CARBON COUNTY PMR SURVEY REPORT

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JUNE 2020
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1.0 PROJECT OVERVIEW

1.1 PROJECT DESCRIPTION

DOWL investigated 181 hydraulic structures and completed 99 bathymetric cross sections in Carbon County and a small part of Yellowstone County from February through June 2020. This effort included 24 structures on Bear Creek; 13 structures on Bluewater Creek; 47 structures on the Clarks Fork of the Yellowstone; seven structures on Cottonwood Creek; 11 structures and two cross sections on Cow Creek; 14 structures on Elbow Creek; two structures on Dry Creek; eight structures and four cross sections on Red Lodge Creek; 52 structures and 80 cross sections on Rock Creek and unnamed tributaries; and three structures and 13 cross sections on the West Fork of Rock Creek. The purpose of the field survey was to augment LiDAR-based mapping and additional bathymetric survey data from 2019 to ultimately be used to revise floodplain mapping.

1.2 PROJECT LOCATION

The field surveys were performed on the Clarks Fork of the Yellowstone and tributaries from near the Wyoming border to the river’s confluence with the Yellowstone River; and on Rock Creek and tributaries from upstream of Red Lodge to the confluence with the Clarks Fork of the Yellowstone. Structure locations are shown in Figures 1 through 17. Bathymetric locations are shown in Figures 18 through 50.

Structures and cross sections were both assigned unique Structure IDs that begin with a three-letter prefix to identify their proper stream.

<table>
<thead>
<tr>
<th>BEA</th>
<th>Bear Creek</th>
<th>DRY</th>
<th>Dry Creek</th>
</tr>
</thead>
<tbody>
<tr>
<td>BLU</td>
<td>Bluewater Creek</td>
<td>ELB</td>
<td>Elbow Creek</td>
</tr>
<tr>
<td>CFY</td>
<td>Clarks Fork of the Yellowstone</td>
<td>RLC</td>
<td>Red Lodge Creek</td>
</tr>
<tr>
<td>COT</td>
<td>Cottonwood Creek</td>
<td>RCC</td>
<td>Rock Creek</td>
</tr>
<tr>
<td>COW</td>
<td>Cow Creek</td>
<td>WES</td>
<td>West Fork of Rock Creek</td>
</tr>
</tbody>
</table>

Table 1- Stream Prefixes

Following the prefix, structures were numbered from downstream to upstream, typically in a format of 010 for the first structure, 020 for the second structure, and progressively greater numbers as the structures proceed upstream. ELB_010, for example, was the most downstream structure on Elbow Creek. Occasionally an intermediate structure was added between two already named structures, in which case the existing used numbers were split. RCC_0153 and RCC_0156, for example, would fall between RCC_0150 and RCC_0160. Structures with a numerical suffix identify an unnamed tributary to the stream, e.g. ELB_100_1 would be the first structure on the most downstream unnamed tributary to Elbow Creek.

Bathymetric cross section IDs were assigned with the stream prefix and a number. For streams with no existing 2019 cross sections, the most downstream cross section would be numbered 100, the second planned cross section 200, and progressively greater numbers as the cross sections move upstream. The most downstream cross section of West Fork of Rock Creek is named WES_100. Similar to structures, intermediate cross sections could be added between existing sections that already had been assigned an ID. RLC_3020, 3040, 3060, and 3060, for example, fall between existing bathymetric cross sections RLC_3000 and RLC_3100.
1.3 GUIDELINES AND STANDARDS

Relevant guidelines and standards related to project activities were downloaded from the Federal Emergency Management Agency (FEMA) website at https://www.fema.gov/guidelines-and-standards-flood-risk-analysis-and-mapping, including:

- Data Capture Guidance General May 2017
- Data Capture Guidance Workflow Details February 2019
- Data Capture Technical Reference February 2019
- FIRM Database Guidance February 2019
- FIRM Database Technical Reference February 2019

1.4 DATUM

Project horizontal and vertical datums are as follows:

- Horizontal coordinates are Montana State Plane grid (NAD83-2011), expressed in international feet.
- Vertical datum is NAVD88, expressed in U.S. Survey feet. GEOID12B was used to determine elevations from Global Positioning System (GPS) observations.

2.0 PROJECT PLANNING

2.1 STRUCTURE AND CROSS SECTION IDENTIFICATION

DOWL worked closely with DNRC staff to identify structure and cross section locations at which to collect data. Of the 181 total structures, 90 were designated as low-detail “inventory” sites at which basic measurements were made to populate a table of structural characteristics. The 81 remaining structures were designated high-detail “GPS survey” sites at which a full, detailed ground survey was performed using survey-grade GPS receivers.

Generally, four cross sections were placed per structure: two upstream and two downstream. After the project was underway, six additional cross sections were added to the project as part of a value-adding amendment to DOWL’s 2019 Bathymetric Survey project. The 99 total cross sections described in Section 1.1 are inclusive of these six added cross sections.

Using public cadastral mapping, DOWL worked with DNRC’s public outreach team to identify landowners with property adjoining required field survey locations. DOWL informed the landowners of DOWL’s intent to conduct the survey and provided contact information for landowners to grant access, deny access, or obtain additional information. Most outreach letter recipients did not respond -- a small percentage requested calls or emails ahead of the survey.
2.2 **Survey Work Maps**

Upon finalization of structure and cross section locations and after initial landowner contacts, DOWL developed cloud-based mapping for field-use using arcgis.com and the Esri Collector application on field tablets and phones. Additional background mapping information was also added to field computers to facilitate efficient cross section surveys.

### 3.0 Field Work

#### 3.1 Control Verification and Densification

During 2019 survey activities, DOWL coordinated with Morrison-Maierle to receive their control values for related LiDAR mapping for Carbon County. DOWL extended control in 2019 using two-hour or longer observations submitted to the Online Positioning User Service (OPUS). Additional control for that season was densified using real-time kinematic and faststatic GPS observations.

The 2020 PMR surveys continued to use the control points and values from 2019 where possible, supplemented by 11 new control points for the summer season. Similar to the year prior, new control values were determined using OPUS solutions and densified with real-time kinematic and faststatic GPS observations. It should be noted that values from point 58 changed between 2019 and 2020 due to observations indicating the coordinate and elevation from 2019 were no longer accurate, possibly due to disturbance to the control point.

A typical control point for both DOWL and Morrison-Maierle is a 5/8”x24” rebar with a 2-inch aluminum cap affixed.

For daily checks, DOWL observed a real-time kinematic observation at another control point. Daily checks of control points were typically within hundredths of a foot and did not have horizontal errors in excess of 0.12-ft. or vertical errors in excess of 0.14-ft.

Tables 2a and 2b provide combined 2019 and 2020 control values.

#### Table 2a: Survey Control

<table>
<thead>
<tr>
<th>Point Name</th>
<th>Northing</th>
<th>Easting</th>
<th>Elevation</th>
<th>Description</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
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</table>
3.2 SURVEY METHODOLOGY

Field surveys were completed using Trimble R8-2 GPS base receivers and Trimble R10 GPS roving receivers. The R8-2 and R10s are enabled to observe supplemental Global Navigational Satellite System (GNSS) satellites, which provides significantly improved satellite visibility over GPS-only receivers.

In areas with severe GPS obstructions, DOWL used Trimble S6 and S7 robotic total stations.

All bathymetric cross sections were completed by wading. Most structures were accessed via public or private roads, but some structures on the on the Clarks Fork of the Yellowstone were accessed via small inflatable watercraft.

Upon investigating structures in the field, 10 were not completed for the following reasons:
- RLC_060 – Fenced in area prevented survey and access to structure. Associated cross sections not completed.
- COT_050, COT_100_1, and COT_100_2 – No apparent structure at location.
- CFY_100_4, CFY_100_6, and CFY_200_6 – No apparent structure at location.
- RCC_010 – No apparent structure at location. Associated cross sections not completed.
- ELB_090 – No apparent structure at location.

<table>
<thead>
<tr>
<th>Point Name</th>
<th>Northing</th>
<th>Easting</th>
<th>Elevation</th>
<th>Description</th>
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</tbody>
</table>

Table 2b- Survey Control
At structure COW_030, the landowner politely asked field crews to leave the property before photos could be taken of the structure.

3.3 FIELD SKETCHES
At each structure, DOWL field personnel developed a sketch of the structure. Detailed GPS survey sketches include point numbers, critical dimensions, a plan view, and a cross sectional view of the upstream face of the structure. Limited detail Inventory sketches include the same information excepting surveyed point numbers.

3.4 FIELD SURVEY PHOTOS
At each cross sections, DOWL field staff took two photos – upstream and downstream –to aid in the analysis of hydraulic conditions by mapping partners.

At structures, DOWL field staff took a minimum of five photos to identify the upstream channel, upstream face, overtopping section, downstream channel, and downstream face. Additional photos submitted with an ALT suffix provide an alternative perspective or viewpoint for a photo.

4.0 KEY PERSONNEL AND DUTIES

Greg Gabel, P.E., C.F.M., Project Manager
Zach Hassler, L.S., CFedS, Chief of Surveys, Primary Landowner Contact
Dean Schock, L.S., Lead Field Surveyor
Andrew Mattie, P.E., Field Work
Drew Vance, E.I., Structure and Cross Section Placement, Planning, and GIS Support; QAQC
Logan Rice, GIS Support, Data Processing
Shannon Muenchow, Data Processing, QAQC
Michael Cochran, L.S., Data Processing

5.0 DATES OF FIELD SURVEYS
Carbon County PMR field surveys metric surveys were completed:
- February 26, 2020
- March 5, 6, 9, 10, 11, 12, 17, 18, 26, 30, and 31 of 2020
- April 6, 7, 8, 9, 14, 17, 20, 21, 22, 23, 27, 28, 29, 30 of 2020
- May 1, 5, 6, 7, 8, 11, 12, 13, 14, 18, 19, 20, 21 of 2020
- June 3, 6, 9, 10, 11 of 2020

6.0 QA/QC

<table>
<thead>
<tr>
<th>QA/QC TASK DESCRIPTION</th>
<th>REVIEWER/DATE</th>
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<tbody>
<tr>
<td>Review for conformance with FEMA guidelines and standards.</td>
<td>Z. HASSLER / D. VANCE JUNE 2020</td>
</tr>
<tr>
<td>QA/QC Task Description</td>
<td>Reviewer/Date</td>
</tr>
<tr>
<td>------------------------------------------------------------</td>
<td>-------------------------------</td>
</tr>
<tr>
<td>Review daily control checks for errors not greater than 0.15 ft.</td>
<td>Z. HASSLER 6/26/20</td>
</tr>
<tr>
<td>Review project control cross-ties to verify accuracy of finalized control.</td>
<td>D. SCHOCK/ Z. HASSLER JUNE 2020</td>
</tr>
<tr>
<td>Review correspondence folder.</td>
<td>Z. HASSLER 6/26/20</td>
</tr>
<tr>
<td>Review feature coding.</td>
<td>S. MUENCHOW 6/26/20</td>
</tr>
<tr>
<td>Review photos folder.</td>
<td>S. MUENCHOW 6/26/20</td>
</tr>
<tr>
<td>Review survey/supplemental folder.</td>
<td>Z. HASSLER 6/26/20</td>
</tr>
</tbody>
</table>
FIGURE 1: PMR STRUCTURE LOCATIONS
OVERVIEW OF FIGURE PANELING
IMAGERY: USGS NATIONAL MAP 2017 | JUNE 2020

- CITIES/TOWNS
- COUNTY BOUNDARIES
- WATERWAYS
FIGURE 2: FIELD SURVEY RESULTS

STRUCTURES & CONTROL POINTS

imagery: USGS NATIONAL MAP 2017 | JUNE 2020
FIGURE 3: FIELD SURVEY RESULTS
STRUCTURES & CONTROL POINTS
FIGURE 6: FIELD SURVEY RESULTS
STRUCTURES & CONTROL POINTS

IMAGERY: USGS NATIONAL MAP 2017 | JUNE 2020
FIGURE 8: FIELD SURVEY RESULTS
STRUCTURES & CONTROL POINTS

IMAGERY: USGS NATIONAL MAP 2017 | JUNE 2020
FIGURE 9: FIELD SURVEY RESULTS
STRUCTURES & CONTROL POINTS

IMAGERY: USGS NATIONAL MAP 2017 | JUNE 2020
FIGURE 11: FIELD SURVEY RESULTS

STRUCTURES & CONTROL POINTS

IMAGERY: USGS NATIONAL MAP 2017 | JUNE 2020
FIGURE 12: FIELD SURVEY RESULTS

STRUCTURES & CONTROL POINTS

IMAGERY: USGS NATIONAL MAP 2017 | JUNE 2020
FIGURE 13: FIELD SURVEY RESULTS

STRUCTURES & CONTROL POINTS

IMAGERY: USGS NATIONAL MAP 2017 | JUNE 2020
FIGURE 14: FIELD SURVEY RESULTS

STRUCTURES & CONTROL POINTS

IMAGERY: USGS NATIONAL MAP 2017 | JUNE 2020
FIGURE 16: FIELD SURVEY RESULTS

STRUCTURES & CONTROL POINTS

IMAGERY: USGS NATIONAL MAP 2017 | JUNE 2020
FIGURE 19: PMR CROSS SECTION LOCATIONS
SMALL-SCALE SPATIAL OVERVIEW OF FIGURE PANELING

CITIES/TOWNS
- CROSS SECTION DATA POINTS
- WATERWAYS

IMAGERY: USGS NATIONAL MAP 2017 | JUNE 2020
FIGURE 20: PMR CROSS SECTION LOCATIONS
SMALL-SCALE SPATIAL OVERVIEW OF FIGURE PANELING
FIGURE 21: PMR CROSS SECTION LOCATIONS
SMALL-SCALE SPATIAL OVERVIEW OF FIGURE PANELING

CITIES/TOWNS
CROSS SECTION DATA POINTS
WATERWAYS

IMAGERY: USGS NATIONAL MAP 2017 | JUNE 2020
FIGURE 22: PMR CROSS SECTION LOCATIONS

SMALL-SCALE SPATIAL OVERVIEW OF FIGURE PANELING

IMAGERY: USGS NATIONAL MAP 2017 | JUNE 2020
FIGURE 23: FIELD SURVEY RESULTS

CROSS SECTION POINTS

IMAGERY: USGS NATIONAL MAP 2017 | JUNE 2020
FIGURE 24: FIELD SURVEY RESULTS
CROSS SECTION POINTS

IMAGERY: USGS NATIONAL MAP 2017 | JUNE 2020
FIGURE 25: FIELD SURVEY RESULTS

CROSS SECTION POINTS

IMAGERY: USGS NATIONAL MAP 2017 | JUNE 2020
FIGURE 26: FIELD SURVEY RESULTS
CROSS SECTION POINTS

CROSS SECTION DATA POINTS
WATERWAYS

IMAGERY: USGS NATIONAL MAP 2017 | JUNE 2020
FIGURE 27: FIELD SURVEY
RESULTS

CROSS SECTION POINTS

IMAGERY: USGS NATIONAL MAP 2017 | JUNE 2020
FIGURE 28: FIELD SURVEY RESULTS

CROSS SECTION POINTS

IMAGERY: USGS NATIONAL MAP 2017 | JUNE 2020
FIGURE 30: FIELD SURVEY RESULTS
CROSS SECTION POINTS

IMAGERY: USGS NATIONAL MAP 2017 | JUNE 2020
FIGURE 31: FIELD SURVEY RESULTS

CROSS SECTION POINTS

0 0.03 0.05 0.1 Miles

CROSS SECTION DATA POINTS
WATERWAYS

IMAGERY: USGS NATIONAL MAP 2017 | JUNE 2020
FIGURE 32: FIELD SURVEY RESULTS

CROSS SECTION POINTS

SOURCE: ESRI, MAXAR, GEOEYE, EARTHSSTAR GEOGRAPHIC, CNES/AIRBUS DS, USDA, USGS, AEROGRID, IGN, AND THE GIS USER COMMUNITY
FIGURE 34: FIELD SURVEY RESULTS

CROSS SECTION POINTS

IMAGERY: USGS NATIONAL MAP 2017 | JUNE 2020
FIGURE 36: FIELD SURVEY RESULTS

CROSS SECTION POINTS

WATERWAYS

CROSS SECTION DATA POINTS

0 0.03 0.05 0.1 Miles

IMAGERY: USGS NATIONAL MAP 2017 | JUNE 2020
FIGURE 37: FIELD SURVEY RESULTS

CROSS SECTION POINTS

0 0.03 0.05 0.1 Miles

CROSS SECTION DATA POINTS
WATERWAYS

IMAGERY: USGS NATIONAL MAP 2017 | JUNE 2020
FIGURE 38: FIELD SURVEY RESULTS

CROSS SECTION POINTS

IMAGERY: USGS NATIONAL MAP 2017 | JUNE 2020
FIGURE 42: FIELD SURVEY RESULTS

CROSS SECTION POINTS

IMAGERY: USGS NATIONAL MAP 2017 | JUNE 2020
FIGURE 44: FIELD SURVEY
RESULTS

CROSS SECTION POINTS

IMAGERY: USGS NATIONAL MAP 2017 | JUNE 2020
FIGURE 45: FIELD SURVEY RESULTS

CROSS SECTION POINTS

IMAGERY: USGS NATIONAL MAP 2017 | JUNE 2020
FIGURE 47: FIELD SURVEY RESULTS

CROSS SECTION POINTS

IMAGERY: USGS NATIONAL MAP 2017 | JUNE 2020
FIGURE 48: FIELD SURVEY RESULTS

CROSS SECTION POINTS

IMAGERY: USGS NATIONAL MAP 2017 | JUNE 2020
FIGURE 49: FIELD SURVEY RESULTS

CROSS SECTION POINTS

IMAGERY: USGS NATIONAL MAP 2017 | JUNE 2020
FIGURE 50: FIELD SURVEY RESULTS

CROSS SECTION POINTS

IMAGERY: USGS NATIONAL MAP 2017 | JUNE 2020

RCC 19800

CROSS SECTION DATA POINTS

WATERWAYS

0 0.03 0.05 0.1 Miles