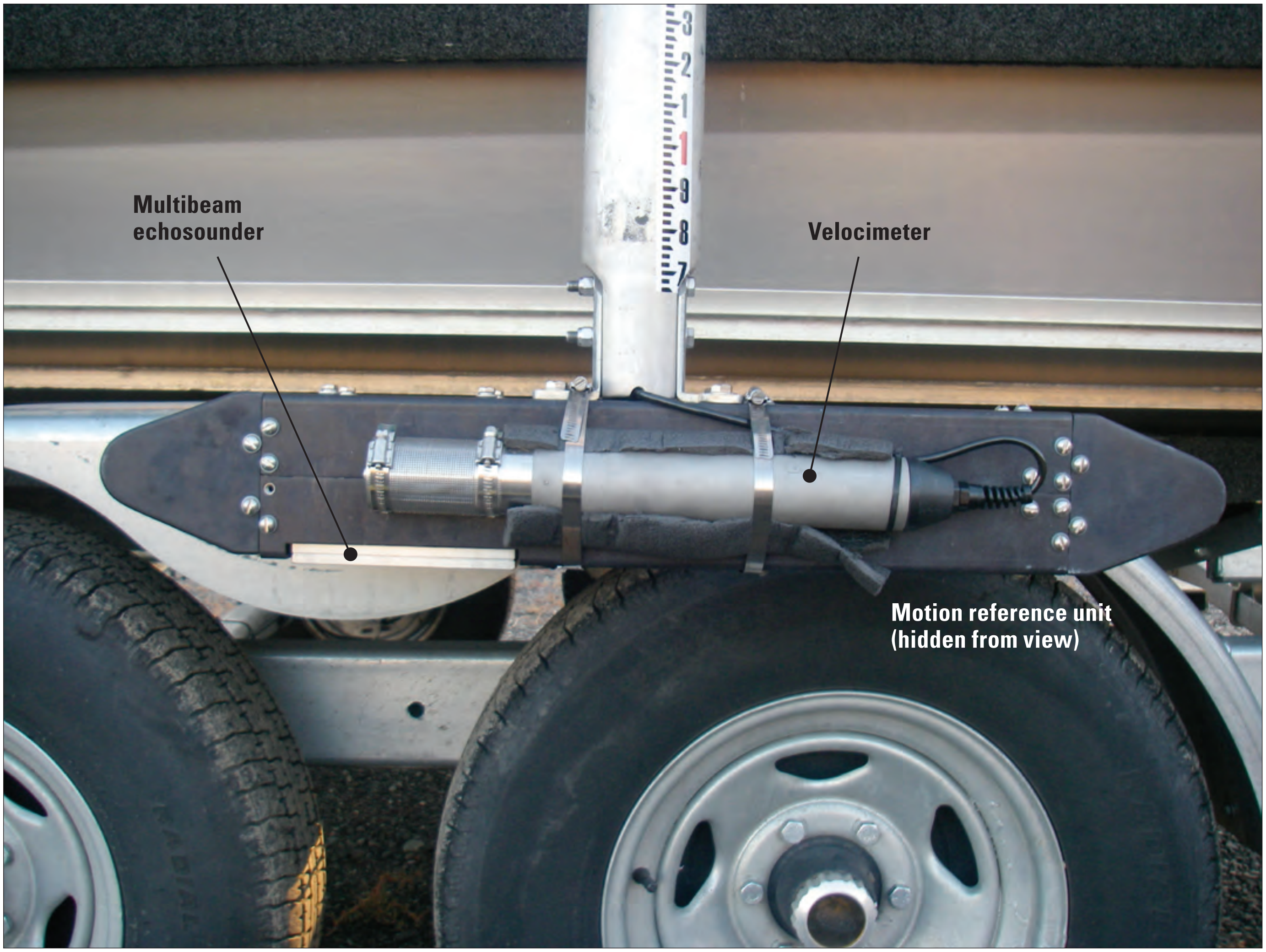


Figure 8. Close-up view of the submerged components of the multibeam echosounder.

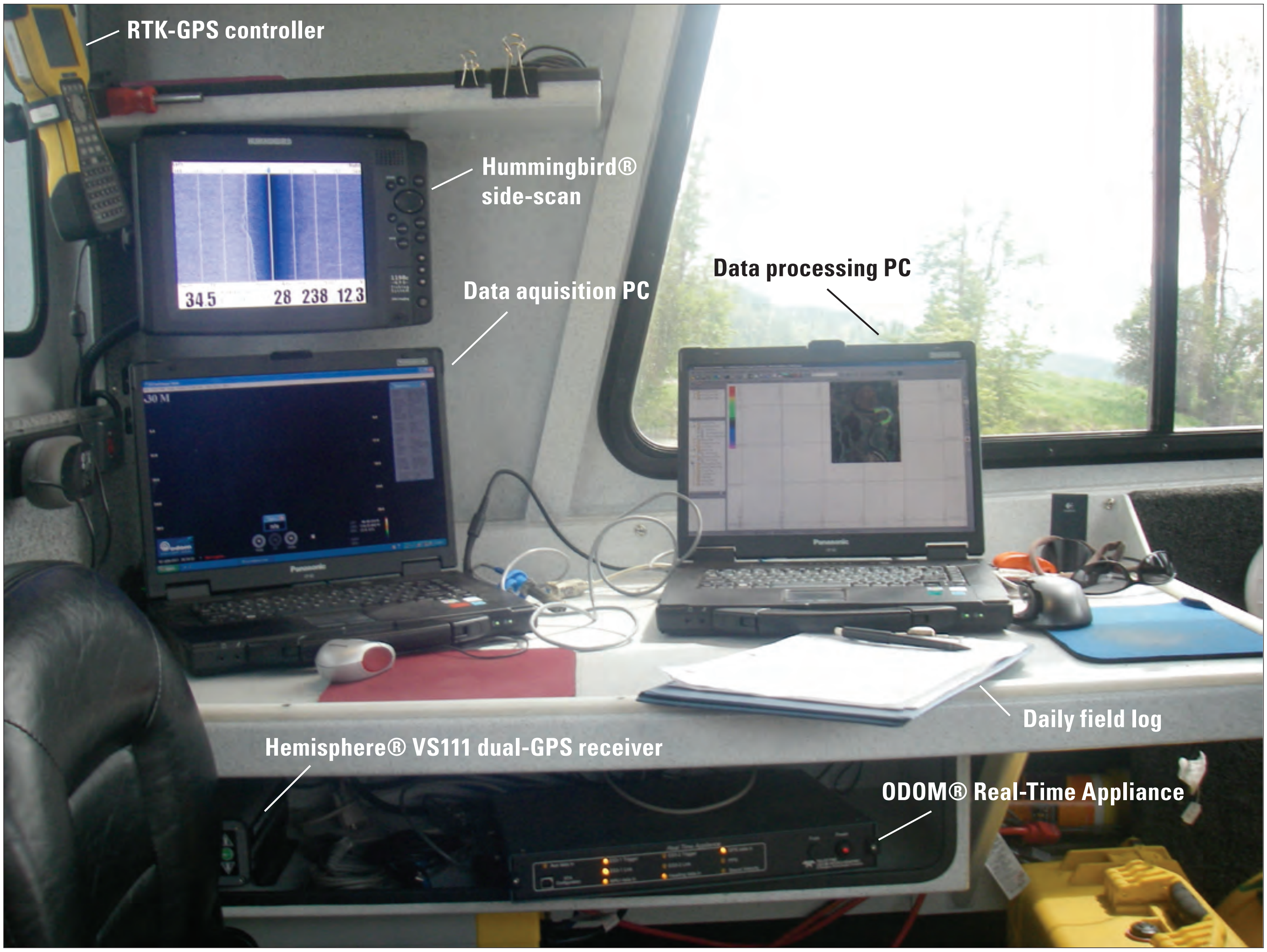


Figure 9. Data acquisition, processing, and display components for the MBE system.

Table 1. Project quality assurance and quality control elements for multibeam bathymetric surveys.

Task	Recommended interval	Measurement precision	Summary
RTK-GPS horizontal and vertical control	1 / project	3rd order or better	Prior to the start of the survey, a reconnaissance survey should occur to verify and/or establish proper vertical and horizontal control within the survey area. If necessary, allow 3 weeks to allow precise ephemeris results for static surveys in areas with no existing horizontal and/or vertical control. The accuracy for the horizontal and vertical control order should be clearly stated as well as the coordinate system used (State Plane preferred, then UTM).
Multibeam echosounder general settings	1 / project	Varies	The general settings include but are not limited to Angular Coverage, ping rate, beam width, pulse length, steering angle, frequency, and bandwidth. Each of these should be noted from the manufacturer.
Environmental settings	1 / project	Varies	A general estimate for the following should be approximated prior to each project: speed of sound, peak-to-peak swell, forward-aft seafloor slope, port-starboard seafloor slope, water level uncertainty, spatial tide prediction uncertainty, sound speed sensor uncertainty (real-time, cast, spatial-temporal variation, thickness of spatial-temporal layer, uncertainty beyond profile, and max depth of SV profile).
MBES sensor offset measurements and uncertainty estimates	1 / project	Varies	The physical offsets (Foreword, starboard, and vertical) for each of the MBES components (RTK-GPS, MRU, and multibeam echosounder) should be measured each time a component is installed. A verification of these measurements should occur at the beginning of each project.
Sound velocity probe calibration	1 / project	±1 foot per second	Each echosounder is required to be factory-calibrated once per year. Prior to each project, each sound velocity probe should be verified that the sound velocity values match the factory-calibration values.
Vessel survey speed limitation	1 / project	± 1 knot	A qualitative estimate for a proper survey speed should be considered prior to the start of each survey. The proper survey speed should take the following into consideration, 1.survey depths, 2.river currents. Slower survey speeds will likely be necessary in areas of higher depths (> 40 feet) and on rivers with high velocities. Under normal conditions, a survey speed ranging from 5 to 7 knots is appropriate.
Multibeam beam-width limitations	1 / project	Varies (degrees)	Beam width restrictions (°) may be required in deeper water where the quality of the outer beams may exceed . This will be decided by the results of the performance test in section, "Quality Assurance."
Overlapping requirement	1 / project	Varies (%)	Overlapping requirements (percent coverage) should be decided prior to the start of the project and is a function of the style of survey.
Bar check verification	1 / project	± 0.05 foot	A bar check should occur once per project to verify the NADIR depth of the multibeam. This can be verified using a rectangular surface that is lowered a known depth and running the bar check utility within HYSWEEP Survey. In addition, a manual check should be made using the GPS, vertical antenna offsett, and depth calculation to verify the estimated corrected depth of the MBES.
Patch test	2 / project	Varies	A patch test should be surveyed prior to the start of each project. It is important that the sound velocity calibration and H/V control limitations have been established prior to the patch test as they could affect the outcome of the test. After each project, a follow-up patch test should occur in the same location using the same lines to verify the first patch test to ensure no changes were incurred during the project. If any physical or equipment changes are made during the project, a new patch test should be surveyed to account for any potential changes this might have to the system.
Horizontal and vertical verification check	1 / day	± 0.01 foot	The horizontal position and vertical elevation verification should occur daily to explain the spatial accuracy of the multibeam system. The horizontal position (X,Y) and vertical elevation (Z) verification can be can be completed using the RTK-GPS to verify an existing or established benchmark in the study area.
Velocity casts	2–3 / day	± 0.01 foot	A velocity cast should occur prior to the survey each day. A second cast should be taken approximately half-way through the day. A third cast should be taken at the end of the day. The frequency of the velocity casts should be increased in areas with a significant stratification. Each of the velocity casts should be loaded into the editing file so that changed to the velocity profile is accounted for during the survey.

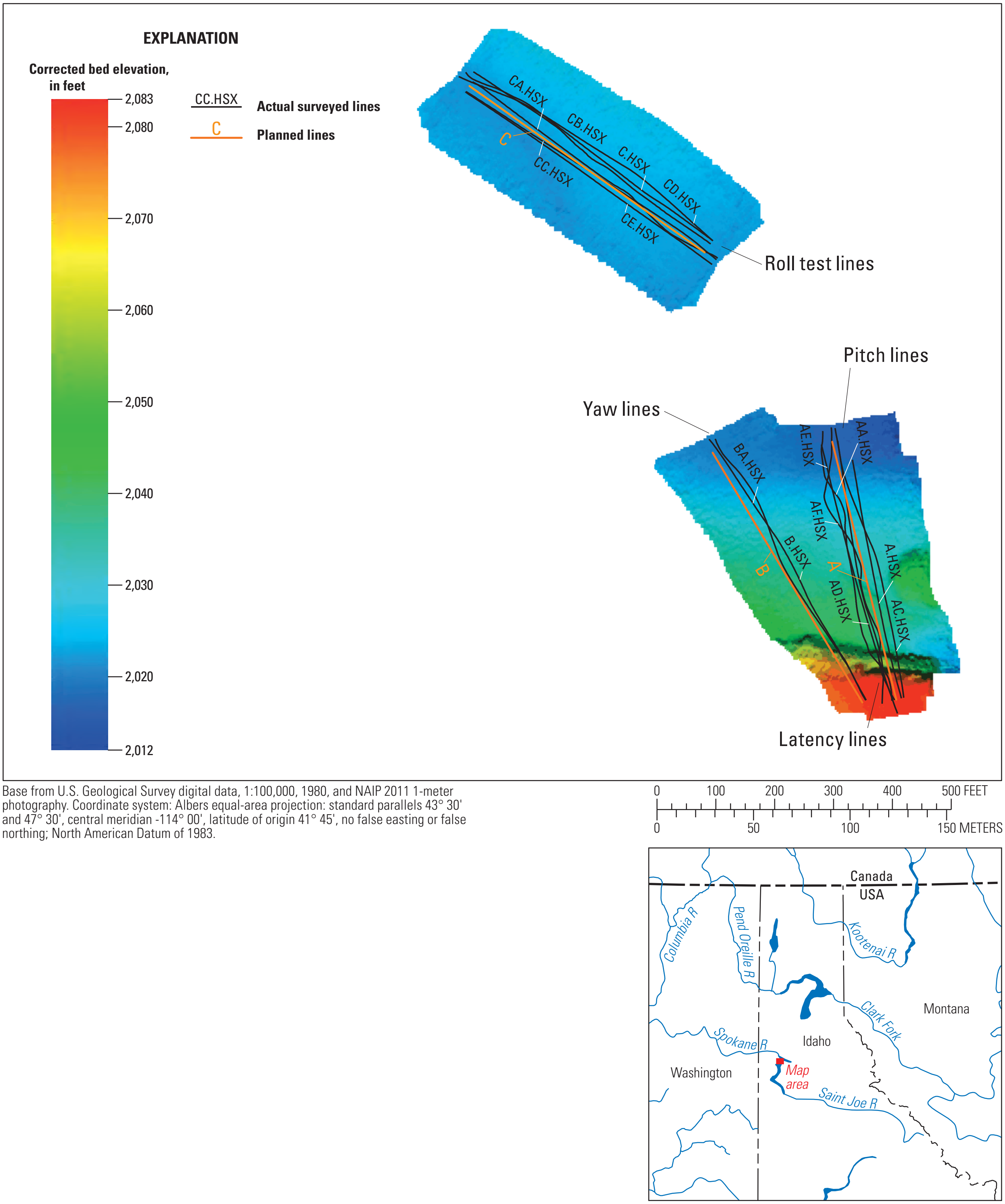


Figure 10. Patch test lines and resulting bathymetry from Lake Coeur d'Alene near Cougar Bay, Idaho.

Quality Control

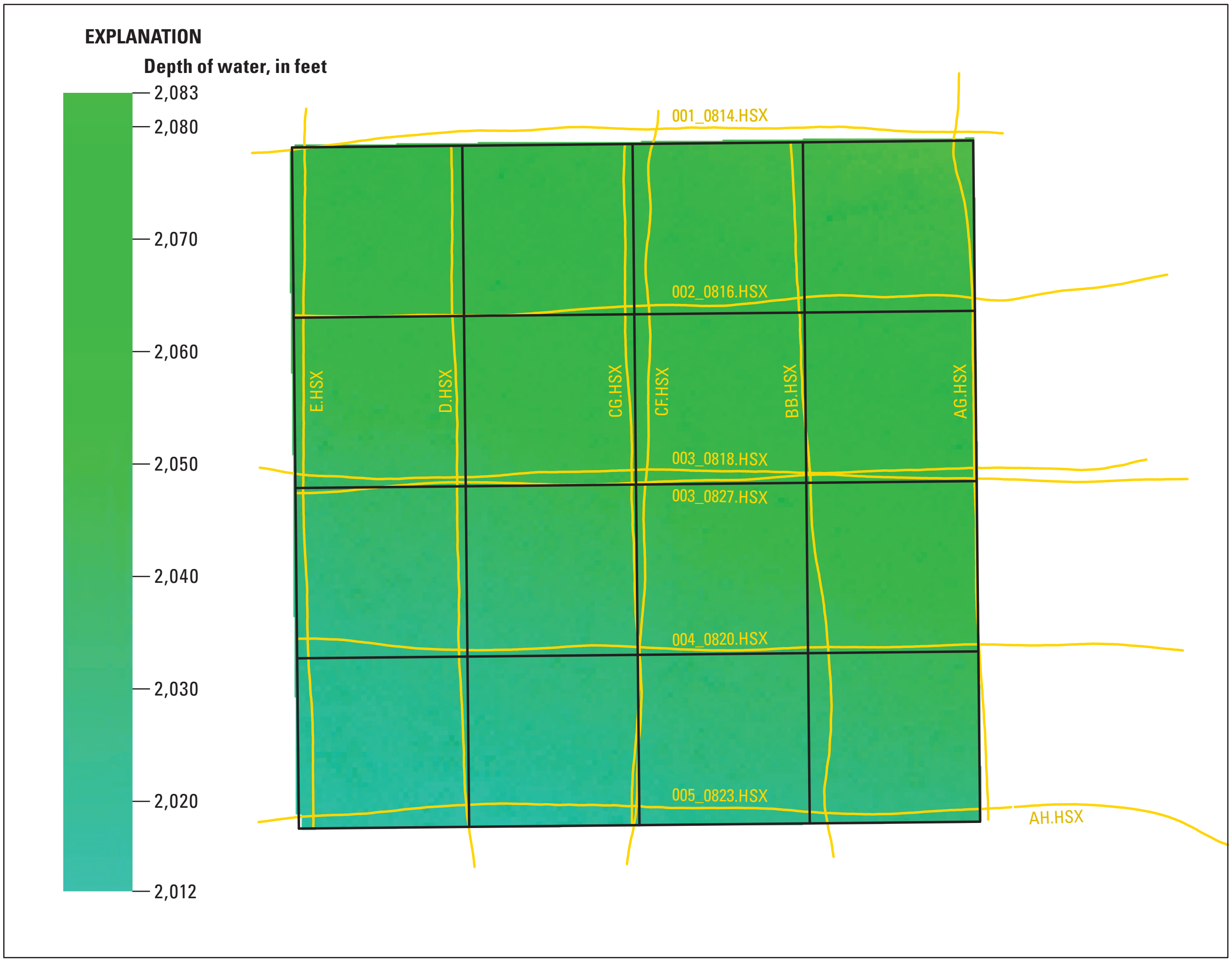
Following the adjustments from the patch test, a performance test (also referred to as a beam angle check) provided quality control by quantifying the accuracy of the MBE (fig. 11). The performance test compared a set of standard survey data against a known reference surface. The reference surface was created by surveying 10 lines (5 parallel and 5 perpendicular) spaced equal to the depth creating 200 percent overlap and edited to remove any data outside of 45° from the NADIR beam. The final reference surface is the best representative surface for a baseline measure to check the performance of the system. Two standard survey lines were surveyed across the center of the reference surface to be used as the performance measure. The standard survey lines were edited using the same methods applied to all data collected. The performance test for the Kootenai River bathymetric surveys was conducted on April 28, 2011, at Lake Coeur d'Alene, Idaho. It was recommended that the performance test be done on the same body of water as the study, but there was not a suitable location within the Kootenai River for the performance test. The output from the performance test includes a summary of how the accuracy of the X,Y, and Z data are distributed through the swath of the MBE. Typically, the integrity of the data is diminished as it deviates from the center (NADIR) beam. The results of the performance test were compared with the minimum performance standards as defined by U.S. Army Corps of Engineers (2004) and are shown in appendix F.

An additional output option from the HYPACK® CUBE module used for quality control is the estimated uncertainty. The uncertainty was estimated for each of the estimated gridded surfaces, for this study a 3×3-foot grid (table 2). Each estimated grid elevation was estimated based on the most statistically significant elevation within the grid. The total number of data points used to develop the grid output were highly variable and depended on the distance from NADIR (decreasing density from NADIR), depth of water (decreasing density with increasing depth), and amount of overlapping data (increasing density with increasing overlap).

Table 2. Quality-control results.

[**Data-quality objectives**: Hard bottom, soft bottom, and other surveys and studies were taken from U.S. Army Corps of Engineers (2002; table 3-1, Corps Accuracy Standards, Quality control, and Quality Assurance Requirements]

Performance standard	Data-quality objectives (±) ft			Quality-control results (±) ft		
	Hard bottom	Soft bottom	Other surveys and studies	Multibeam echosounder bathymetric survey in meander reach	Substrate Enhancement Project near Shorty's Island and Myrtle Creek	Braided reach cross-section monitoring surveys
Resultant elevation accuracy (95%)						
depth < 15 ft	0.5	0.5	1.0	0.5–0.64	0.5–0.7	0.48
15 ft < depth ≤ 40 ft	1	1.0	2.0			NA
depth > 40 ft	1	1.0	2.0			NA
Horizontal Positioning System Accuracy (ft)	< 6	6.0	16.0	<1	<1	<1
Supplemental control accuracy						
Horizontal	3rd order	3rd order	3rd order	2nd order	2nd order	2nd order
Vertical	3rd order	3rd order	3rd order	2nd order	2nd order	2nd order
Minimum survey coverage density	100% Sweep	200 ft	500 ft	≈ 100% Sweep	NA	NA



Base from U.S. Geological Survey digital data, 1:100,000, 1980, and NAIP 2011 1-meter photography. Coordinate system: Albers equal-area projection: standard parallels 43° 30' and 47° 30', central meridian -114° 00', latitude of origin 41° 45', no false easting or false northing; North American Datum of 1983.

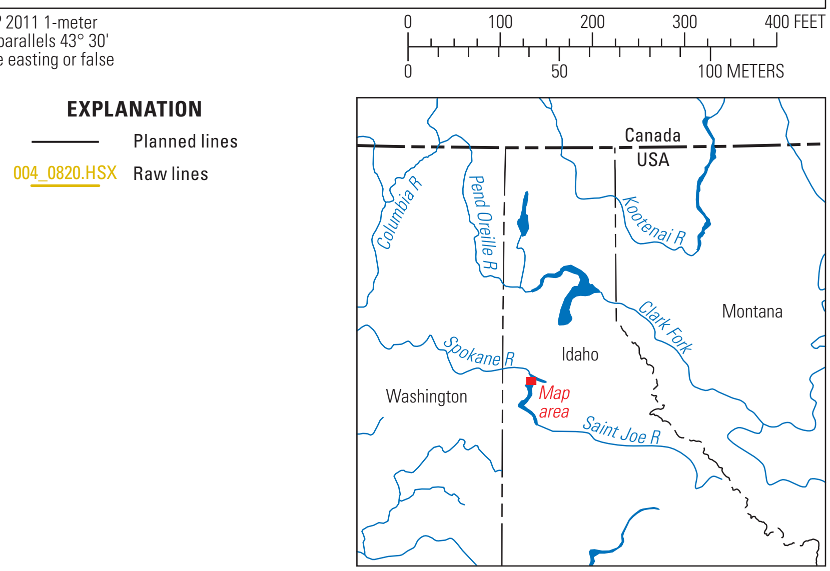


Figure 11. Performance Test reference lines, standard lines, and resulting bathymetry from Lake Coeur d'Alene near Cougar Bay, Idaho.

Bathymetric Survey Data

Edited raw data are presented in a generic ASCII XYZ format in the most raw form so that it can be used in various types of geospatial software applications. The digital elevation data were projected using UTM Zone 11 North, North American Datum of 1983 (NAD 83) units of U.S. feet and the North American Vertical Datum of 1988 units of U.S. feet. Tables 3, 4, and 5 present a description of the MBE bathymetric data from each of the three survey areas. A thorough description and ASCII XYZ data are provided in the metadata for each survey area.

Multibeam Echosounding Survey in Meander Reach

Single-beam echosounder (SBE) bathymetric data were collected within this reach in 2002 (Barton and others, 2004), but did not provide a full coverage of the channel bottom. SBE bathymetry is not as desirable as multibeam echosounder (MBE) bathymetry for use in two-dimensional flow models. The MBE data will be used to update the bathymetric surfaces used to develop and update one- and two-dimensional flow models. In addition, the data provided a nearly continuous surface that could aid in the delineation of sediment facies features in the river, such as lacustrine clay, bedrock, sand, scour holes, and other geomorphic features that are useful in describing the known habitat for the white sturgeon. The extent of the survey coverage and MBE bathymetry are presented in table 3.

Table 3. Multibeam echosounder bathymetric survey in meander reach.

[River mile indicates a 1-mile reach beginning at the River Mile number. Data and metadata can be accessed at http://water.usgs.gov/lookup/getspatial?ds694_meander_reach_2011]

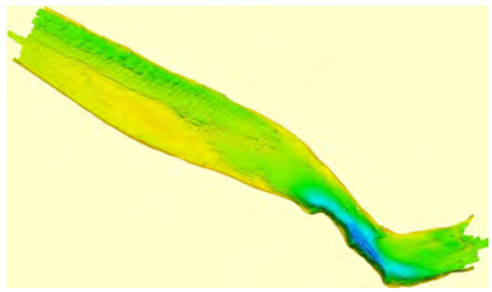
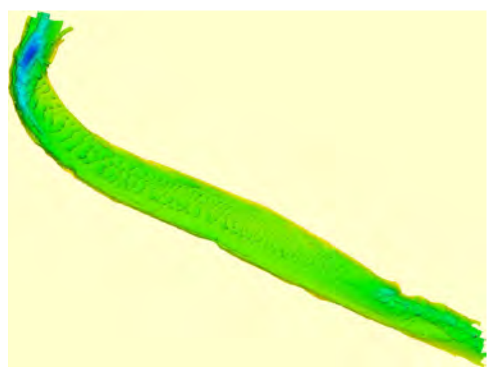
Survey extent	Image	Survey date	File name
River Mile 151		05-19-2011	RM151.xyz
River Mile 150		05-19-2011	RM150.xyz
River Mile 149		05-12-2011	RM149.xyz
River Mile 141		05-3-2011	RM141.xyz
River Mile 140		05-3-2011	RM140.xyz

Table 3. Multibeam echosounder bathymetric survey in meander reach—Continued.

[River mile indicates a 1-mile reach beginning at the River Mile number. Data and metadata can be accessed at http://water.usgs.gov/lookup/getspatial?ds694_meander_reach_2011]

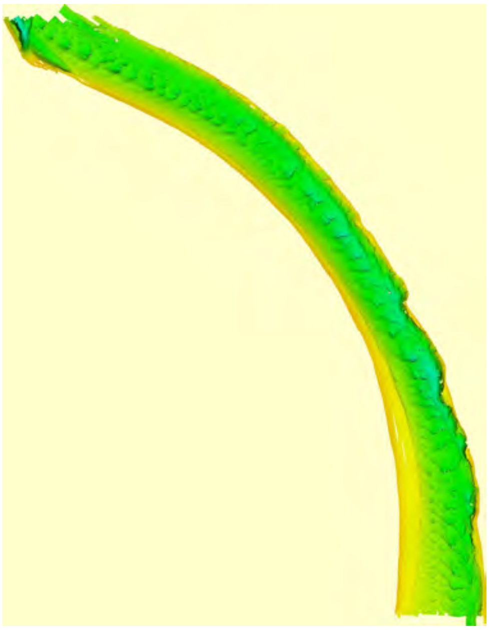
Survey extent	Image	Survey date	File name
River Mile 139		05-04-2011 to 05-05-2011	RM139.xyz
River Mile 138		05-5-2011	RM138.xyz

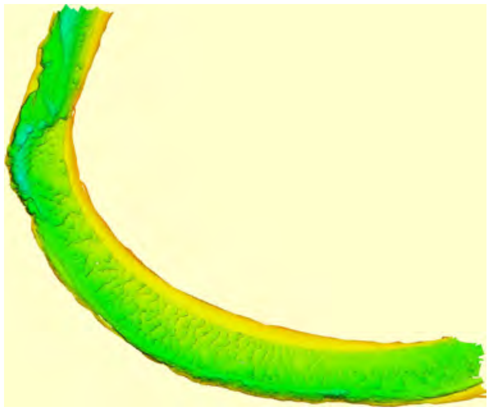
Table 3. Multibeam echosounder bathymetric survey in meander reach—Continued.

[River mile indicates a 1-mile reach beginning at the River Mile number. Data and metadata can be accessed at http://water.usgs.gov/lookup/getspatial?ds694_meander_reach_2011]

Survey extent	Image	Survey date	File name
River Mile 137		05-31-2011	RM137.xyz
River Mile 136		06-1-2011	RM136.xyz

Table 3. Multibeam echosounder bathymetric survey in meander reach—Continued.

[River mile indicates a 1-mile reach beginning at the River Mile number. Data and metadata can be accessed at http://water.usgs.gov/lookup/getspatial?ds694_meander_reach_2011]

Survey extent	Image	Survey date	File name
River Mile 135		06-01-2011 to 06-02-2011	RM135.xyz
River Mile 134		06-2-2011	RM134.xyz

Substrate Enhancement Project near Shorty's Island and Myrtle Creek

The cross-sections and longitudinal profiles were surveyed on the ascending (May) and descending (July) limbs of the spring runoff hydrograph. The extent of the survey coverage and MBE bathymetry are presented in table 4.

Table 4. Substrate enhancement project near Shorty's Island and Myrtle Creek.

[Data and metadata can be accessed at http://water.usgs.gov/lookup/getspatial?ds694_substrate_enhancement_2011]

Survey extent	Link to map image	Survey date	File name
Myrtle Creek and Shorty's Island		05-18-2011	Substrate_Enhancement_Project_ bathymetry_May_2011
Myrtle Creek and Shorty's Island		07-12-11 to 07-13-2011	Substrate_Enhancement_Project_ bathymetry_July_2011

Braided Reach Cross-Section Monitoring Surveys

The survey included two survey periods:

1. Ascending limb of the high spring flows in May, and
2. Descending limb of the high spring flows in July and August 2011.

The extent of the survey coverage and MBE system bathymetry are presented in table 5.

Table 5. Braided reach cross-section monitoring surveys.

[Data and metadata can be accessed at http://water.usgs.gov/lookup/getspatial?ds694_braided_reach_2011]

Survey extent	Lind to map image	Survey date	File name
Braided reach cross sections	 	05-16-2011 to 05-17-2011	KR2011_BraidedXSections_May.xyz
	 	07-12-2011	KR2011_BraidedXSections_July.xyz

Acknowledgments

The author expresses appreciation to the Kootenai Tribe of Idaho and to the Bonneville Power Administration for funding and logistical support during the bathymetric surveys. The author also would like to thank all USGS Idaho Water Science Center colleagues for their assistance with data collection.

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Appendixes

Appendixes are presented as Microsoft© Excel spreadsheets and can be accessed and downloaded at http://pubs.usgs.gov/ds/694/.

Appendix A. Daily Logs.

Appendix B. Quality Control Parameters Defined for Estimating Total Propagated Uncertainty.

Appendix C. Multibeam Echosounder Physical Offsets.

Appendix D. Patch Test, April 28, 2011.

Appendix E. Patch Test, June 15, 2011.

Appendix F. Performance Test, April 28, 2011.

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Publishing support provided by the U.S. Geological Survey
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Fosness—**Bathymetric Surveys of the Kootenai River near Bonners Ferry, Idaho—Water Year 2011**—Data Series 694