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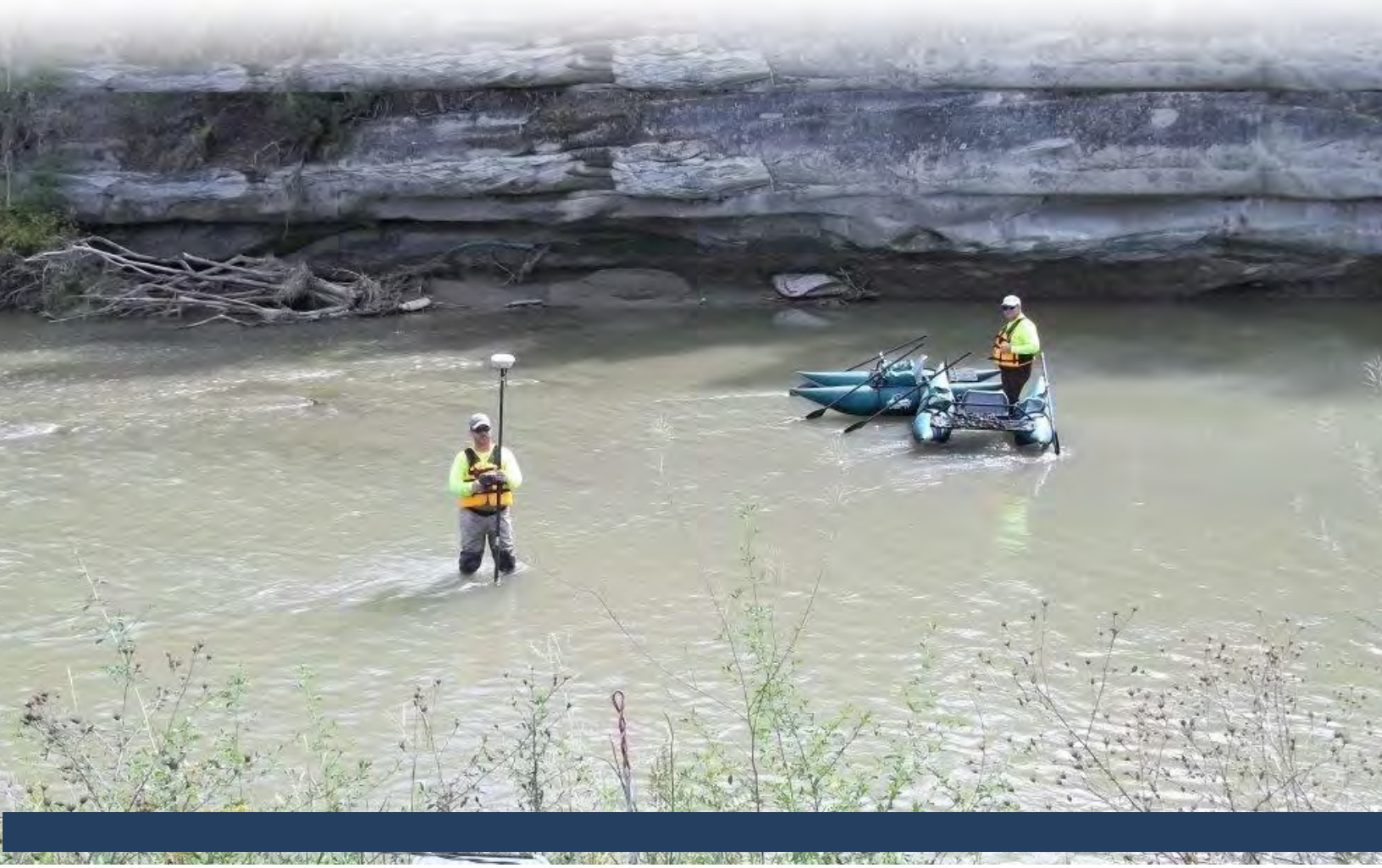
RESTORING OUR ENVIRONMENT DESIGNING OUR FUTURE



Musselshell River Floodplain Study – Phase 1

Final Structure and Bathymetric Survey Report

Montana DNRC

January 23, 2015

Pioneer Technical Services, Inc. 106 Pronghorn Trail, Bozeman Montana 59718

www.pioneer-technical.com

Phase 1 Musselshell River Floodplain Study

Structure and Bathymetric Survey Report

Prepared for:

State of Montana, Department of Natural Resources and Conservation

1424 9th Avenue, Montana 59620

Prepared by:

Pioneer Technical Services, Inc.

106 Pronghorn Trail

Bozeman, Montana 59718

Musselshell River Floodplain Study – Phase 1

Structure and Bathymetric Survey Report

January 23, 2015

I hereby certify that all work products (maps, reports, etc.) prepared for this project were done so under my direct supervision and that I am a duly Licensed Professional Land Surveyor under the laws of the State of Montana.

Jared A. Lay, P.L.S.

Date: 01/23/15 Montana Registration No. 17305

Pioneer Technical Services, Inc.
1309 Cole Ave
Helena, MT 59601

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1 INTRODUCTION

The mainstem of the Musselshell River extends approximately 335 miles from its mouth at Fort Peck Reservoir to the confluence of the North and South Forks of the Musselshell near the town of Martinsdale, Montana. During the spring runoff in 2011, the river significantly flooded with peaks exceeding the 200-year event throughout the watershed. The flood resulted in devastating damages, including significant physical changes to the river channel as documented in the *Musselshell River Flood Rehabilitation River Assessment Triage Team (RATT) Summary Report* (Applied Geomorphology and RATT, 2012) (RATT Summary Report).

The existing floodplain mapping for the mainstem Musselshell River includes some, limited detail, and approximate Zone A level study reaches that date back to the late 1970s and early 1980s. In 2013, the City of Roundup and Musselshell County requested assistance from the Montana Department of Natural Resources and Conservation (DNRC) to update their floodplain mapping. The DNRC, in partnership with the Federal Emergency Management Agency (FEMA), the Musselshell River communities, and other stakeholders initiated work to produce new floodplain studies along select reaches of the river. In 2012, the U.S. Army Corp of Engineers (USACE) produced a Light Detection and Ranging (LiDAR) survey for the entire length of the Musselshell River corridor that provided a 1-meter grid Digital Elevation Model (DEM) of the basin and channel topography above the water surface.

This first phase of the Musselshell River floodplain study(ies) will provide the groundwork for scoping and completing floodplain mapping projects throughout the Musselshell River corridor. This phase of the project is comprised of the following activities:

1. Structure and bathymetric survey for a 10-mile reach near Roundup, Montana;
2. Field reconnaissance and hydraulic structure assessment; and
3. Hydrologic analysis.

This report documents the data acquisition, processing methods, accuracy assessment, and results for Activity 1: the structure and bathymetric survey completed in September 2014.

2 PURPOSE OF INVESTIGATION

The purpose of this investigation was to conduct a detailed hydraulic structure and bathymetric survey for a 10-mile reach in the vicinity of Roundup, Montana.
The information collected from this investigation will support future floodplain studies along the Musselshell River. This investigation included the following three activities:

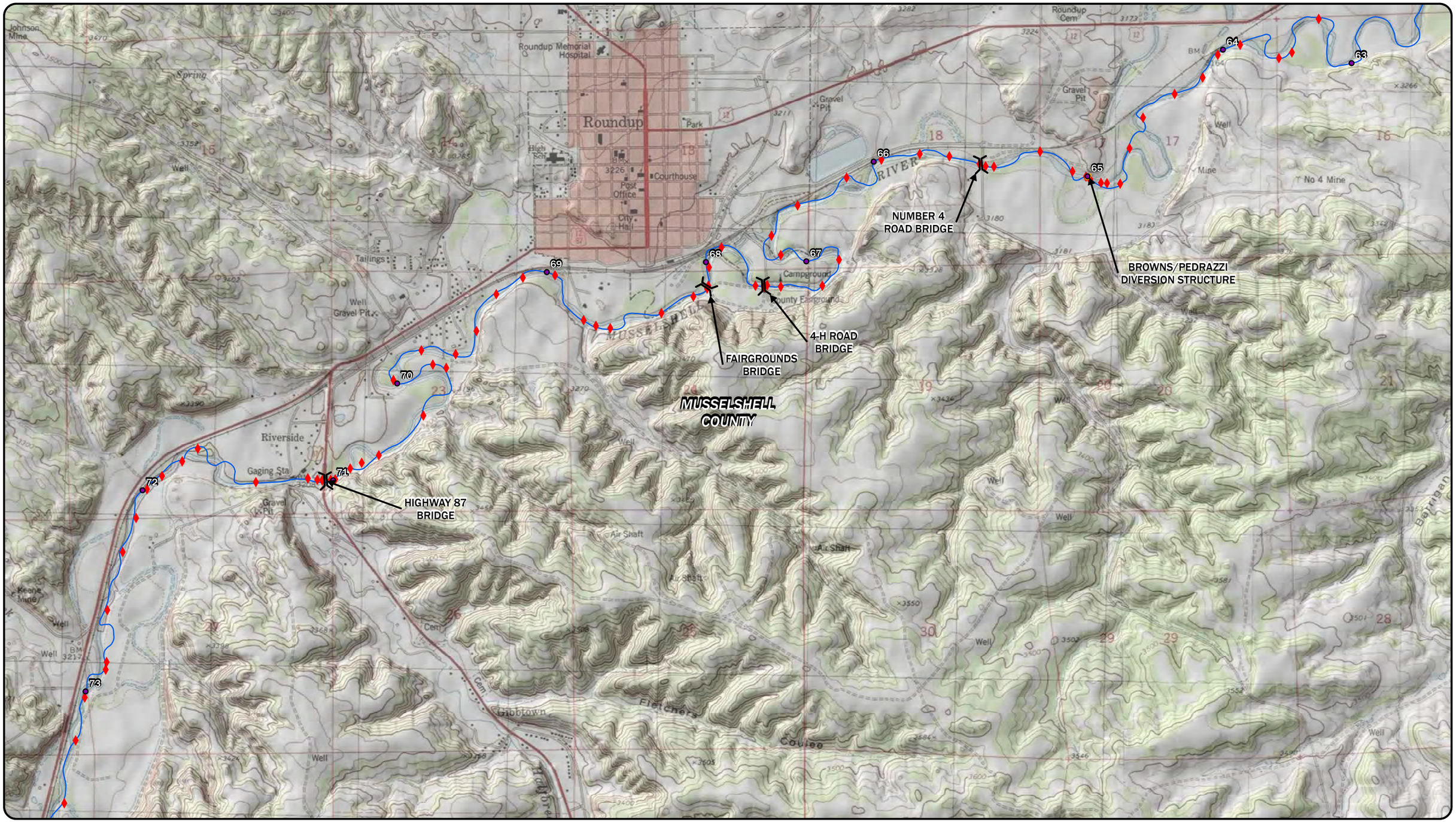
1. A hydraulic structure survey of four bridges and one diversion structure including:
    a. Highway 87 Bridge southwest of Roundup.
    b. 2nd Street East, County Fairground Bridge.
    c. 4-H Road, County Fairground Bridge.

   d. Number 4 Road Bridge.
   e. Browns/Pedrazzi diversion structure.

2. A bathymetric cross-section survey of the Musselshell River starting approximately 5 miles downstream of Roundup and extending 10 miles upstream (between Musselshell County River Mile (RM) 63 and RM 73.

3. The development of a merged DEM, incorporating the 2014 bathymetric data with 2012 USACE LiDAR data provided by the Montana DNRC.

Figure 1 shows the extent of the study reach.



LEGEND

- RIVER MILES
- SURVEYED BRIDGE
- DIVERSIONS
- SURVEYED BATHYMETRIC CROSS-SECTION

N

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PROJECTION/ZONE: MSP
DATUM: NAD 83
UNITS: INTERNATIONAL FEET
SOURCE: PIONEER/NRIS
ESRI WORLD IMAGERY-LAST UPDATED 10/14

0 1,000 2,000 4,000
Feet

FIGURE 1

PIONEER TECHNICAL SERVICES, INC.

MUSSELSHELL RIVER
SURVEY EXTENTS
AND OVERVIEW

DATE: 11/18/2014

Path: P:\DNRC\Musselshell Hydrologic Study\GIS\MSLSHELL_SRVY_FIG-001-14.mxd

3 METHODOLOGY

The survey work was conducted by Pioneer Technical Services, Inc. (Pioneer) between September 2, 2014, and September 18, 2014. The survey team was led by Jared Lay (PLS, CFedS) and included Mark Stratton (LSI) and Michael Newhouse (CST Level II Field).

3.1 Control Survey

The following instrumentation and methodologies were used to establish the survey control network used in the structure and bathymetric survey.

3.1.1 Control Survey Instrumentation

Trimble R8 Model 3 GNSS (R8) receivers were used during both static and RTK GPS applications. The R8 is capable of receiving satellite signals from all available satellites and when using Real Time Kinematic (RTK) Global Positioning System (GPS) procedures, it provides a 10 millimeter (mm) + 1 parts per million (ppm) horizontal accuracy and a 20 mm + 1 ppm vertical accuracy. This receiver is used in tandem with the Trimble TSC3 data collector running Trimble Access Software. This software allows a seamless transition between GPS and conventional surveying.

When terrain and conditions required conventional equipment, a Trimble S6 Robotic Total Station was used. The S6 employs robotic technology allowing for perfect alignment on the target prism, essentially eliminating pointing error. Once the S6 is set up and running, it follows the 360-degree prism automatically. Each visible point is collected using only one person. For applications where a desired shot is unreachable or unsafe to physically occupy, the S6 can be switched to direct reflector mode. The instrument is pointed directly at the target and measured remotely. This direct reflector mode produces errors of 2 mm + 2 ppm.

3.1.2 Control and Monumentation

An initial and independent control point, CP-1, was established along Winchester Road, south of Roundup atop the breaks on the right bank of the Musselshell River. This point monument consisted of a 5/8-inch by 24-inch rebar driven flush with the ground and topped with a 2-inch Pioneer aluminum cap. The aluminum cap was marked with the year “2014” and “1” designating the control point number. Figure 2 shows an example of a typical monument cap.

Figure 2 Typical Control Cap Used.

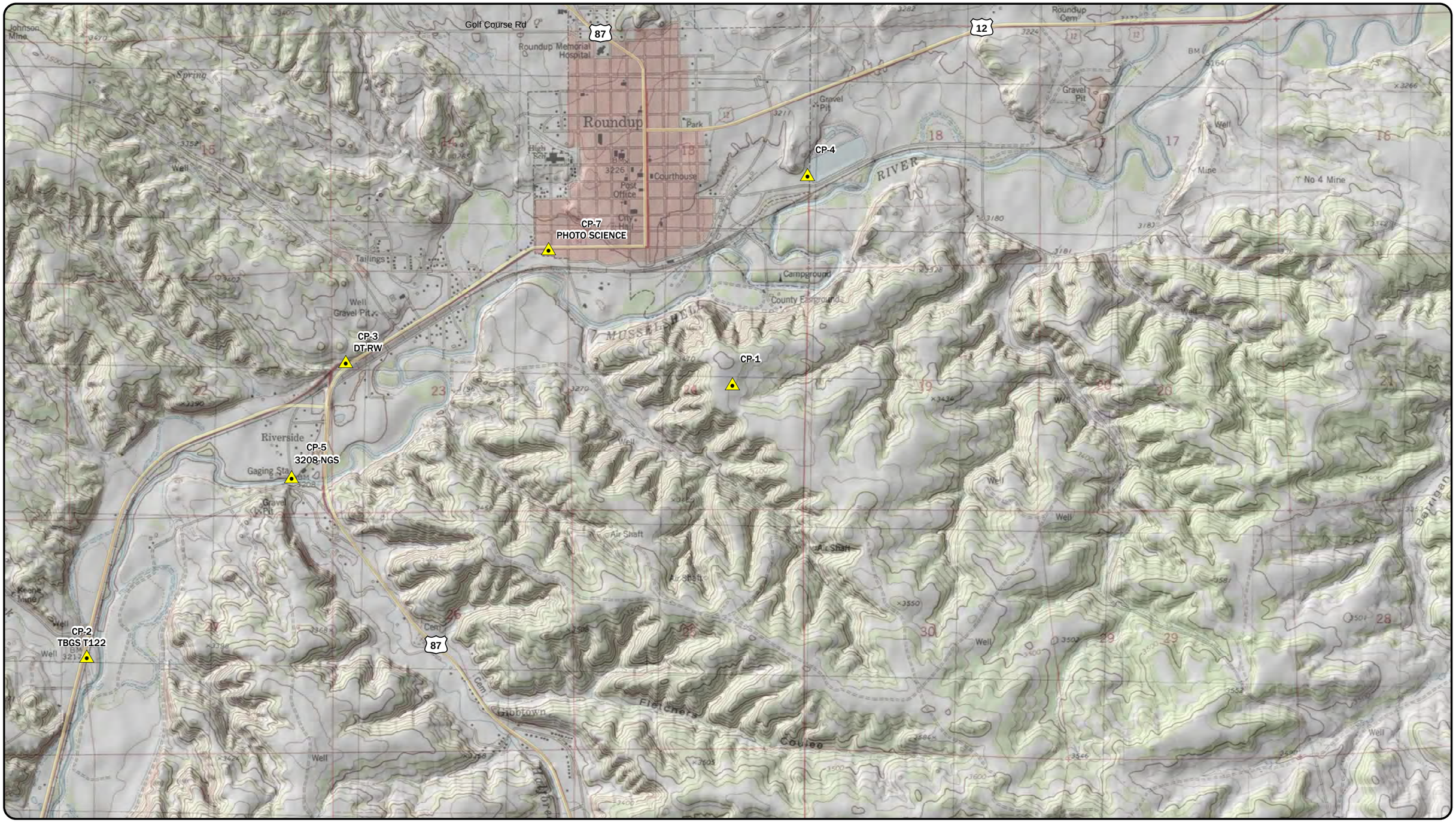
Two additional points (CP-3 and CP-4) were established and used as base positions. Points CP-3 and CP-4 were tied using RTK GPS methods. The locations of these two control points provided for shorter baselines which help reduce the ppm error associated with long baselines.

Point CP-3 was an existing right-of-way monument set by Montana Department of Transportation (MDT). The right-of-way monument consisted of a 5/8-inch by 24-inch rebar driven flush with the ground and topped with a 2-inch MDT aluminum cap, marked "R/W." Point CP-4 consisted of a 5/8-inch by 24-inch rebar driven flush with the ground and topped with a 2-inch Pioneer aluminum cap.

To verify the positions of the control relative to existing National Geodetic Survey (NGS) benchmarks, NGS points "T122" (CP-2) and "3208" (CP-5) were also tied using RTK GPS procedures. The average elevation difference between the two NGS elevation values and Pioneer survey values was ±0.10 feet. This places the vertical survey within the 95% Confidence envelope between 2 centimeters (cm) and 5 cm per Federal Geodetic Data Committee (FGDC)-STD-007.2-1998 Part 2 Table 2.1. The NGS data sheets for these two control points can be found in Appendix A.

Additional checks were completed using the LiDAR control points set by Photo Science (the company that produced the 2012 ACOE LiDAR). Photo Science control points typically consisted of a 2-inch MAG nail with a plastic washer marked "SURVEY MARKER."

Figure 3 shows the locations of the Control Points.



LEGEND

CP

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PROJECTION/ZONE: MSP
DATUM: NAD 83
UNITS: INTERNATIONAL FEET
SOURCE: PIONEER/NRIS
ESRI WORLD IMAGERY-LAST UPDATED 10/14

0 1,000 2,000 4,000
Feet

FIGURE 3

CONTROL POINT LOCATIONS

PIONEER TECHNICAL SERVICES, INC.

DATE: 11/18/2014

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3.1.3 Methodology

A Trimble R8 Model 3 GNSS receiver atop a fixed height tripod was used to gather the position of CP-1. The receiver was placed in static mode and set to record measurements every 30 seconds. Two independent sessions, one 3-hour session and one 7-hour session, were collected on separate days. These sessions were sent to the NGS Online Positioning User System (OPUS) for post-processing to the existing Continuously Operating Reference Stations (CORS).

The two independent sessions were processed with differences less than 0.02 feet horizontally and 0.06 feet vertically. The positions were averaged and accepted as the value for CP-1.

The RTK GPS procedures using two independently fixed 3-minute sessions were used to tie control points 2 through 5. An independent OPUS check was completed on CP-3. The results were received and differences between OPUS and RTK were less than 0.04 feet horizontally and 0.05 feet vertically. We accepted our RTK positions and used points CP-1, CP-3 and CP-4 as base positions throughout the course of this survey. Points CP-2 and CP-5 served as verification checks into the NAVD 88 datum.

The 2012 USACE LiDAR information and survey control was provided to Pioneer by DNRC. Within the LiDAR information was a ground control report from Photo Sciences. This report provided control point information in UTM Zone 12 North, NAD83 (2007) meters. The LiDAR control was converted into Montana State Plane, NAD83 international feet, NAVD88 US feet. These points and their respective coordinates were extracted from the report and converted to the Montana State Plane system using the conversion program Corpscon 6.0.1. This conversion process allowed us to create points for a physical check on the ground surface that directly corresponded to the LiDAR data collection.

Photo Science control points CP-6, CP-7, CP-8 and CTR-24 were also tied as checks against the existing LiDAR data. All measured vertical coordinates had differences of less than 0.10 feet. This falls within the 5 cm (0.16 feet) accuracy classification per FGDC-STD-007.2-1998 Part 2 Table 2. Using the observed baseline lengths, this roughly correlates to the reported accuracy of RTK GPS, i.e., 1 cm +1 ppm horizontally and 2 cm +1 ppm vertically.

Control coordinate comparisons can be found in Appendix B.

3.2 Field Survey

The following instrumentation and methodologies were used to acquire data for the structure and bathymetric survey. All survey data were collected relative to the following coordinate system, data, and units: Montana State Plane, NAD83 International feet, NAVD88 US feet.

3.2.1 Instrumentation

The instrumentation described in the previous control survey section was used for the structure and bathymetric portion of this survey, specifically the Trimble R8 GNSS Model 3 receiver and the Trimble S6 Robotic Total Station. Both pieces of equipment were used in tandem with the Trimble TSC3 data collector running Trimble Access Software.

3.2.2 Methodology

3.2.2.1 Structure Survey

The RTK GPS and conventional techniques were used to collect the bridge and diversion structure data. Typically two temporary control points were established near the bridge location, one being upstream of the bridge and the other downstream. The Trimble S6 Robotic total station was then placed over one control point and a back-sight check was completed on the other control point. This process was repeated for points on the opposite side of the bridge. The majority of the points were collected using the 360-degree prism; however, when it proved most efficient, the reflectorless technology was employed. Typically this was while collecting the Low Chord points on the underside of the bridge. Pioneer crews were able to aim the instrument directly at the point they wanted to collect and measure a position.
Points were stored using codes compliant with FEMA data capture standards (FEMA, May 2013).

In addition to the structure survey, 4 river channel bathymetric cross-sections were surveyed to facilitate hydraulic modeling of the structures in the ACOE HEC-RAS hydraulic model. The cross-sections were located and surveyed according to HEC-RAS bridge structure hydraulic modeling guidelines.

Both the upstream and downstream faces of the bridge were collected. Bridge widths are defined as the horizontal distance of the structure perpendicular to traffic. Bridge spans are defined the horizontal distance between abutments/piers. The diversion widths are defined as the horizontal distance of diversion perpendicular to the flow of the water.

3.2.2.2 Bathymetric Survey

Prior to conducting the fieldwork, proposed locations for the bathymetric survey cross-sections were developed using National Agriculture Imagery Program (NAIP) 2013 aerial photogrammetry. These proposed locations were reviewed by DNRC prior to initiating the fieldwork. The proposed cross-section location coordinates were uploaded into the survey GPS instruments and staked in the field. Surveyed cross-section locations were then adjusted based on field observations, to be measured at channel riffle sections where present. It should be noted that the Musselshell River is in a highly disturbed condition and the channel bed structure often departs significantly from

equilibrium gravel bed river geomorphic features. Bathymetric cross-section information was collected using RTK GPS procedures as outlined above. A 2.1 meter fixed height rod topped with a Trimble R8 GNSS Model 3 receiver was carried in hand as the operator waded across the river collecting points at cross-section stations. This procedure allowed the operator to directly locate the channel thalweg (CHCL) and measure that position. Additional shots collected include channel (CH), Toe of Slope (TOS), Edge of Water (EW), Top of Bank (TOB) and Ground (GR). The descriptors used in the bathymetric survey correspond to the FEMA data capture standards (FEMA, 2013).

Where the water was too deep to wade, survey data were collected using a one-person pontoon-type float. The operator on the float would row to a cross-section station and position the rod in the water. A system was used that allowed the float operator to support the rod without the use of his hands and thereby control the float. Another operator positioned on the bank would collect the surveyed position via a Bluetooth connection between the receiver and data collector. This methodology allowed for safe handling of the float while accurately collecting positions with the survey equipment. All points collected below the surface of the water have the same accuracy as those collected above the water using RTK GPS procedures.

3.2.3 Accuracy Verification

3.2.3.1 Field Survey

Different levels of accuracy can be achieved using RTK GNSS procedures. Pioneer exercises a rigorous standard practice to ensure that topographic data are collected at an accuracy level of ±0.15 feet horizontally and ±0.15 feet vertically. Our standard of practice is as follows:

1. Initial quality control: All Pioneer projects start with a known control point or a point whose position has been established by using the NGS OPUS. *"OPUS solutions using 2 hours or more of static GPS data yield a RMSE of 0.8 (0.03'), 2.1(0.07'), and 3.4 cm (0.11') in the north, east and up components of the derived positional coordinates, respectively. Results drastically improve for solutions containing 3 hours or more of GPS data*."[1] The OPUS report for CP-1 is provided in Appendix C.

2. Set receivers to not record with Positional Dilution of Precision greater than 6.0 (values over 6.0 generally produce low confidence level results).

3. Set receivers to not record measurements from satellites lower than 10 degrees below the horizon (signals received from satellites lower on the horizon introduce more error due to refraction through the earth's atmosphere).

4. Set receivers to not collect any measurement that is not based on a fixed solution (a float solution is not a reliable solution and accuracy plummets).

[1] Accuracy of OPUS solutions for 1- to 4-h observing sessions, http://www.ngs.noaa.gov/CORS/Articles/OPUSGPSSol.pdf

5. Set receivers to not collect any measurement that has a higher than 0.15 feet RMS value horizontally or vertically (typical measurements are well within this range and this value represents the most inaccurate position collected).

6. Keep baselines less than 5.0 miles (this limits the ppm degradation to an acceptable level, typically less than 0.10 feet vertically).

7. Perform a check tie on another control point. Work does not proceed unless an acceptable value is achieved (typically less than 0.10 feet).

Pioneer conducted an independent static survey of CP-1. The RTK GPS procedures were used to tie existing NGS control and existing Photo Science Control. The elevations were an average of 0.10 feet higher than NGS benchmarks and an average of 0.05 feet lower than the Photo Science control. Consequently, our survey control is a good match to both existing control schemes and emulates the 2-cm accuracy level as defined per FGDC-STD-007.2-1998 Part 2 Table 2. Following our standard for topographic data collection, results are within 0.15 feet horizontally and 0.15 feet vertically for cross-section and structure coordinates.

3.2.4 Merged DEM

The Musselshell River 2014 bathymetric survey data were merged with the Musselshell River 2012 ACOE LIDAR survey (LiDAR) to extend the river channel ground surface below the LiDAR water surface.

3.2.4.1 Methods

Musselshell River 2014 bathymetric survey data were imported into Autocad Civil 3D along with the Musselshell USACE 2012 LiDAR (LiDAR) 3D hydro-flattened breaklines (representing the water surface at the time of the LiDAR).

Channel bathymetry in-between the surveyed cross-sections, was defined by creating channel thalweg and toe of slope breaklines, which were assigned elevations by interpolating elevations between the surveyed cross-sections.

Using NAIP 2013 aerial imagery for reference, the channel thalweg was defined by drawing a 3D feature line along the estimated thalweg alignment which tied into the 2014 bathymetric cross-section thalweg survey points at each intersection with the bathymetric cross-sections.

Toe of slope breaklines were developed by horizontally and vertically offsetting the LiDAR hydro-flattened breaklines. The hydro-flattened breaklines were offset 5.0 feet horizontally and -2.0 feet vertically (the approximate average offset from LIDAR edge of water to the surveyed toe of slope at the bathymetric cross-sections). Where the surveyed toe of slope varied more than 0.5 feet from the standard 5H:2V offset, the offset was adjusted upstream and downstream of the cross-section to reflect the survey data.

Using the developed breaklines and bathymetric survey point data a Triangular Irregular Network (TIN) surface was created in Civil 3D that represented channel surface below the 2012 LiDAR water surface. The 2014 bathymetry water surface was generally at or below that of the LiDAR surface. In places where the 2014 bathymetric water surface extended beyond the 2012 LiDAR water surface boundary, the bathymetric data were extended beyond the LIDAR hydro-flattened breaklines into the LiDAR topography.

LiDAR tile boundaries were imported into Civil 3D and the bathymetric surface was organized to match the LIDAR tile boundaries. The finished surface contours for each tile were then exported as a shapefile with 0.5-foot contours.

Each tile contour shapefile was brought into ArcGis 10.1 and then converted to a DEM raster. The bathymetry DEM raster was converted back to contours to check the accuracy of the conversion. The 2012 LIDAR DEM raster was then merged with the 2014 bathymetry raster, maintaining the same pixel type, cell size and bands as the 2012 LIDAR DEM. Contours and Hillshade imagery were created from the new merged raster as well as cross-sections to check for accuracy. This process was repeated for each tile.

4 RESULTS

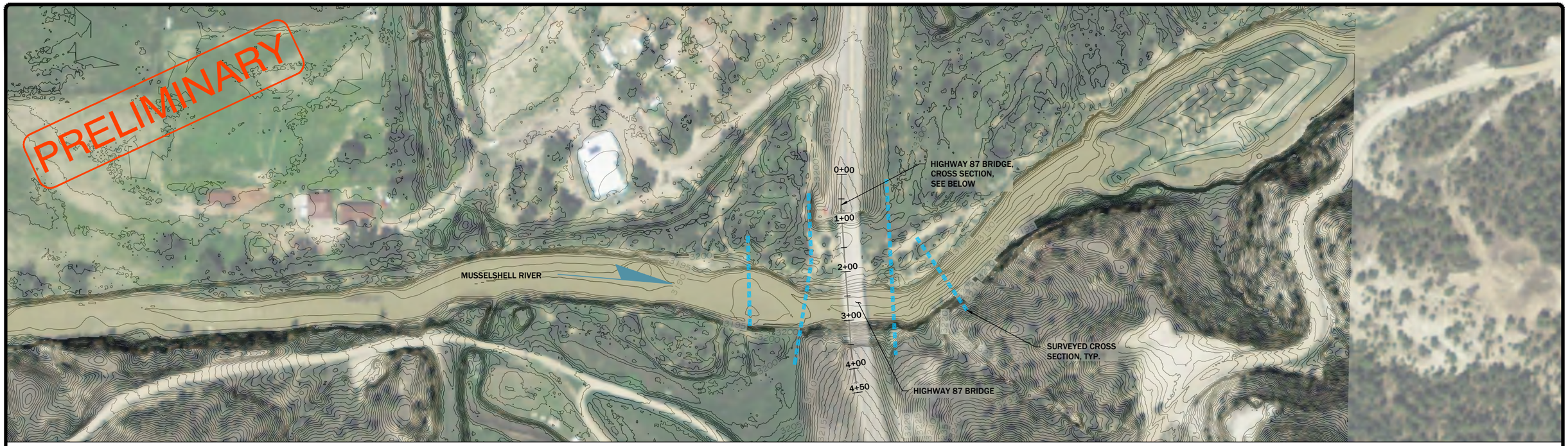
4.1 Structure Survey

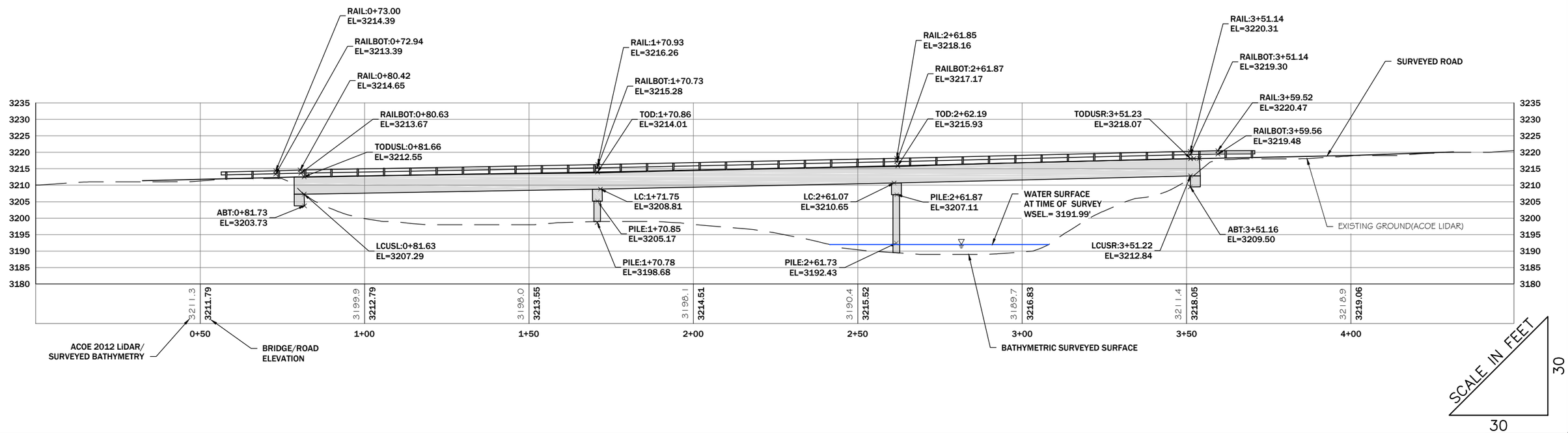
Figure 1 shows the overall locations of the five surveyed structures. Figure 4 through Figure 7 provides a plan and profile for each of the surveyed bridge structures and Figure 8 provides a plan and profile of the diversion structure. The plan views include the location of the bathymetric cross-sections that were surveyed to support the structure hydraulic modeling. The profiles provide the upstream bridge face survey shots including the water surface.

Digital data for the structural survey data are provided on a CD in Appendix D. The structural survey data included in this report can be used to conduct detailed hydraulic modeling of the bridge and diversion structure to support Zone AE level floodplain studies.

Table 1 to Table 4 provide bridge data in a HEC-RAS format. These tables are also provided electronically in Appendix D.

Field photographs of the structures are provided in Appendix E.





NOTES:
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2. STRUCTURE TYPE: BRIDGE.
3. STRUCTURE MATERIAL TYPE: CONCRETE.
4. STRUCTURE CONDITION: GOOD.
5. PIER DIAMETER = 16".
6. BRIDGE WIDTH = 42.0'.
7. SPAN 1 = NORTH ABUTMENT TO PIER = 89.2'.
8. SPAN 2 = PIER TO PIER = 91.0'
9. SPAN 3 = PIER TO SOUTH ABUTMENT = 89.2'.
10. MUSSELSHELL COUNTY RIVER MILE = 71.

N

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UNITS:	INT. FEET
SOURCE:	PIONEER/ACOE 2012

SCALE IN FEET
0 100 200

FIGURE 4

PIONEER TECHNICAL SERVICES, INC.
106 PRONGHORN TRAIL, SUITE A
BOZEMAN, MONTANA 59718
(406) 388-8578

HIGHWAY 87 BRIDGE PLAN & PROFILE

DATE: 11/18/14

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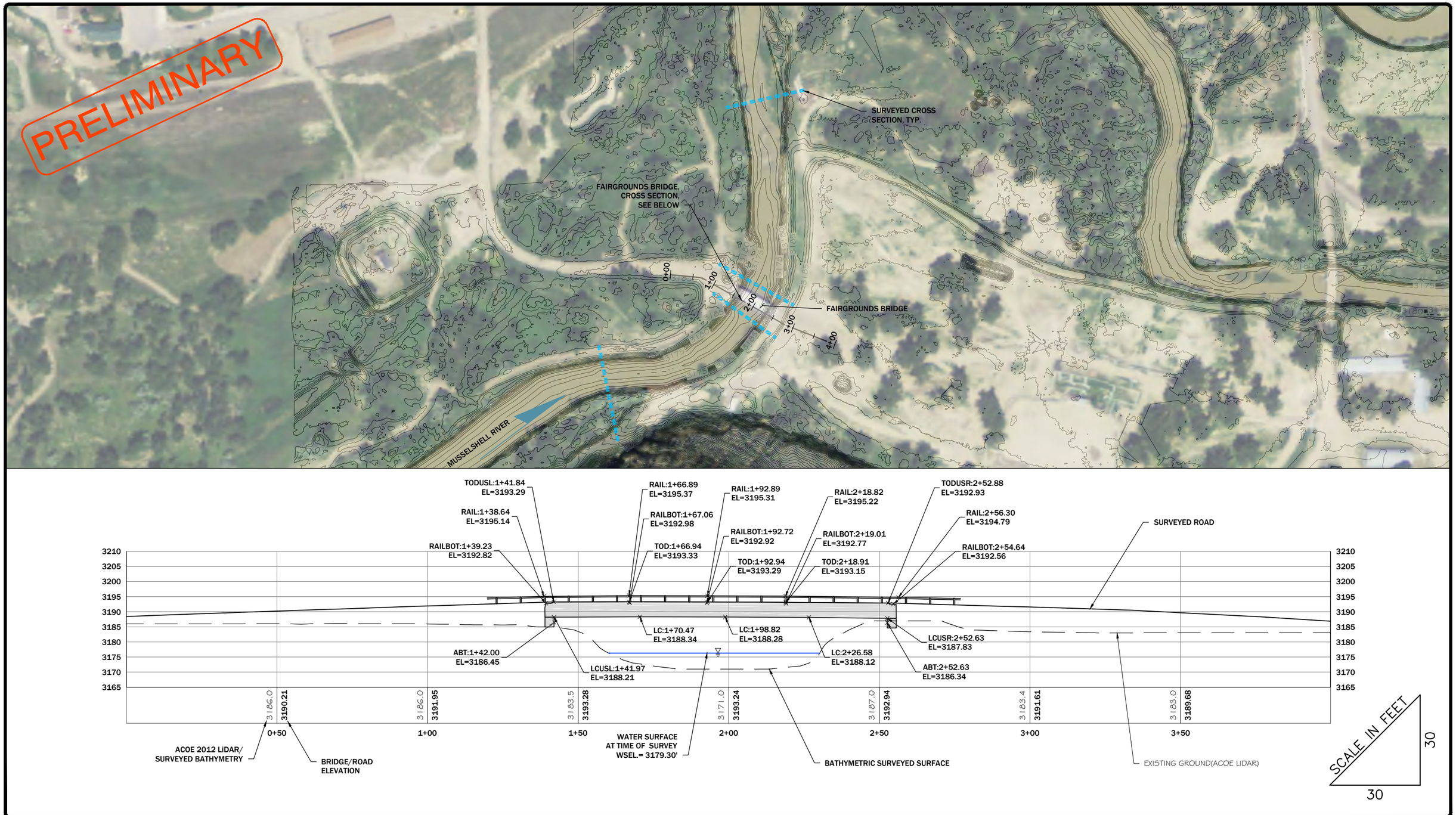

NOTES:
1. PROFILE VIEW REPRESENTS UPSTREAM FACE OF BRIDGE.
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3. STRUCTURE MATERIAL TYPE: CONCRETE.
4. STRUCTURE CONDITION: GOOD.
5. BRIDGE WIDTH = 21.8'.
6. BRIDGE SPAN = 110.7'.
7. MUSSELSHELL COUNTY RIVER MILE = 68.1.

N

DISPLAYED AS:
COORD SYS/ZONE: MSP NAD83
DATUM: NAVD88
UNITS: INT. FEET
SOURCE: PIONEER/ACOE 2012

SCALE IN FEET
0 100 200

FIGURE 5

PIONEER TECHNICAL SERVICES, INC.
106 PRONGHORN TRAIL, SUITE A
BOZEMAN, MONTANA 59718
(406) 388-8578

MUSSELSHELL COUNTY
FAIRGROUNDS
BRIDGE
PLAN & PROFILE

DATE: 11/18/14

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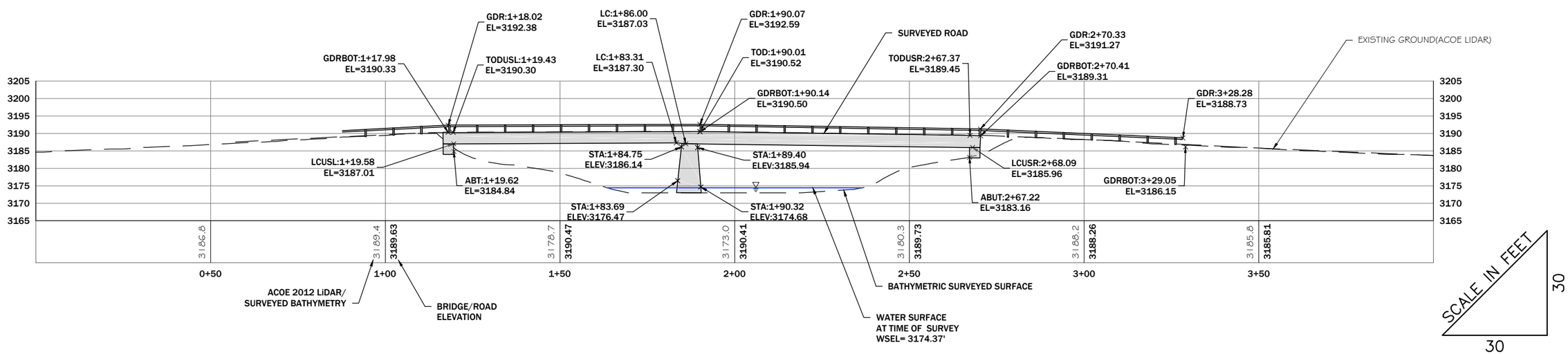

NOTES:
1. PROFILE VIEW REPRESENTS UPSTREAM FACE OF BRIDGE.
2. STRUCTURE TYPE: BRIDGE.
3. STRUCTURE MATERIAL TYPE: WOOD WITH STEEL ABUTMENT.
4. STRUCTURE CONDITION: POOR.
5. BRIDGE WIDTH = 16.1'.
6. SPAN 1 = NORTH ABUTMENT TO PIER = 70.6'.
7. SPAN 2 = PIER TO SOUTH ABUTMENT = 78.0'.
8. MUSSELSHELL COUNTY RIVER MILE = 67.6.

N

DISPLAYED AS:
COORD SYS/ZONE: MSP NAD83
DATUM: NAVD88
UNITS: INT. FEET
SOURCE: PIONEER/ACOE 2012

SCALE IN FEET
0 100 200

FIGURE 6

PIONEER TECHNICAL SERVICES, INC.
106 PRONGHORN TRAIL, SUITE A
BOZEMAN, MONTANA 59718
(406) 388-8578

4-H ROAD BRIDGE PLAN & PROFILE

DATE: 11/18/14

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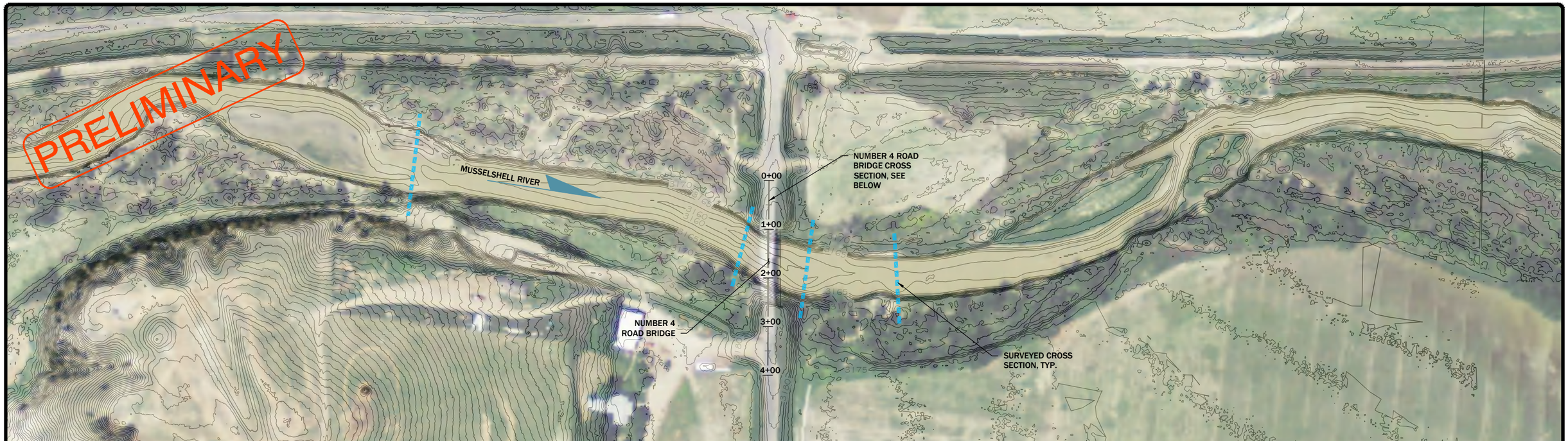
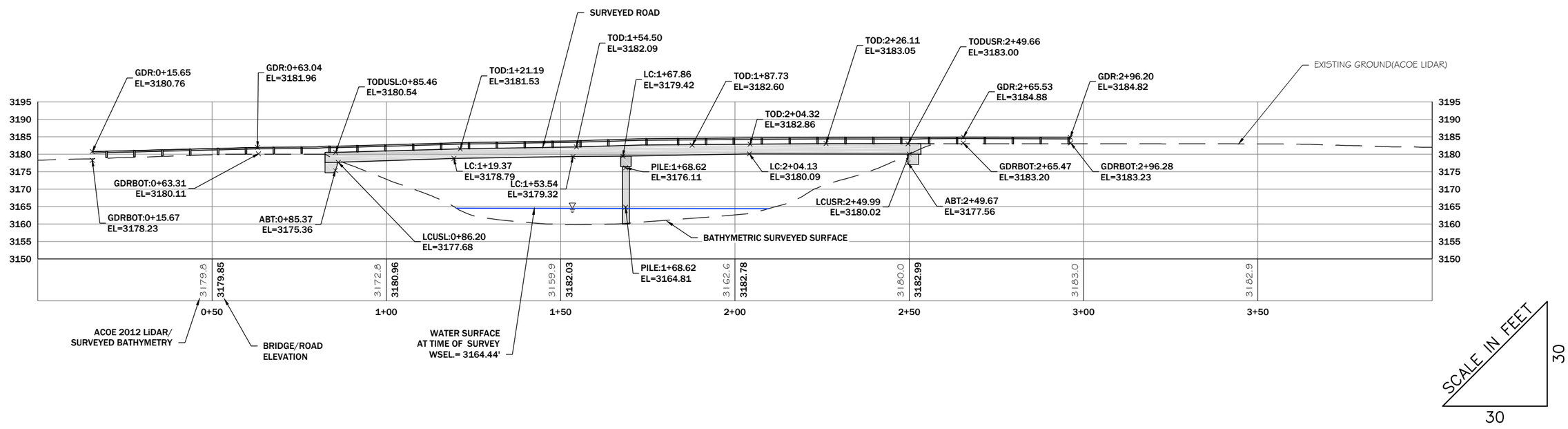




NOTES:
1. PROFILE VIEW REPRESENTS UPSTREAM FACE OF BRIDGE.
2. STRUCTURE TYPE: BRIDGE.
3. STRUCTURE MATERIAL TYPE: CONCRETE.
4. STRUCTURE CONDITION: GOOD.
5. PIER DIAMETER = 16".
6. BRIDGE WIDTH = 26.2'.
7. SPAN 1 = NORTH ABUTMENT TO PIER = 82.4'.
8. SPAN 2 = PIER TO SOUTH ABUTMENT = 81.4'.
9. MUSSELSHELL COUNTY RIVER MILE = 65.5

N

DISPLAYED AS:	
COORD SYS/ZONE:	MSP NAD83
DATUM:	NAVD88
UNITS:	INT. FEET
SOURCE:	PIONEER/ACOE 2012

SCALE IN FEET
0 100 200

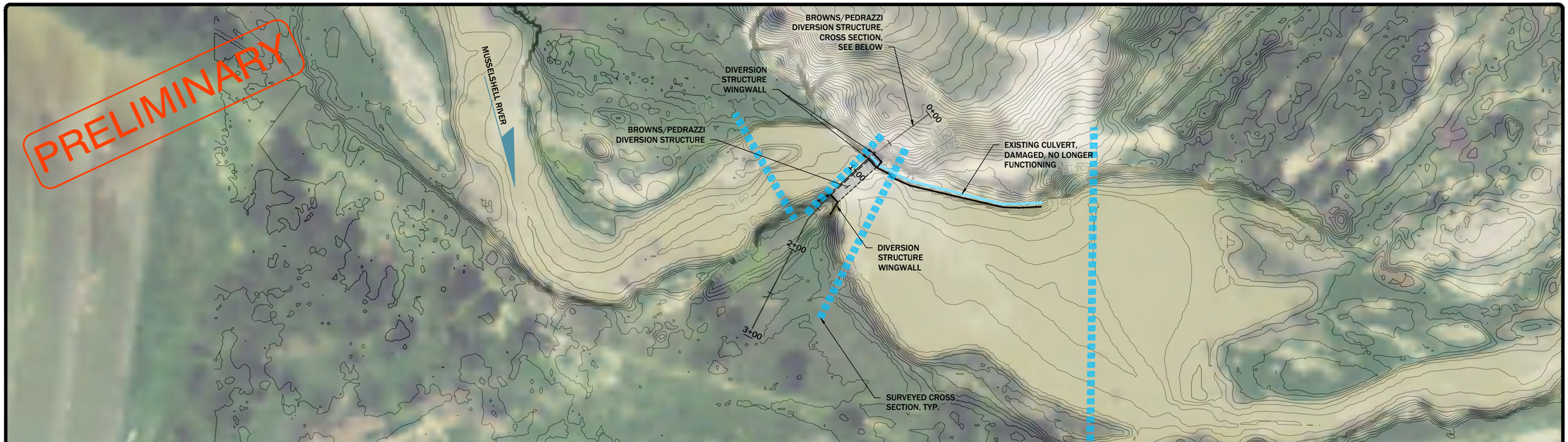
FIGURE 7

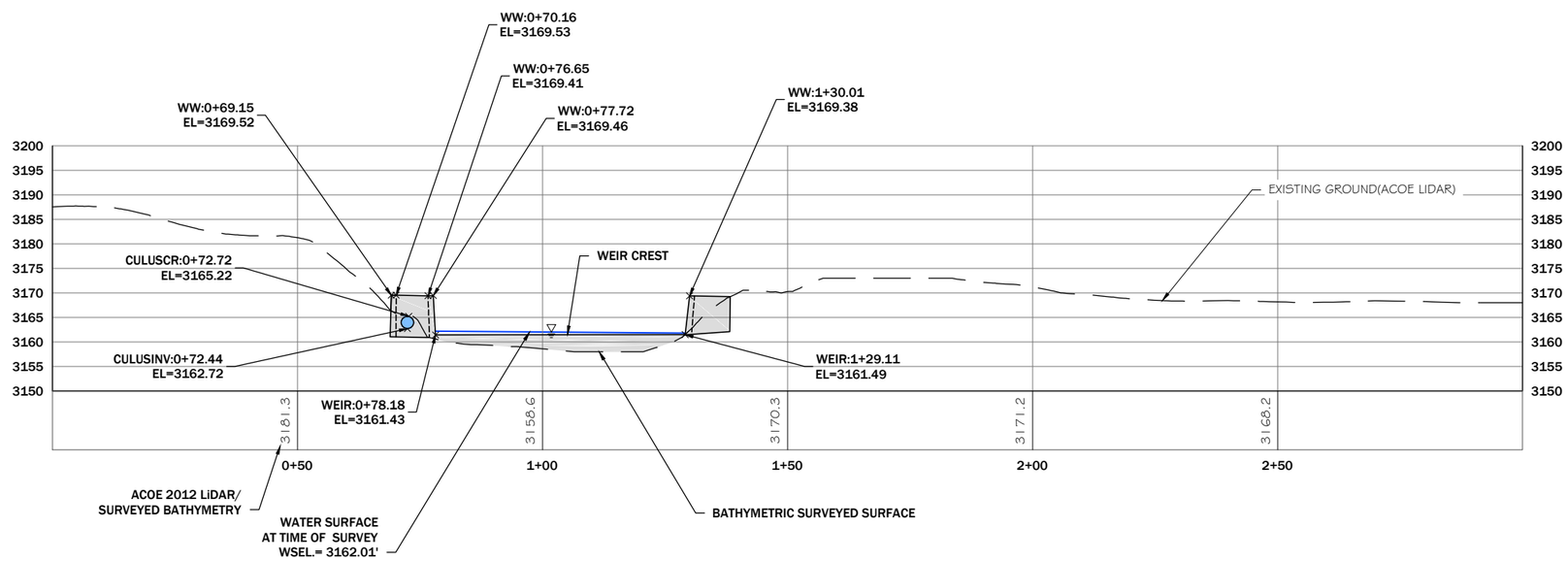
PIONEER TECHNICAL SERVICES, INC.
106 PRONGHORN TRAIL, SUITE A
BOZEMAN, MONTANA 59718
(406) 388-8578

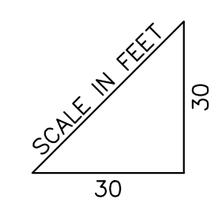
NUMBER 4 ROAD BRIDGE PLAN & PROFILE

DATE: 11/18/14

11/18/2014 4:42:06 PM P:\DNRC\MUSSELSHELL HYDROLOGIC STUDY\DRAWINGS\BRIDGE\MSLSHL-BRG-FIG-001-14.DWG







NOTES:
1. PROFILE VIEW REPRESENTS FACE OF WEIR.
2. STRUCTURE TYPE: DIVERSION.
3. STRUCTURE MATERIAL TYPE: CONCRETE.
4. STRUCTURE CONDITION: FAIR, NO LONGER DIVERTS WATER, CULVERT IS DEMOLISHED.
5. STRUCTURE WIDTH = 50.9'.
6. MUSSELSHELL COUNTY RIVER MILE = 65.

N

	DISPLAYED AS:
COORD SYS/ZONE:	MSP NAD83
DATUM:	NAVD88
UNITS:	INT. FEET
SOURCE:	PIONEER/ACOE 2012

SCALE IN FEET
0 50 100

FIGURE 8

BROWNS/PEDRAZZI DIVERSION STRUCTURE PLAN & PROFILE

PIONEER TECHNICAL SERVICES, INC.
106 PRONGHORN TRAIL, SUITE A
BOZEMAN, MONTANA 59718
(406) 388-8578

DATE: 11/18/14

Table 1 Highway 87 Bridge Data

Bridge: **Highway 87 Bridge**

Bridge Geometry

Distance[1]: 89.5 ft **Width[2]:** 42 ft

Upstream			Downstream		
Station[3]	**High Chord**	**Low Chord**	**Station[3]**	**High Chord**	**Low Chord**
81.63	3212.55	3207.29	81.56	3210.12	3204.96
171.75	3214.01	3208.81	171.54	3211.69	3206.57
261.07	3215.93	3210.65	260.94	3213.59	3208.42
351.22	3218.07	3212.84	350.94	3215.81	3210.63

Upstream Embankment Slope[4]: 4:1

Downstream Embankment Slope[4]: 4:1

Pier Geometry

Upstream			Downstream		
CL Station	**Pier Width**	**Elevation**	**CL Station**	**Pier Width**	**Elevation**
170.78	1.33	3198.68	170.83	1.33	3200.9
	1.33	3205.17		1.33	3202.85
	3	3205.31		3	3202.88
	3	3208.81		3	3206.57
261.73	1.33	3189.48	262.08	1.33	3189.55
	1.33	3207.11		1.33	3204.61
	3	3207.27		3	3204.63
	3	3210.65		3	3208.42

Pier Type: Cylinder Capped Pile Pier

Notes:

1. Distance from upstream surveyed cross section to upstream edge of bridge.
2. Bridge width
3. Station corresponds to alignment on figures provided in Bathymetric Survey. Where surveyed Low chord and High chord stations differ the Low chord station was used.
4. Embankment slopes approximated from 2012 LiDAR.

Table 2 Fairgrounds Bridge Data

Bridge: **Fairgrounds**

Bridge Geometry

Distance[1]: 24.4 ft **Width[2]:** 21.8 ft

Upstream			Downstream		
Station[3]	**High Chord**	**Low Chord**	**Station[3]**	**High Chord**	**Low Chord**
141.97	3193.29	3188.21	141.95	3193.32	3188.23
170.47	3193.33	3188.34	169.92	3193.45	3188.33
198.82	3193.29	3188.28	198.07	3193.42	3188.26
226.58	3193.15	3188.12	226.47	3193.27	3188.12
252.63	3192.93	3187.83	252.70	3193.00	3187.79

Upstream Embankment Slope[4]: 50:1

Downstream Embankment Slope[4]: 50:1

Pier Geometry

Pier Type: Clear Span Bridge

Notes:

1. Distance from upstream surveyed cross section to upstream edge of bridge.
2. Bridge width
3. Station corresponds to alignment on figures provided in Bathymetric Survey. Where surveyed Low chord and High chord stations differ the Low chord station was used.
4. Road Embankment slopes approximated from 2012 LiDAR.

Table 3 4-H Road Bridge Data

Bridge: **4-H Road**

Bridge Geometry

Distance[1]: 36.3 ft **Width[2]:** 16.1 ft

Upstream			Downstream		
Station[3]	**High Chord**	**Low Chord**	**Station[3]**	**High Chord**	**Low Chord**
119.58	3190.3	3187.01	119.09	3190.3	3187.05
186	3190.52	3187.03	171.54	3190.44	3188.32
268.09	3189.45	3185.96	260.94	3189.37	3185.94

Upstream Embankment Slope[4]: 2.5:1

Downstream Embankment Slope[4]: 2.5:1

Pier Geometry

Upstream			Downstream		
CL Station	**Pier Width**	**Elevation**	**CL Station**	**Pier Width**	**Elevation**
187.1	7	3172.99	189.8	7	3173.5
	4.5	3187.03		4.5	3188.32

Pier Type: Triangular Nosed Wall Pier

Notes:

1. Distance from upstream surveyed cross section to upstream edge of bridge.
2. Bridge width (parallel to flow, perpendicular to travel)
3. Station corresponds to alignment on figures provided in Bathymetric Survey. Where surveyed Low chord and High chord stations differ the Low chord station was used.
4. Embankment slopes approximated from 2012 LiDAR.

Table 4 Number 4 Road Bridge Data

Bridge: **Number 4 Road Bridge**

Bridge Geometry

Distance[1]: 58.7 ft **Width[2]:** 26.2 ft

Upstream			Downstream		
Station[3]	**High Chord**	**Low Chord**	**Station[3]**	**High Chord**	**Low Chord**
86.20	3180.54	3177.68	91.88	3180.84	3177.89
119.37	3181.53	3178.79	120.41	3181.67	3178.70
167.86	3182.30	3179.42	155.06	3182.25	3179.35
204.13	3182.86	3180.09	189.40	3182.50	3179.67
249.99	3183.00	3180.02	256.08	3182.96	3180.00

Upstream Embankment Slope[4]: 3:1

Downstream Embankment Slope[4]: 3:1

Pier Geometry

Upstream			Downstream		
CL Station	**Pier Width**	**Elevation**	**CL Station**	**Pier Width**	**Elevation**
168.62	1.33	3160.1	173.11	1.33	3160.1
	1.33	3176.11		1.33	3175.97
	3	3176.23		3	3176.08
	3	3179.42		3	3179.35

Pier Type: Cylinder Capped Pile Pier

Notes:

1. Distance from upstream surveyed cross section to upstream edge of bridge.
2. Bridge width (parallel to flow, perpendicular to travel).
3. Station corresponds to alignment on figures provided in Bathymetric Survey. Where surveyed Low chord and High chord stations differ the Low chord station was used.
4. Embankment slopes approximated from 2012 LiDAR.

4.2 Bathymetric Survey

Figure 1 shows the locations of the bathymetric survey cross-sections. A total of 73 cross-sections were surveyed over the 10-mile reach, an average of approximately 7 cross-sections per mile with an average spacing of 700 feet. All survey data was collected in Montana State Plane NAD 83 International Feet, NAVD 88 US Feet

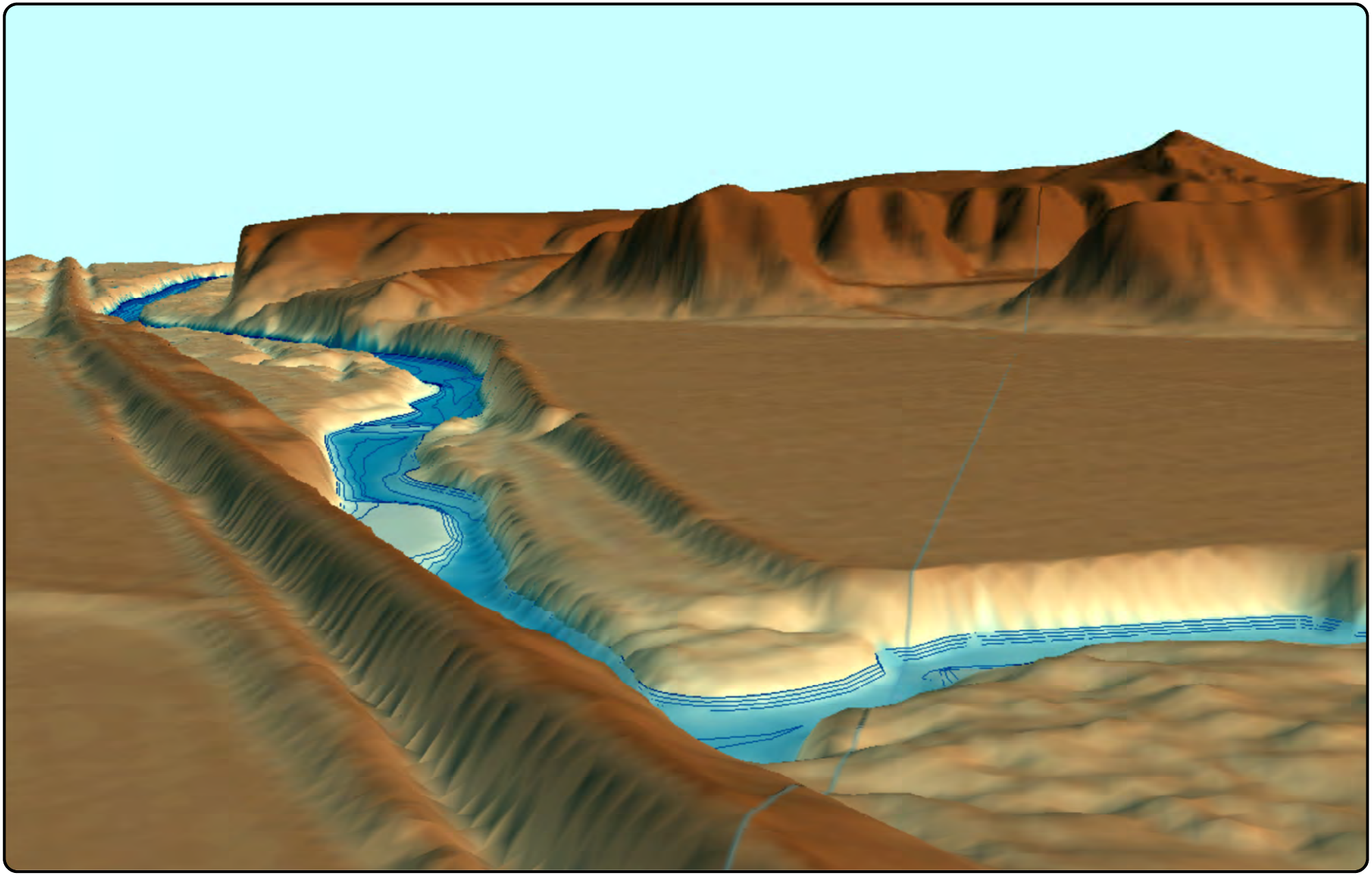
Data for the bathymetric survey data are provided on a CD in Appendix D. The data are in a comma delimited Point, Northing, Easting, Elevation, Description (PNEZD) CSV format. Figure 9 provides a plan view showing the bathymetric contours of the merged DEM and the individual DEM Tile boundaries. The merged DEM was submitted to DNRC as a digital work product in UTM Zone 12 North, NAD83 (2007) meters.

Field photographs of the bathymetric cross-sections are provided in Appendix E.

This merged DEM can be used to produce a HEC-RAS model suitable for detailed hydraulic modeling

4.3 Deliverables

WORK PRODUCT	FILE TYPE	PROJECTION\DATUM\UNITS
Structure Survey	Comma delimited, PNEZD CSV	MSP NAD 83 IF, NAVD 88 US Feet
Bathymetric Survey	Comma delimited, PNEZD CSV Shape file	MSP NAD 83 IF, NAVD 88 US Feet MSP NAD 83 IF, NAVD 88 US Feet
Merged DEM	Raster Bare Earth Model ESRI Grid 1 meter Resolution, DEM	UTM Zone 12 North, NAD83 (2007) meters NAVD 88 US Feet
Data Report	PDF	NA



LEGEND

Bathymetric Contours

2012 LiDAR Water Surface

DISPLAYED AS:
PROJECTION/ZONE: NAD83 NSRS 2007 UTM Z12N
DATUM: NAVD 88
UNITS: FEET
SOURCE: ACOE 2012/PIONEER

FIGURE 9

PIONEER TECHNICAL SERVICES, INC.

BATHYMETRIC SURVEY
MERGED LiDAR
DEM OVERVIEW

DATE: 11/18/2014

Path: P:\DNRC\Musselshell Hydrologic Study\GIS\Survey-Bathymetry\Report\Figure9.mxd

5 REFERENCES

Applied Geomorphology and RATT, 2012. Musselshell River Flood Rehabilitation River Assessment Triage Team (RATT) Summary Report.

FEMA 2013, Data Capture Standards Technical Reference, Draft May 2013, Risk MAP Version ID: 2.3.2.1

APPENDIX A. NGS DATA SHEETS

The NGS Data Sheet

See file dsdata.txt for more information about the datasheet.

```
PROGRAM = datasheet95, VERSION = 8.5
1         National Geodetic Survey,   Retrieval Date = NOVEMBER 13, 2014
 RV0105 ***********************************************************************
 RV0105  DESIGNATION -  3208
 RV0105  PID         -  RV0105
 RV0105  STATE/COUNTY-  MT/MUSSELSHELL
 RV0105  COUNTRY     -  US
 RV0105  USGS QUAD   -  ROUNDUP (1979)
 RV0105
 RV0105                        *CURRENT SURVEY CONTROL
 RV0105  ______________________________________________________________________
 RV0105* NAD 83(1986) POSITION- 46 25 41.0    (N) 108 34 23.3    (W)   HD_HELD2
 RV0105* NAVD 88 ORTHO HEIGHT -   978.453 (meters)     3210.14  (feet) ADJUSTED
 RV0105  ______________________________________________________________________
 RV0105  GEOID HEIGHT    -        -13.34  (meters)                     GEOID12A
 RV0105  DYNAMIC HEIGHT  -        978.319 (meters)     3209.70  (feet) COMP
 RV0105  MODELED GRAVITY -    980,444.6   (mgal)                       NAVD 88
 RV0105
 RV0105  VERT ORDER      -  SECOND    CLASS 0
 RV0105
 RV0105.The horizontal coordinates were established by autonomous hand held GPS
 RV0105.observations and have an estimated accuracy of +/- 10 meters.
 RV0105.
 RV0105.The orthometric height was determined by differential leveling and
 RV0105.adjusted by the NATIONAL GEODETIC SURVEY
 RV0105.in June 1991.
 RV0105
 RV0105.Photographs are available for this station.
 RV0105
 RV0105.The dynamic height is computed by dividing the NAVD 88
 RV0105.geopotential number by the normal gravity value computed on the
 RV0105.Geodetic Reference System of 1980 (GRS 80) ellipsoid at 45
 RV0105.degrees latitude (g = 980.6199 gals.).
 RV0105
 RV0105.The modeled gravity was interpolated from observed gravity values.
 RV0105
 RV0105;                    North         East    Units  Estimated Accuracy
 RV0105;SPC MT       -   242,456.      671,201.      MT  (+/- 10 meters HH2 GPS)
 RV0105
 RV0105                          SUPERSEDED SURVEY CONTROL
 RV0105
 RV0105  NGVD 29 (??/??/92)  977.686  (m)         3207.62   (f) ADJ UNCH    2 0
 RV0105
 RV0105.Superseded values are not recommended for survey control.
 RV0105
 RV0105.NGS no longer adjusts projects to the NAD 27 or NGVD 29 datums.
 RV0105.See file dsdata.txt to determine how the superseded data were derived.
 RV0105
 RV0105_U.S. NATIONAL GRID SPATIAL ADDRESS: 12TXS8646044471(NAD 83)
 RV0105
 RV0105_MARKER: DD = SURVEY DISK
 RV0105_SETTING: 36 = SET IN A MASSIVE STRUCTURE
```

```
RV0105_SP_SET: ABUTMENT
RV0105_STAMPING: 3208 1916
RV0105_STABILITY: B = PROBABLY HOLD POSITION/ELEVATION WELL
RV0105
RV0105  HISTORY     - Date     Condition        Report By
RV0105  HISTORY     - 1916     MONUMENTED       USGS
RV0105  HISTORY     - 1938     GOOD             CGS
RV0105  HISTORY     - 20090426 POOR             GEOCAC
RV0105  HISTORY     - 20140903 POOR             INDIV
RV0105  HISTORY     - 20140903 POOR             INDIV
RV0105
RV0105                          STATION DESCRIPTION
RV0105
RV0105'DESCRIBED BY US GEOLOGICAL SURVEY 1916
RV0105'2.0 MI SW FROM ROUNDUP.
RV0105'2.0 MILES SOUTHWEST ALONG THE CHICAGO, MILWAUKEE, ST. PAUL AND PACIFIC
RV0105'RAILROAD FROM THE STATION AT ROUNDUP, MUSSELSHELL COUNTY, 114 FEET
RV0105'EAST OF THE CENTERLINE OF THE SPUR TRACK TO MINE 2 AT KLEIN, AT AN
RV0105'ABANDONED THROUGH-TRUSS HIGHWAY BRIDGE OVER MUSSELSHELL RIVER, AND IN
RV0105'THE TOP OF THE WEST END OF THE NORTH CONCRETE ABUTMENT.  A UNITED
RV0105'STATES GEOLOGICAL SURVEY STANDARD DISK, STAMPED 3208 1916.
RV0105
RV0105                          STATION RECOVERY (1938)
RV0105
RV0105'RECOVERY NOTE BY COAST AND GEODETIC SURVEY 1938
RV0105'RECOVERED IN GOOD CONDITION.
RV0105
RV0105                          STATION RECOVERY (2009)
RV0105
RV0105'RECOVERY NOTE BY GEOCACHING 2009 (MEL)
RV0105'HH2     462541.0 1083423.3
RV0105'POOR CONDITION.  MARK HAS BEEN MUTILATED WITH SHARP TOOL LEAVING JUST
RV0105'A FEW OF THE STAMPING CHARACTERS READABLE. ABUTMENT IN GOOD CONDITION,
RV0105'BUT THE BRIDGE HAS BEEN REMOVED.
RV0105
RV0105                          STATION RECOVERY (2014)
RV0105
RV0105'RECOVERY NOTE BY INDIVIDUAL CONTRIBUTORS 2014
RV0105'RECOVERED IN POOR CONDITION (MARK MUTILATED) ON THE NORTHWEST BRIDGE
RV0105'ABUTMENT (FROM AN ABANDONED HIGHWAY BRIDGE ACROSS THE MUSSELSHELL
RV0105'RIVER), BY PIONEER TECHNICAL SERVICES SEPT. 2ND, 2014 WITH THE
RV0105'FOLLOWING OPUS ADJUSTED MONTANA STATE PLANE COORDINATES=
RV0105'N= 795471.3483 IF
RV0105'E= 2202107.8542 IF
RV0105'Z= 3210.205 USF
RV0105'USING GEOID 12A, TRIMBLE R8-3 GNSS RECEIVERS.
RV0105
RV0105                          STATION RECOVERY (2014)
RV0105
RV0105'RECOVERY NOTE BY INDIVIDUAL CONTRIBUTORS 2014
RV0105'RECOVERED IN POOR CONDITION (MARK MUTILATED) ON THE NORTHWEST BRIDGE
RV0105'ABUTMENT (FROM AN ABANDONED HIGHWAY BRIDGE ACROSS THE MUSSELSHELL
RV0105'RIVER), BY PIONEER TECHNICAL SERVICES SEPT. 2ND, 2014 WITH THE
RV0105'FOLLOWING OPUS ADJUSTED MONTANA STATE PLANE COORDINATES=
RV0105'N= 795471.3483 IF
RV0105'E= 2202107.8542 IF
RV0105'Z= 3210.205 USF
RV0105'USING GEOID 12A, TRIMBLE R8-3 GNSS RECEIVERS.

*** retrieval complete.
Elapsed Time = 00:00:02
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The NGS Data Sheet

See file dsdata.txt for more information about the datasheet.

```
PROGRAM = datasheet95, VERSION = 8.5
1         National Geodetic Survey,   Retrieval Date = NOVEMBER 13, 2014
 RV0087 ***********************************************************************
 RV0087  DESIGNATION -  T 122
 RV0087  PID         -  RV0087
 RV0087  STATE/COUNTY-  MT/MUSSELSHELL
 RV0087  COUNTRY     -  US
 RV0087  USGS QUAD   -  ROUNDUP (1979)
 RV0087
 RV0087                        *CURRENT SURVEY CONTROL
 RV0087  ______________________________________________________________________
 RV0087* NAD 83(1986) POSITION- 46 25 03.     (N) 108 35 27.     (W)   SCALED
 RV0087* NAVD 88 ORTHO HEIGHT -   981.267 (meters)     3219.37  (feet) ADJUSTED
 RV0087  ______________________________________________________________________
 RV0087  GEOID HEIGHT    -        -13.32  (meters)                    GEOID12A
 RV0087  DYNAMIC HEIGHT  -        981.132 (meters)     3218.93  (feet) COMP
 RV0087  MODELED GRAVITY -    980,443.1   (mgal)                      NAVD 88
 RV0087
 RV0087  VERT ORDER      -  SECOND    CLASS 0
 RV0087
 RV0087.The horizontal coordinates were scaled from a topographic map and have
 RV0087.an estimated accuracy of +/- 6 seconds.
 RV0087.
 RV0087.The orthometric height was determined by differential leveling and
 RV0087.adjusted by the NATIONAL GEODETIC SURVEY
 RV0087.in June 1991.
 RV0087
 RV0087.The dynamic height is computed by dividing the NAVD 88
 RV0087.geopotential number by the normal gravity value computed on the
 RV0087.Geodetic Reference System of 1980 (GRS 80) ellipsoid at 45
 RV0087.degrees latitude (g = 980.6199 gals.).
 RV0087
 RV0087.The modeled gravity was interpolated from observed gravity values.
 RV0087
 RV0087;                    North         East    Units  Estimated Accuracy
 RV0087;SPC MT       -   241,270.      669,860.      MT  (+/- 180 meters Scaled)
 RV0087
 RV0087                          SUPERSEDED SURVEY CONTROL
 RV0087
 RV0087  NGVD 29 (??/??/92)  980.496  (m)         3216.84   (f) ADJ UNCH    2 0
 RV0087
 RV0087.Superseded values are not recommended for survey control.
 RV0087
 RV0087.NGS no longer adjusts projects to the NAD 27 or NGVD 29 datums.
 RV0087.See file dsdata.txt to determine how the superseded data were derived.
 RV0087
 RV0087_U.S. NATIONAL GRID SPATIAL ADDRESS: 12TXS851432(NAD 83)
 RV0087
 RV0087_MARKER: DB = BENCH MARK DISK
 RV0087_SETTING: 36 = SET IN A MASSIVE STRUCTURE
 RV0087_SP_SET: ABUTMENT
 RV0087_STAMPING: T 122 1934
```

```
RV0087_STABILITY: B = PROBABLY HOLD POSITION/ELEVATION WELL
RV0087_SATELLITE: THE SITE LOCATION WAS REPORTED AS SUITABLE FOR
RV0087+SATELLITE: SATELLITE OBSERVATIONS - September 02, 2014
RV0087
RV0087  HISTORY     - Date     Condition        Report By
RV0087  HISTORY     - 1934     MONUMENTED       CGS
RV0087  HISTORY     - 20090216 GOOD             GEOCAC
RV0087  HISTORY     - 20140902 GOOD             INDIV
RV0087  HISTORY     - 20140902 GOOD             INDIV
RV0087
RV0087                          STATION DESCRIPTION
RV0087
RV0087'DESCRIBED BY COAST AND GEODETIC SURVEY 1934
RV0087'3.4 MI SW FROM ROUNDUP.
RV0087'3.4 MILES SOUTHWEST ALONG THE CHICAGO, MILWAUKEE, ST. PAUL AND PACIFIC
RV0087'RAILROAD FROM THE STATION AT ROUNDUP, MUSSELSHELL COUNTY, AT BRIDGE
RV0087'BB-194, IN THE TOP OF THE SOUTHWEST CONCRETE ABUTMENT, 6 FEET WEST OF
RV0087'THE CENTERLINE OF THE MAIN TRACK, AND 1 FOOT LOWER THAN THE TRACK. A
RV0087'STANDARD DISK, STAMPED T 122 1934.
RV0087
RV0087                          STATION RECOVERY (2009)
RV0087
RV0087'RECOVERY NOTE BY GEOCACHING 2009 (MEL)
RV0087'HH2  46 25 02.6  108 35 28.5
RV0087
RV0087                          STATION RECOVERY (2014)
RV0087
RV0087'RECOVERY NOTE BY INDIVIDUAL CONTRIBUTORS 2014
RV0087'RECOVERED IN GOOD CONDITION ON THE NORTHWEST RAILROAD (ABANDONDED)
RV0087'BRIDGE ABUTMENT THAT CROSSES AN UNNAMED CREEK JUST EAST OF HWY 12,
RV0087'BETWEEN LOWERY ROAD AND JOHNSON LANE, BY PIONEER TECHNICAL SERVICES
RV0087'SEPT. 2ND, 2014 WITH THE FOLLOWING OPUS ADJUSTED MONTANA STATE PLANE
RV0087'COORDINATES=
RV0087'N= 791519.4191 IF
RV0087'E= 2197589.5206 IF
RV0087'Z= 3219.5015 USF
RV0087'USING GEOID 12A, TRIMBLE R8-3 GNSS RECEIVERS.
RV0087
RV0087                          STATION RECOVERY (2014)
RV0087
RV0087'RECOVERY NOTE BY INDIVIDUAL CONTRIBUTORS 2014
RV0087'RECOVERED IN GOOD CONDITION ON THE NORTHWEST RAILROAD (ABANDONDED)
RV0087'BRIDGE ABUTMENT THAT CROSSES AN UNNAMED CREEK JUST EAST OF HWY 12,
RV0087'BETWEEN LOWERY ROAD AND JOHNSON LANE, BY PIONEER TECHNICAL SERVICES
RV0087'SEPT. 2ND, 2014 WITH THE FOLLOWING OPUS ADJUSTED MONTANA STATE PLANE
RV0087'COORDINATES=
RV0087'N= 791519.4191 IF
RV0087'E= 2197589.5206 IF
RV0087'Z= 3219.5015 USF
RV0087'USING GEOID 12A, TRIMBLE R8-3 GNSS RECEIVERS.

*** retrieval complete.
Elapsed Time = 00:00:01
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APPENDIX B. CONTROL COORDINATE COMPARISONS

NGS RECORD, HORIZONTAL COORDINATES ARE NOT PROVIDED ON NGS DATASHEETS			NAVD88 (US FT)	
PIONEER PT#	**NORTHING**	**EASTING**	**ELEVATION**	**DESCRIPTION**
CP-2	NA	NA	3219.37	T122-NGS
CP-5	NA	NA	3210.14	3208-NGS

PIONEER TECHNICAL SURVEY COORDINATES, MONTANA STATE PLANE NAD83 (2011), INTERNATIONAL FEET			NAVD88 (US FT)					
PIONEER PT#	**NORTHING**	**EASTING**	**ELEVATION**	**DESCRIPTION**		**ΔN**	**ΔE**	**ΔZ**
CP-1	797534.454	2211830.955	3473.064	CP-AC		NA	NA	NA
CP-2	791519.419	2197589.521	3219.502	T122-NGS		NA	NA	0.13
CP-3	798024.075	2203301.114	3216.474	CP-MDT-RW		NA	NA	NA
CP-4	802145.547	2213484.676	3181.499	CP-AC		NA	NA	NA
CP-5	795471.348	2202107.854	3210.205	3208-NGS		NA	NA	0.07

PHOTO SCIENCE COORDINATES, NAD83 UTM ZONE 12 NAVD88 (meters)			NAVD88 (meters)	
PT#	**NORTHING**	**EASTING**	**ELEVATION**	**DESCRIPTION**
CP-6	5134458.542	680561.444	1031.628	MAG hub in center of drive at fence int
CP-7	5146043.303	688160.172	972.503	corner sidewalk intersection
CP-8	5150208.953	698551.095	953.625	SW corner cattle guard
CTR-24	5146193.67	689252.161	970.883	corner sidewalk at slope change

PHOTO SCIENCE COORDINATES,CONVERTED TO MONTANA STATE PLANE COORDINATES NAD83 (2007) INTERNATIONAL FEET			NAVD88 (US FT)	
PT#	**NORTHING**	**EASTING**	**ELEVATION**	**DESCRIPTION**
CP-6	762998.071	2182144.453	3384.600	MAG hub in center of drive at fence int
CP-7	800507.947	2207772.028	3190.620	corner sidewalk intersection
CP-8	813521.02	2242093.471	3128.685	SW corner cattle guard
CTR-24	800933.345	2211361.198	3185.305	corner sidewalk at slope change

PIONEER TECHNICAL SURVEY COORDINATES, MONTANA STATE PLANE NAD83 (2011) INTERNATIONAL FEET			NAVD88 (US FT)				
PIONEER PT#	**NORTHING**	**EASTING**	**ELEVATION**	**DESCRIPTION**	**ΔN**	**ΔE**	**ΔZ**
CK106	762998.047	2182144.439	3384.550	CP-6	-0.024	-0.014	-0.05
CK107	800507.916	2207772.176	3190.525	CP-7	-0.031	0.148	-0.10
CK108	813521.015	2242093.571	3128.715	CP-8	-0.005	0.100	0.03
CK224	800933.2649	2211361.3	3185.2169	CTR-24	-0.080	0.102	-0.09

BY HOLDING THE OPUS SOLUTION, PIONEER TECHNICAL ELEVATIONS ARE AN AVERAGE OF 0.10' HIGHER THAN NGS REPORTED POSITIONS AND AN AVERAGE OF 0.05' LOWER THAN COORDINATES SUPPLIED BY PHOTO SCIENCE. THESE ERRORS ARE VERY NEAR THE LIMITS OF RTK GPS AND WERE ACCEPTED BY PIONEER TECHNICAL.

APPENDIX C. OPUS REPORT

From: opus
To: mnewhouse@pioneer-technical.com
Subject: OPUS solution : 06062460.14o OP1410444521337
Date: Thursday, September 11, 2014 8:10:41 AM

FILE: 06062460.14o OP1410444521337

NGS OPUS SOLUTION REPORT
==========

All computed coordinate accuracies are listed as peak-to-peak values.
For additional information: http://www.ngs.noaa.gov/OPUS/about.jsp#accuracy

USER: mnewhouse@pioneer-technical.com DATE: September 11, 2014
RINEX FILE: 0606246o.14o TIME: 14:09:27 UTC

SOFTWARE: page5 1209.04 master90.pl 022814 START: 2014/09/03 14:22:00
EPHEMERIS: igr18083.eph [rapid] STOP: 2014/09/03 21:33:30
NAV FILE: brdc2460.14n OBS USED: 18724 / 19595 : 96%
ANT NAME: TRMR8_GNSS3 NONE # FIXED AMB: 93 / 100 : 93%
ARP HEIGHT: 1.75 OVERALL RMS: 0.013(m)

REF FRAME: NAD_83(2011)(EPOCH:2010.0000) IGS08 (EPOCH:2014.6733)

X:	-1400001.899(m)	0.004(m)	-1400002.766(m)	0.004(m)
Y:	-4175821.221(m)	0.003(m)	-4175819.982(m)	0.003(m)
Z:	4599340.641(m)	0.009(m)	4599340.613(m)	0.009(m)

LAT:	46 26 0.33880	0.006(m)	46 26 0.35927	0.006(m)
E LON:	251 27 56.01417	0.005(m)	251 27 55.95723	0.005(m)
W LON:	108 32 3.98583	0.005(m)	108 32 4.04277	0.005(m)
EL HGT:	1045.228(m)	0.006(m)	1044.588(m)	0.006(m)
ORTHO HGT:	1058.583(m)	0.014(m)	[NAVD88 (Computed using GEOID12A)]	

	UTM COORDINATES (Zone 12)	STATE PLANE COORDINATES SPC (2500 MT)
Northing (Y) [meters]	5145159.957	243088.504
Easting (X) [meters]	689414.957	674166.076
Convergence [degrees]	1.78700939	0.70631083
Point Scale	1.00004104	0.99944336
Combined Factor	0.99987721	0.99927963

US NATIONAL GRID DESIGNATOR: 12TXS8941445159(NAD 83)

BASE STATIONS USED

PID	DESIGNATION	LATITUDE	LONGITUDE	DISTANCE(m)
DL7728	P051 BILLINGSAPMT2005 CORS ARP	N454823.741	W1083246.070	69691.9
DM7133	MTLW LEWISTOWN CORS ARP	N470314.929	W1092633.764	97887.8
DI3064	BIL6 BILLINGS 6 CORS ARP	N455816.251	W1075948.499	66053.8

NEAREST NGS PUBLISHED CONTROL POINT

RV0107	X 124	N462626.	W1083233.	1005.9

This position and the above vector components were computed without any
knowledge by the National Geodetic Survey regarding the equipment or

field operating procedures used.

From: opus
To: mnewhouse@pioneer-technical.com
Subject: OPUS solution : 06062451.14o OP1410444494623
Date: Thursday, September 11, 2014 8:09:00 AM

FILE: 06062451.14o OP1410444494623

NGS OPUS SOLUTION REPORT
==========

All computed coordinate accuracies are listed as peak-to-peak values.
For additional information: http://www.ngs.noaa.gov/OPUS/about.jsp#accuracy

USER: mnewhouse@pioneer-technical.com DATE: September 11, 2014
RINEX FILE: 0606245u.14o TIME: 14:08:48 UTC

SOFTWARE: page5 1209.04 master52.pl 022814 START: 2014/09/02 20:53:00
EPHEMERIS: igr18082.eph [rapid] STOP: 2014/09/03 00:13:00
NAV FILE: brdc2450.14n OBS USED: 7418 / 7727 : 96%
ANT NAME: TRMR8_GNSS3 NONE # FIXED AMB: 38 / 42 : 90%
ARP HEIGHT: 1.75 OVERALL RMS: 0.014(m)

REF FRAME: NAD_83(2011)(EPOCH:2010.0000) IGS08 (EPOCH:2014.6711)

X:	-1400001.906(m)	0.003(m)	-1400002.773(m)	0.003(m)
Y:	-4175821.236(m)	0.005(m)	-4175819.997(m)	0.005(m)
Z:	4599340.651(m)	0.006(m)	4599340.623(m)	0.006(m)
LAT:	46 26 0.33864	0.004(m)	46 26 0.35911	0.004(m)
E LON:	251 27 56.01409	0.004(m)	251 27 55.95714	0.004(m)
W LON:	108 32 3.98591	0.004(m)	108 32 4.04286	0.004(m)
EL HGT:	1045.246(m)	0.007(m)	1044.606(m)	0.007(m)
ORTHO HGT:	1058.601(m)	0.015(m)	[NAVD88 (Computed using GEOID12A)]	

	UTM COORDINATES (UTM (Zone 12))	STATE PLANE COORDINATES (SPC (2500 MT))
Northing (Y) [meters]	5145159.952	243088.499
Easting (X) [meters]	689414.956	674166.074
Convergence [degrees]	1.78700937	0.70631081
Point Scale	1.00004104	0.99944336
Combined Factor	0.99987721	0.99927962

US NATIONAL GRID DESIGNATOR: 12TXS8941445159(NAD 83)

BASE STATIONS USED

PID	DESIGNATION	LATITUDE	LONGITUDE	DISTANCE(m)
DL7728	P051 BILLINGSAPMT2005 CORS ARP	N454823.741	W1083246.070	69691.9
DM7133	MTLW LEWISTOWN CORS ARP	N470314.929	W1092633.764	97887.8
DG9745	MTEI ENGINC CORS ARP	N454447.035	W1083600.736	76546.2

NEAREST NGS PUBLISHED CONTROL POINT

RV0107	X 124	N462626.	W1083233.	1005.9

This position and the above vector components were computed without any
knowledge by the National Geodetic Survey regarding the equipment or

field operating procedures used.

From: opus
To: mnewhouse@pioneer-technical.com
Subject: OPUS solution : 06062470.14o OP1410444540891
Date: Thursday, September 11, 2014 8:09:54 AM

FILE: 06062470.14o OP1410444540891

NGS OPUS SOLUTION REPORT
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All computed coordinate accuracies are listed as peak-to-peak values.
For additional information: http://www.ngs.noaa.gov/OPUS/about.jsp#accuracy

USER: mnewhouse@pioneer-technical.com DATE: September 11, 2014
RINEX FILE: 0606247p.14o TIME: 14:09:45 UTC

SOFTWARE: page5 1209.04 master53.pl 022814 START: 2014/09/04 15:00:00
EPHEMERIS: igr18084.eph [rapid] STOP: 2014/09/05 00:24:00
NAV FILE: brdc2470.14n OBS USED: 21512 / 23445 : 92%
ANT NAME: TRMR8_GNSS3 NONE # FIXED AMB: 118 / 124 : 95%
ARP HEIGHT: 1.75 OVERALL RMS: 0.014(m)

REF FRAME: NAD_83(2011)(EPOCH:2010.0000) IGS08 (EPOCH:2014.6762)

X:	-1402407.734(m)	0.004(m)	-1402408.601(m)	0.004(m)
Y:	-4174818.766(m)	0.008(m)	-4174817.527(m)	0.008(m)
Z:	4599408.614(m)	0.003(m)	4599408.586(m)	0.003(m)

LAT:	46 26 6.19485	0.004(m)	46 26 6.21530	0.004(m)
E LON:	251 25 54.25691	0.001(m)	251 25 54.19994	0.001(m)
W LON:	108 34 5.74309	0.001(m)	108 34 5.80006	0.001(m)
EL HGT:	967.022(m)	0.008(m)	966.383(m)	0.008(m)
ORTHO HGT:	980.369(m)	0.016(m)	[NAVD88 (Computed using GEOID12A)]	

	UTM COORDINATES UTM (Zone 12)	STATE PLANE COORDINATES SPC (2500 MT)
Northing (Y) [meters]	5145260.192	243237.748
Easting (X) [meters]	686811.162	671566.174
Convergence [degrees]	1.76252933	0.68157029
Point Scale	1.00002899	0.99944308
Combined Factor	0.99987742	0.99929160

US NATIONAL GRID DESIGNATOR: 12TXS8681145260(NAD 83)

BASE STATIONS USED

PID	DESIGNATION	LATITUDE	LONGITUDE	DISTANCE(m)
DM7133	MTLW LEWISTOWN CORS ARP	N470314.929	W1092633.764	95941.0
DG9745	MTEI ENGINC CORS ARP	N454447.035	W1083600.736	76597.2
DL7758	P722 YNPBASSRCHMT2005 CORS ARP	N452725.985	W1093415.586	133654.8

NEAREST NGS PUBLISHED CONTROL POINT

RV0106	W 124	N462602.	W1083411.	171.4

This position and the above vector components were computed without any
knowledge by the National Geodetic Survey regarding the equipment or

field operating procedures used.

APPENDIX D. STRUCTURE AND BATHYMETRIC SURVEY DIGITAL DATA

APPENDIX E. FIELD PHOTOGRAPHS

PIONEER TECHNICAL SERVICES, INC.	Photo Number: XS-1 R-L
	Date: 9/10/2014
	Description: Looking from Right Bank to Left Bank at XS-1
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: XS-2 L-R
	Date: 9/10/2014
	Description: Looking from Left bank to Right Bank at XS-2
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: XS-3 L-R
	Date: 9/10/2014
	Description: Looking from Left bank to Right Bank at XS-3
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: XS-4 R-L
	Date: 9/10/2014
	Description: Looking from Right Bank to Left Bank at XS-4
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: XS-5 R-L
	Date: 9/10/2014
	Description: Looking from Right Bank to Left Bank at XS-5
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: XS-6 L-R
	Date: 9/10/2014
	Description: Looking from Left bank to Right Bank at XS-6
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: XS-7 L-R
	Date: 9/10/2014
	Description: Looking from Left bank to Right Bank at XS-7
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: XS-8 L-R
	Date: 9/9/2014
	Description: Looking from Left bank to Right Bank at XS-8
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: XS-9 L-R
	Date: 9/9/2014
	Description: Looking from Left bank to Right Bank at XS-9
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: XS-10 R-L
	Date: 9/9/2014
	Description: Looking from Right Bank to Left Bank at XS-10
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: XS-11 R-L
	Date: 9/9/2014
	Description: Looking from Right Bank to Left Bank at XS-11
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: XS-12 R-L
	Date: 9/9/2014
	Description: Looking from Right Bank to Left Bank at XS-12
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: XS-13 R-L
	Date: 9/9/2014
	Description: Looking from Right Bank to Left Bank at XS-13
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: XS-14 R-L
	Date: 9/9/2014
	Description: Looking from Right Bank to Left Bank at XS-14
	Project: Musselshell River Floodplain Study - Phase 1

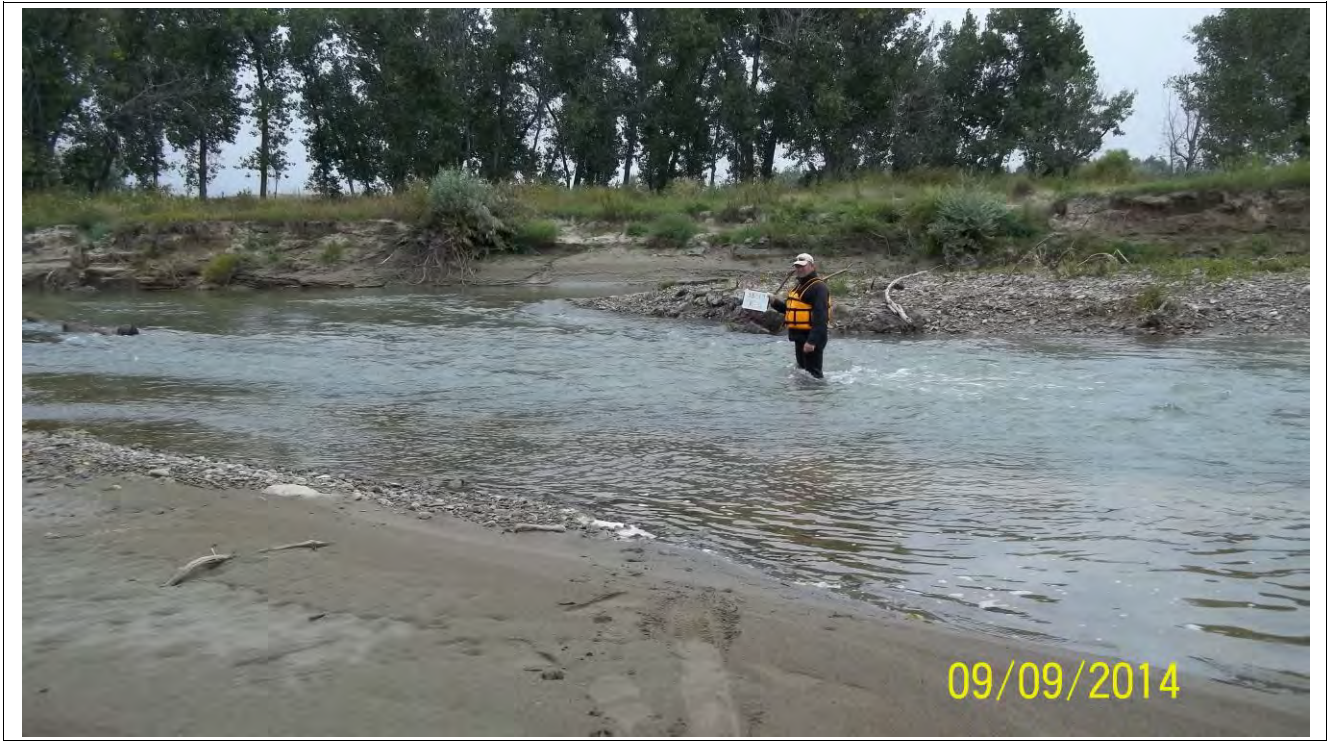
PIONEER TECHNICAL SERVICES, INC.	Photo Number: XS-15 R-L
	Date: 9/9/2014
	Description: Looking from Right Bank to Left Bank at XS-15
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: XS-16 R-L
	Date: 9/9/2014
	Description: Looking from Right Bank to Left Bank at XS-16
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: XS-17 L-R
	Date: 9/9/2014
	Description: Looking from Left bank to Right Bank at XS-17
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: XS-18 L-R
	Date: 9/9/2014
	Description: Looking from Left bank to Right Bank at XS-18
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: XS-18 DOWNSTREA
	Date: 9/9/2014
	Description: Looking downstream from left to right at XS-18
	Project: Musselshell River Floodplain Study - Phase 1

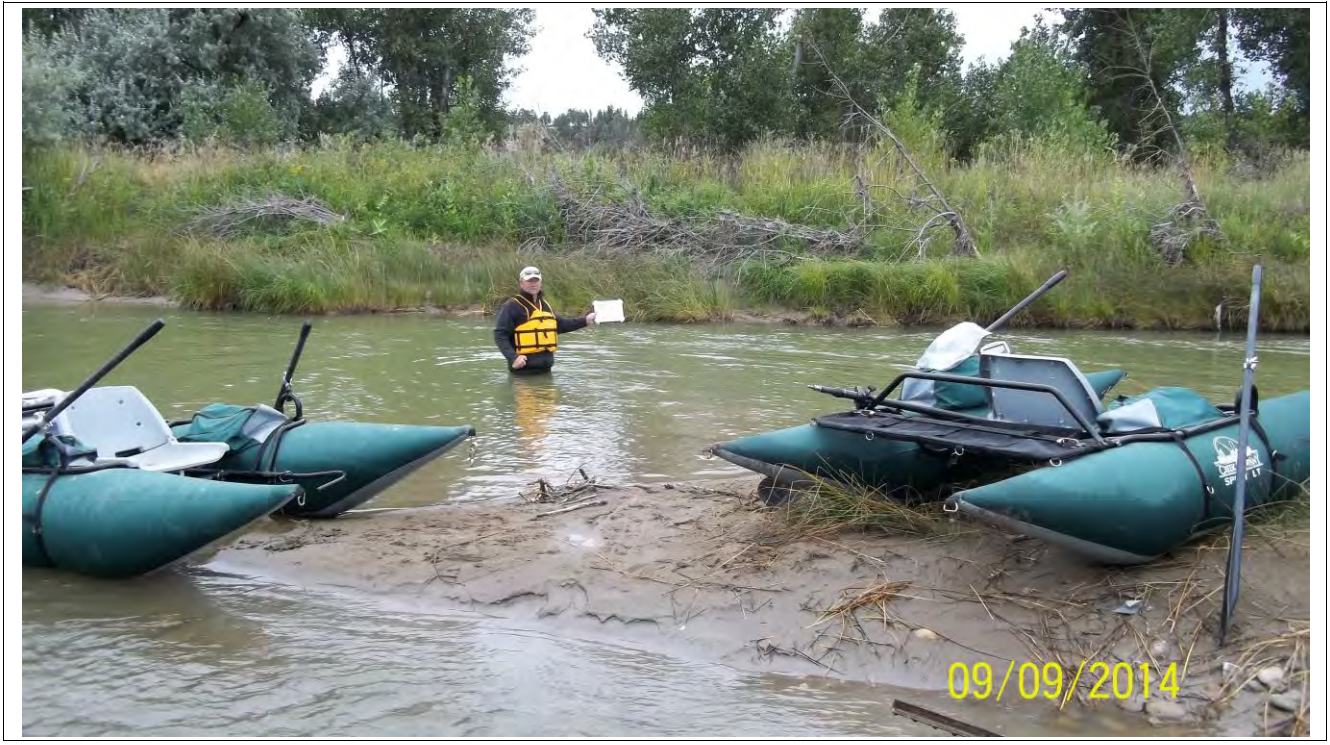


PIONEER TECHNICAL SERVICES, INC.	Photo Number: XS-19 R-L
	Date: 9/9/2014
	Description: Looking from Right Bank to Left Bank at XS-19
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: XS-20 L-R
	Date: 9/9/2014
	Description: Looking from Left Bank to Right Bank at XS-20
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: XS-21 L-R
	Date: 9/9/2014
	Description: Looking from Left Bank to Right Bank at XS-21
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: XS-22 R-L
	Date: 9/9/2014
	Description: Looking from Right Bank to Left Bank at XS-22
	Project: Musselshell River Floodplain Study - Phase 1



PIONEER TECHNICAL SERVICES, INC.	Photo Number: XS-23 L-R
	Date: 9/9/2014
	Description: Looking from Left Bank to Right Bank at XS-23
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: XS-23.1 R-L
	Date: 9/8/2014
	Description: Looking from Right Bank to Left Bank at XS-23.1
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: XS-24 L-R
	Date: 9/8/2014
	Description: Looking from Left Bank to Right Bank at XS-24
	Project: Musselshell River Floodplain Study - Phase 1

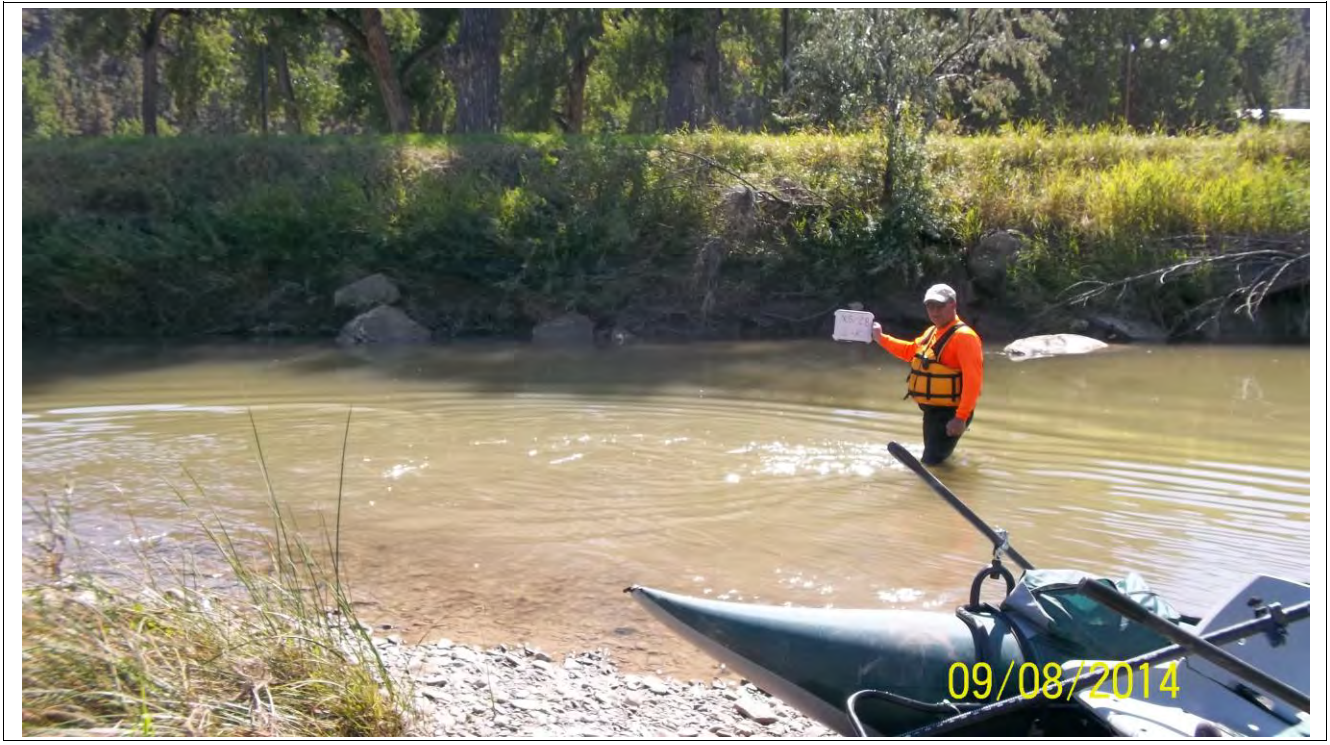
PIONEER TECHNICAL SERVICES, INC.	Photo Number: XS-24.1 R-L
	Date: 9/8/2014
	Description: Looking from Right Bank to Left Bank at XS-24.1
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: XS-24.2 L-R
	Date: 9/8/2014
	Description: Looking from Left Bank to Right Bank at XS-24.2
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: XS-25 R-L
	Date: 9/8/2014
	Description: Looking from Right Bank to Left Bank at XS-25
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: XS-26 L-R
	Date: 9/8/2014
	Description: Looking from Left Bank to Right Bank at XS-26
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: XS-27 L-R
	Date: 9/8/2014
	Description: Looking from Left Bank to Right Bank at XS-27
	Project: Musselshell River Floodplain Study - Phase 1



PIONEER TECHNICAL SERVICES, INC.	Photo Number: XS-28 L-R
	Date: 9/8/2014
	Description: Looking from Left Bank to Right Bank at XS-28
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: XS-29 L-R
	Date: 9/8/2014
	Description: Looking from Left Bank to Right Bank at XS-29
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: XS-30 R-L
	Date: 9/8/2014
	Description: Looking from Right Bank to Left Bank at XS-30
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: XS-31 L-R
	Date: 9/8/2014
	Description: Looking from Left Bank to Right Bank at XS-31
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: XS-32 L-R
	Date: 9/8/2014
	Description: Looking from Left Bank to Right Bank at XS-32
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: XS-33 L-R
	Date: 9/5/2014
	Description: Looking from Left Bank to Right Bank at XS-33
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: XS-34 L-R
	Date: 9/5/2014
	Description: Looking from Left Bank to Right Bank at XS-34
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: XS-35 L-R
	Date: 9/5/2014
	Description: Looking from Left Bank to Right Bank at XS-35
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: XS-37 L-R
	Date: 9/5/2014
	Description: Looking from Left Bank to Right Bank at XS-37
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: XS-38 R-L
	Date: 9/5/2014
	Description: Looking from Right Bank to Left Bank at XS-38
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: XS-39 R-L
	Date: 9/5/2014
	Description: Looking from Right Bank to Left Bank at XS-39
	Project: Musselshell River Floodplain Study - Phase 1

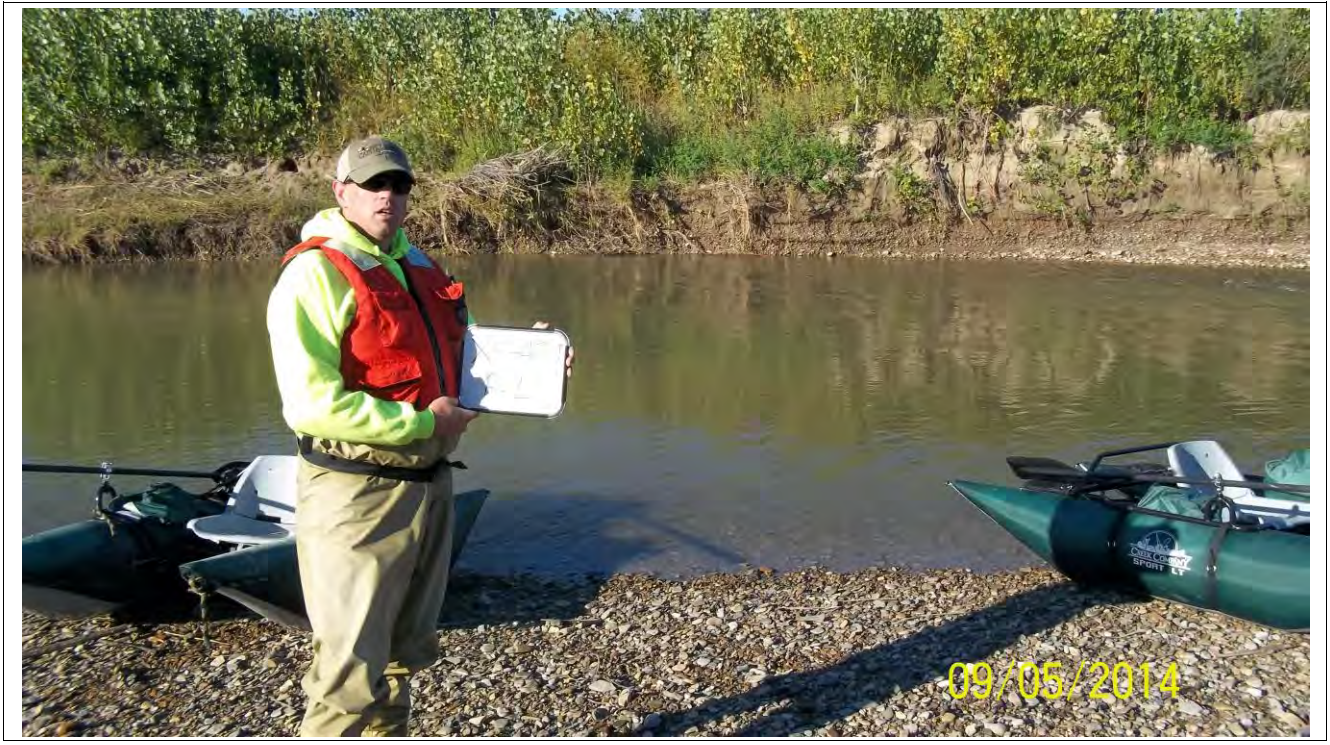
PIONEER TECHNICAL SERVICES, INC.	Photo Number: XS-40 R-L
	Date: 9/5/2014
	Description: Looking from Right Bank to Left Bank at XS-40
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: XS-41 L-R
	Date: 9/5/2014
	Description: Looking from Left Bank to Right Bank at XS-41
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: XS-42 L-R
	Date: 9/5/2014
	Description: Looking from Left Bank to Right Bank at XS-42
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: XS-42.1 L-R
	Date: 9/5/2014
	Description: Looking from Left Bank to Right Bank at XS-42.1
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: XS-43 L-R
	Date: 9/5/2014
	Description: Looking from Left Bank to Right Bank at XS-43
	Project: Musselshell River Floodplain Study - Phase 1



PIONEER TECHNICAL SERVICES, INC.	Photo Number: XS-43.1 R-L
	Date: 9/5/2014
	Description: Looking from Right Bank to Left Bank at XS-43.1
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: XS-44 R-L
	Date: 9/4/2014
	Description: Looking from Right Bank to Left Bank at XS-44
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: XS-45 R-L
	Date: 9/4/2014
	Description: Looking from Right Bank to Left Bank at XS-45
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: XS-46 R-L
	Date: 9/4/2014
	Description: Looking from Right Bank to Left Bank at XS-46
	Project: Musselshell River Floodplain Study - Phase 1

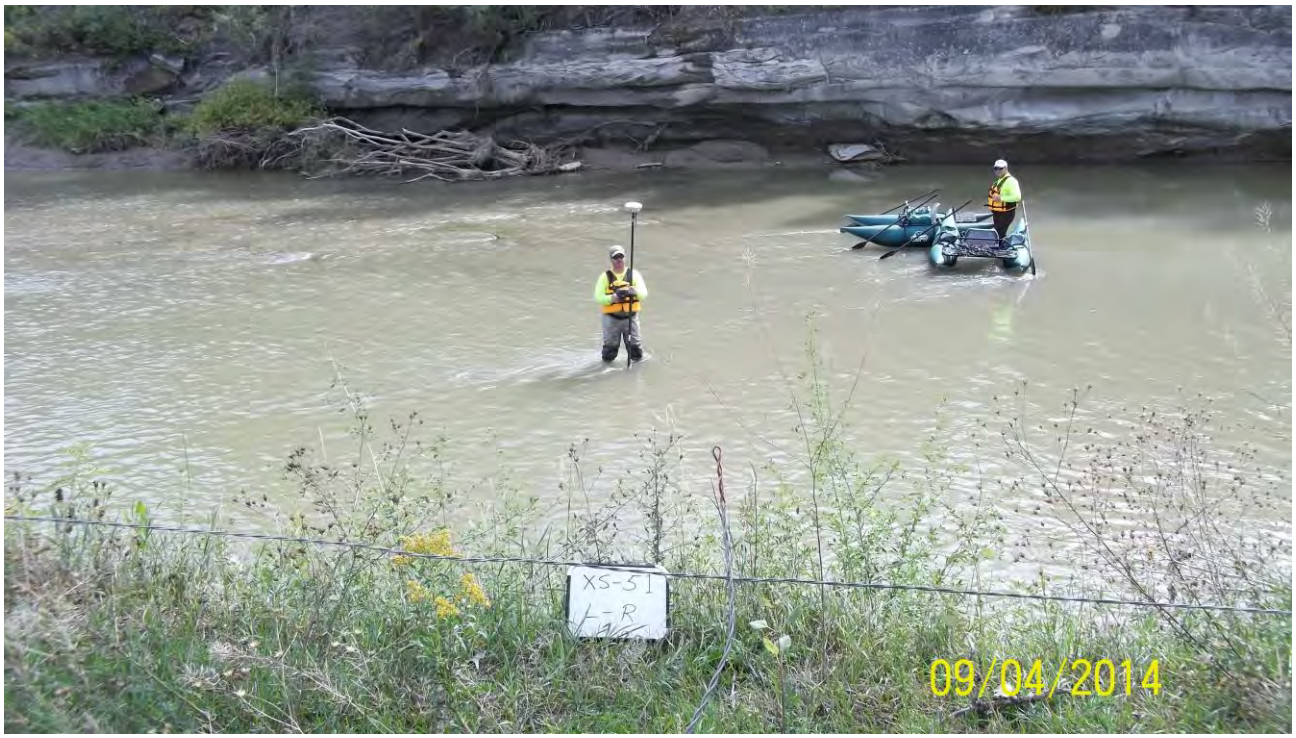
PIONEER TECHNICAL SERVICES, INC.	Photo Number: XS-47 R-L
	Date: 9/4/2014
	Description: Looking from Right Bank to Left Bank at XS-47
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: XS-48 R-L
	Date: 9/4/2014
	Description: Looking from Right Bank to Left Bank at XS-48
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: XS-49 L-R
	Date: 9/4/2014
	Description: Looking from Left Bank to Right Bank at XS-49
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: XS-49U L-R
	Date: 9/4/2014
	Description: Looking from Left Bank to Right Bank at XS-49U
	Project: Musselshell River Floodplain Study - Phase 1

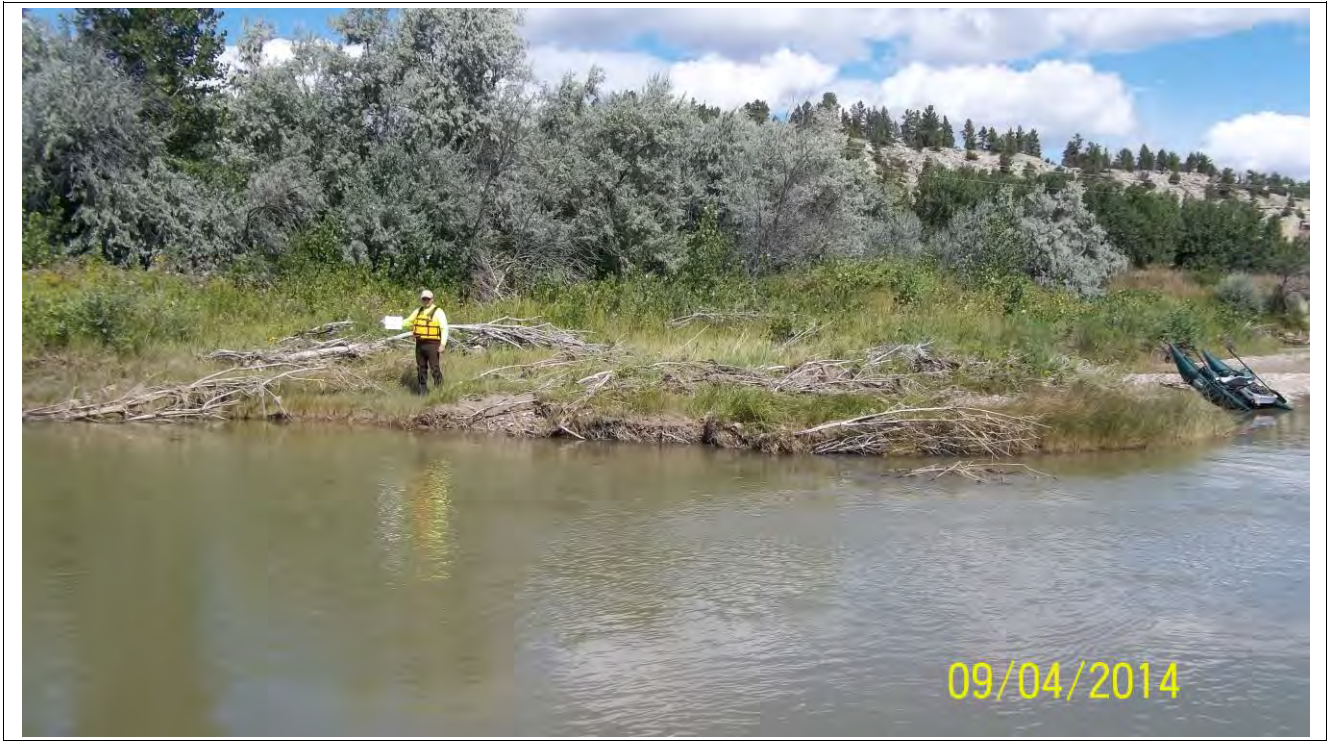
PIONEER TECHNICAL SERVICES, INC.	Photo Number: XS-50 L-R
	Date: 9/4/2014
	Description: Looking from Left Bank to Right Bank at XS-50
	Project: Musselshell River Floodplain Study - Phase 1



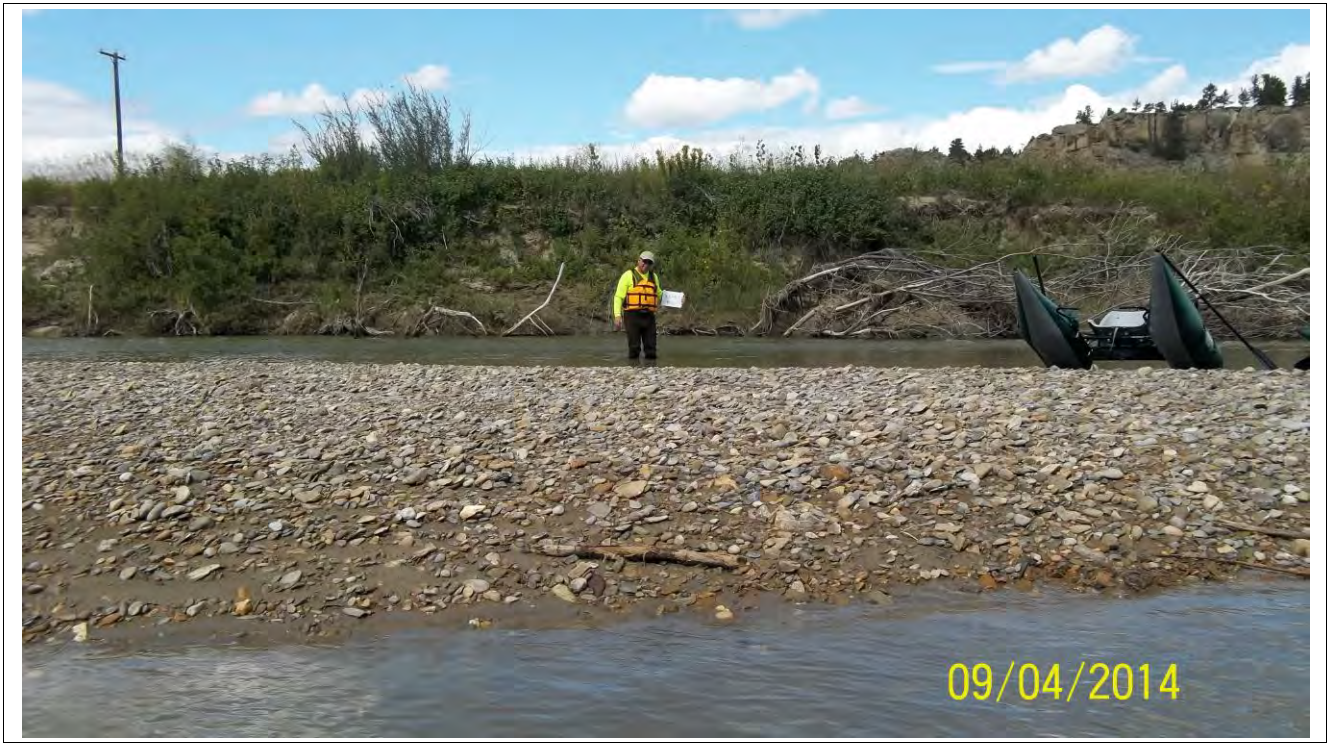
PIONEER TECHNICAL SERVICES, INC.	Photo Number: XS-51 L-R
	Date: 9/4/2014
	Description: Looking from Left Bank to Right Bank at XS-51
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: XS-52 R-L
	Date: 9/4/2014
	Description: Looking from Right Bank to Left Bank at XS-52
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: XS-53 R-L
	Date: 9/4/2014
	Description: Looking from Right Bank to Left Bank at XS-53
	Project: Musselshell River Floodplain Study - Phase 1



PIONEER TECHNICAL SERVICES, INC.	Photo Number: XS-54 L-R
	Date: 9/4/2014
	Description: Looking from Left Bank to Right Bank at XS-54
	Project: Musselshell River Floodplain Study - Phase 1



PIONEER TECHNICAL SERVICES, INC.	Photo Number: XS-55 R-L
	Date: 9/4/2014
	Description: Looking from Right Bank to Left Bank at XS-55
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: XS-56 L-R
	Date: 9/4/2014
	Description: Looking from Left Bank to Right Bank at XS-56
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: XS-57 L-R
	Date: 9/4/2014
	Description: Looking from Left Bank to Right Bank at XS-57
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: XS-58 L-R
	Date: 9/4/2014
	Description: Looking from Left Bank to Right Bank at XS-58
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: XS-59 R-L
	Date: 9/4/2014
	Description: Looking from Right Bank to Left Bank at XS-59
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: XS-60 R-L
	Date: 9/3/2014
	Description: Looking from Right Bank to Left Bank at XS-60
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: XS-61 L-R
	Date: 9/3/2014
	Description: Looking from Left Bank to Right Bank at XS-61
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: XS-62 L-R
	Date: 9/3/2014
	Description: Looking from Left Bank to Right Bank at XS-62
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: XS-63 L-R
	Date: 9/3/2014
	Description: Looking from Left Bank to Right Bank at XS-63
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: 2NDST-BRIDGE
	Date: 9/17/2014
	Description: Looking East to West across the 2nd Street Bridge
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: 2NDST-DSL
	Date: 9/17/2014
	Description: View of 2nd Street Bridge from Downstream Left
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: 2NDST-DSR
	Date: 9/17/2014
	Description: View of 2nd Street Bridge from Downstream Right
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: 2NDST-USL
	Date: 9/17/2014
	Description: View of 2nd Street Bridge from Upstream Left
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: 2NDST-USR
	Date: 9/17/2014
	Description: View of 2nd Street Bridge from Upstream Right
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: 87-DSL1
	Date: 9/17/2014
	Description: View of Highway 87 Bridge from Downstream Left
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: 87-DSL2
	Date: 9/17/2014
	Description: View of Downstream Left side of Highway 87 Bridge
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: 87-USL1
	Date: 9/17/2014
	Description: View of Highway 87 Bridge from Upstream Left
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: 87-USL2
	Date: 9/17/2014
	Description: View of Highway 87 Bridge from Upstream Left
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: DIV-1
	Date: 9/18/2014
	Description: End of Culvert at Diversion Structure
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: DIV-2
	Date: 9/18/2014
	Description: View of East end of Diversion Wall on Downstream Left
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: DIV-3
	Date: 9/18/2014
	Description: View of Diversion wall looking west from DSL side
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: DIV-4
	Date: 9/18/2014
	Description: View of Diversion wall looking west from DSL side
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: DIV-5
	Date: 9/18/2014
	Description: View of Diversion wall looking west from DSL side
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: DIV-6
	Date: 9/18/2014
	Description: View of Diversion wall looking west from DSL side
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: DIV-7
	Date: 9/18/2014
	Description: View of right bank wing wall from DSL side of diversion structure
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: DIV-8
	Date: 9/18/2014
	Description: View of abandoned headgate at diversion structure from USL side
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: DIV-9
	Date: 9/18/2014
	Description: View of diversion structure from USL side
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: FAIR-OLD1
	Date: 9/17/2014
	Description: View of TCP on downstream side of 4-H Road Bridge
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: FAIR-OLD4
	Date: 9/17/2014
	Description: View of 4-H Road Bridge from DSL side
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: FAIR-OLD6
	Date: 9/17/2014
	Description: View of 4-H Road Bridge from USR side
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: FAIR-OLD7
	Date: 9/17/2014
	Description: View of 4-H Road Bridge from USL side
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: FAIR-OLD8
	Date: 9/17/2014
	Description: View of 4-H Road Bridge from USL side
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: FAIR-OLD10
	Date: 9/17/2014
	Description: View of 4-H Road Bridge from USL side
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: FAIR-OLD-DS1
	Date: 9/17/2014
	Description: View of 4-H Road Bridge from DSR side
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: FAIR-OLD-DS2
	Date: 9/17/2014
	Description: View of 4-H Road Bridge from DSL side
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: FAIR-OLD-US1
	Date: 9/17/2014
	Description: View of 4-H Road Bridge from USR side
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: FAIR-OLD-US2
	Date: 9/17/2014
	Description: View of 4-H Road Bridge from USL side
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: NUM4-DSL
	Date: 9/18/2014
	Description: View of #4 Bridge from DSL side
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: NUM4-DSR
	Date: 9/18/2014
	Description: View of #4 Bridge from DSR side
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: NUM4-USL
	Date: 9/18/2014
	Description: View of #4 Bridge from USL side
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: NUM4-USR1
	Date: 9/18/2014
	Description: View of #4 Bridge from USR side
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: NUM4-USR2
	Date: 9/18/2014
	Description: View of #4 Bridge from USR side
	Project: Musselshell River Floodplain Study - Phase 1

PIONEER TECHNICAL SERVICES, INC.	Photo Number: ABUT-TYPICAL
	Date: 9/18/2014
	Description: View of #4 Bridge from USL side
	Project: Musselshell River Floodplain Study - Phase 1