Preliminary Design Plan
Clark Fork River Operable Unit
Phases 5 and 6

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Acronyms and Abbreviations

AGI	Applied Geomorphology, Inc.
As	arsenic
bgs	below ground surface
BMP	best management practice
BNSF	Burlington Northern Santa Fe (Railway)
Cd	cadmium
CFR	Clark Fork River
CFROU	Clark Fork River Operable Unit
cfs	cubic feet per second
CMZ	channel migration zone
COC	contaminant of concern
CQAP	Construction Quality Assurance Plan
CSBMPP	Construction Stormwater Best Management Practices Plan
Cu	copper
DEQ	Montana Department of Environmental Quality
dS/m	deciSiemens per meter
DSR	(Floodplain Investigation) Data Summary Report
EBPL	Eroding Bank and Pool Location
ESRI	Economic and Social Research Institute
FEWA	Function Effective Wetland Area
ft	foot
ft/s	feet per second
Geum	Geum Environmental Consulting, Inc.
GHH	Geomorphic, Hydrologic, and Hydraulic (Investigation)
GLO	General Land Office
GPS	global positioning system
HEC-RAS	Hydraulic Engineering Circular – River Analysis System
IC	institutional control
IDW	inverse distance weighted (method)
in	inch
K	potassium
lbs/sq ft	pounds per square foot
LiDAR	Light Detection and Ranging
mg/kg	milligrams per kilogram
mm	millimeter
MUTCD	Manual on Uniform Traffic Control Devices

NAIP	National Agriculture Imagery Program
NPS	National Park Service
NRCS	(USDA) Natural Resource Conservation Service
NRDP	Natural Resource Damage Program
NWI	National Wetlands Inventory
P	phosphorus
Pb	lead
PDP	Preliminary Design Plan
ppm	parts per million
PZ	piezometer
QA	quality assurance
QC	quality control
RD/RA	Remedial Design/Remedial Action
R_c	Radius of curvature
RipES	Riparian Evaluation System
ROD	Record of Decision
USACE	U. S. Army Corps of Engineers
USDA	U.S. Department of Agriculture
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. (Department of the Interior) Geological Survey
W_{cf}	Channel Forming Flow Width
WSE	water surface elevation
XRF	X-ray fluorescence
Zn	zinc

Section 1.0 Introduction

The Clark Fork River Operable Unit (CFROU) is part of the Milltown Reservoir/Clark Fork River Superfund Site and includes the uppermost 120 miles of the Clark Fork River (CFR) between Warm Springs Ponds and Missoula, Montana. The Operable Unit is divided into three reaches (A, B, and C) as shown on Figure 1.

The Montana Department of Environmental Quality (DEQ), as lead agency, oversees, manages, coordinates, designs, and implements the Remedial Action for the Clark Fork Site, in consultation with the U.S. Environmental Protection Agency (USEPA). DEQ coordinates with the State of Montana Natural Resource Damage Program (NRDP) and the U.S. National Park Service (NPS) for the implementation and integration of restoration components into the Work. Four primary functions of consultation and coordination among the agencies for the CFROU are to 1) understand and receive the information to be collected, 2) understand how that information is to be analyzed, 3) provide review and comment, and 4) maximize the use of the resources available for and the environmental benefits to the Clark Fork Site in the successful and cost-effective completion of the Work.

This project site is designated as Phases 5 and 6 (Figure 2), covering 4.5 river miles of Reach A from river mile 7.8 to river mile 12.3. Phases 5 and 6 encompass the reach of river through the Dry Cottonwood Creek Ranch from Galen Road to Gemback Road. The Riparian Evaluation System (RipES) (USEPA, 2004) along with other generated Remedial Design investigation and characterization was used to develop the Preliminary Design Plan. Specifically, two recent reports provided further investigation and characterization for this particular project: the Floodplain Investigation Data Summary Report (TerraGraphics, 2012a) (DSR), encompasses the floodplain sampling to determine the extent of the floodplain deposited tailings; and the Geomorphic, Hydrologic, and Hydraulic Investigation (TerraGraphics, 2012b) (GHH) provides supporting analyses for the remediation design.

This Preliminary Design Plan presents the scope of the Agencies' intended activities for the Phases 5 and 6 remedy. The Preliminary Design Plan also describes the purpose, objectives, and performance targets of the project; summarizes Phase-specific data from prior investigations; and presents the basis of design which includes the design concept, criteria for, and analyses of the intended activities. This draft Preliminary Design Plan is accompanied by a preliminary design drawing set showing, among other things, the proposed floodplain grading and streambank treatments. This report has been prepared for DEQ by its consultants for this project: TerraGraphics Environmental Engineering, Inc. (TerraGraphics), Applied Geomorphology, Inc. (AGI), and Geum Environmental Consulting, Inc. (Geum).

1.1 Site Background

Heavy metals originating from historic mining activities, milling and smelting processes associated with the Anaconda Company operations in Butte and Anaconda have accumulated on the Clark Fork River streambanks and floodplain over a period of at least 100 years. The primary sources of contamination are tailings and contaminated sediments mixed with soils in the streambanks and floodplains, which erode during high flow events and enter the river and

other surface waters. In addition to erosion, heavy metals are leached from the contaminated sediments and tailings directly into the groundwater and eventually to surface water. These contaminant transport pathways result in impacts to terrestrial and aquatic life along the Clark Fork River as described in the Record of Decision (ROD) for the site (USEPA/DEQ, 2004).

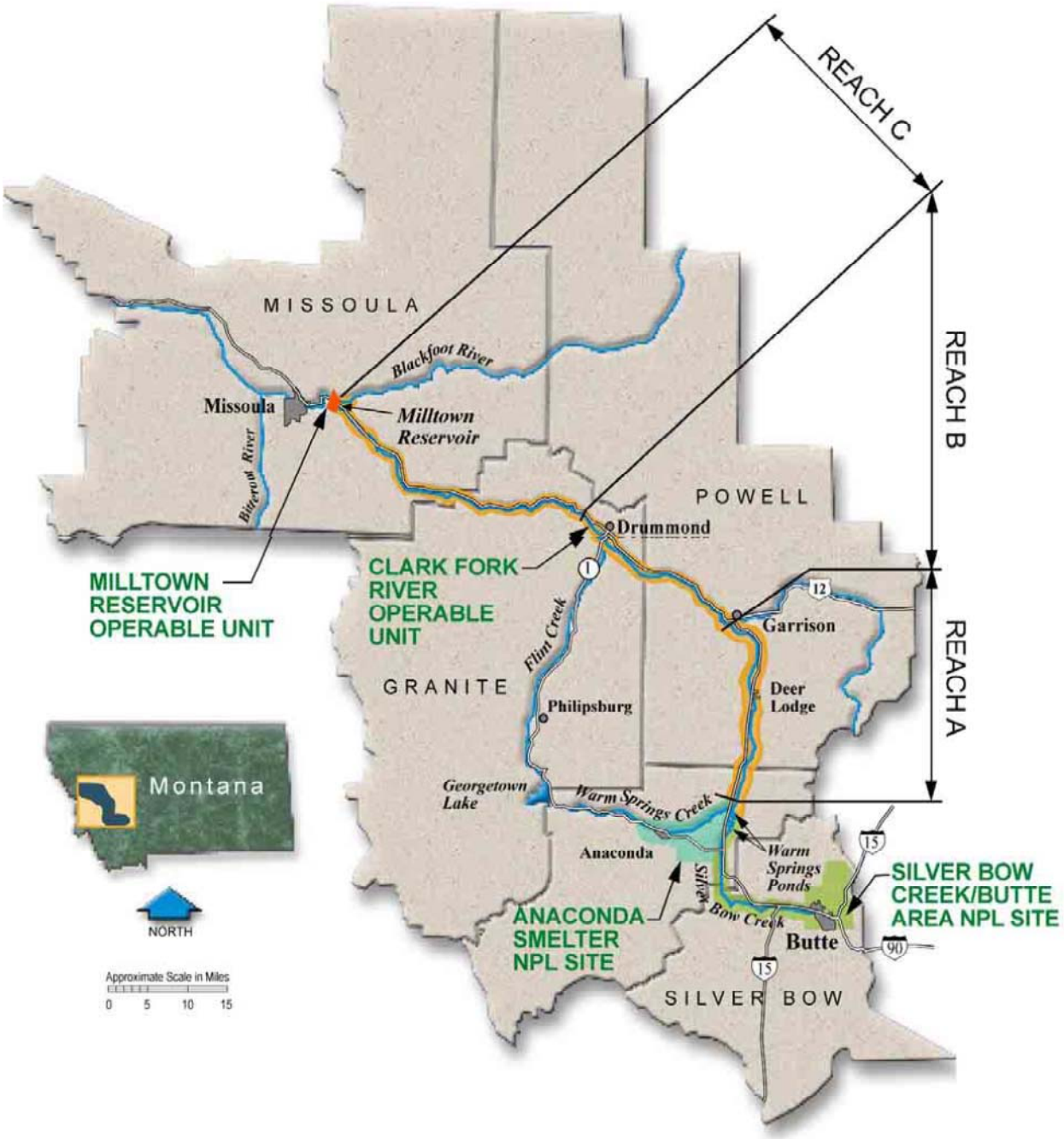


Figure 1. Clark Fork River Operable Unit (USEPA/DEQ, 2004)

1.2 Site Location and Description

The CFROU is located within Deer Lodge, Granite, Powell, and Missoula counties. The upstream boundary of the Operable Unit is located at the confluence of Silver Bow Creek and the original CFR channel just downstream of Warm Springs Ponds. The original channel of the river upstream of this point was obliterated when Warm Springs Ponds were built. The downstream boundary is the former Milltown Reservoir Sediments Operable Unit, just east of Missoula, Montana. The CFROU was divided into three main reaches (A, B, and C) as shown in Figure 1. This project site, designated as Phases 5 and 6, is located in Reach A of the CFROU in Deer Lodge County, Montana. Phases 5 and 6 encompass the reach of river through Dry Cottonwood Creek Ranch, from Galen Road at the southern, upstream end to the Powell County line about 300 feet north of Gemback Road (Figure 2). The site contains 4.5 river miles of sinuous channel, extending from river mile 7.8 to river mile 12.3. Bridges cross the CFR at Galen Road and Gemback Road. Irrigation water is diverted along this reach for the Whalen, West Side, and Alvi Beck ditches. The majority of the site is currently operated as part of a 2,300-acre working cattle ranch owned by Dry Cottonwood Creek LLC and managed and partially owned by the Clark Fork Coalition. A small portion in the northwest corner of the site is owned by Two Bar Ranch.

1.3 Purpose

This Preliminary Design Plan (PDP) applies design-level factors to site-specific conditions, which through remedial design/remedial action (RD/RA) allow implementation of ROD requirements, including Performance Standards and Remedial Goals. Considerations include groundwater, riparian vegetation, geomorphic stability, contaminant sampling, ownership, infrastructure, land use, and certain site-specific remedy requirements. The purpose of this PDP is to present pertinent information on site-specific conditions, the basis of the design approach, design criteria, and an analysis of the proposed design.

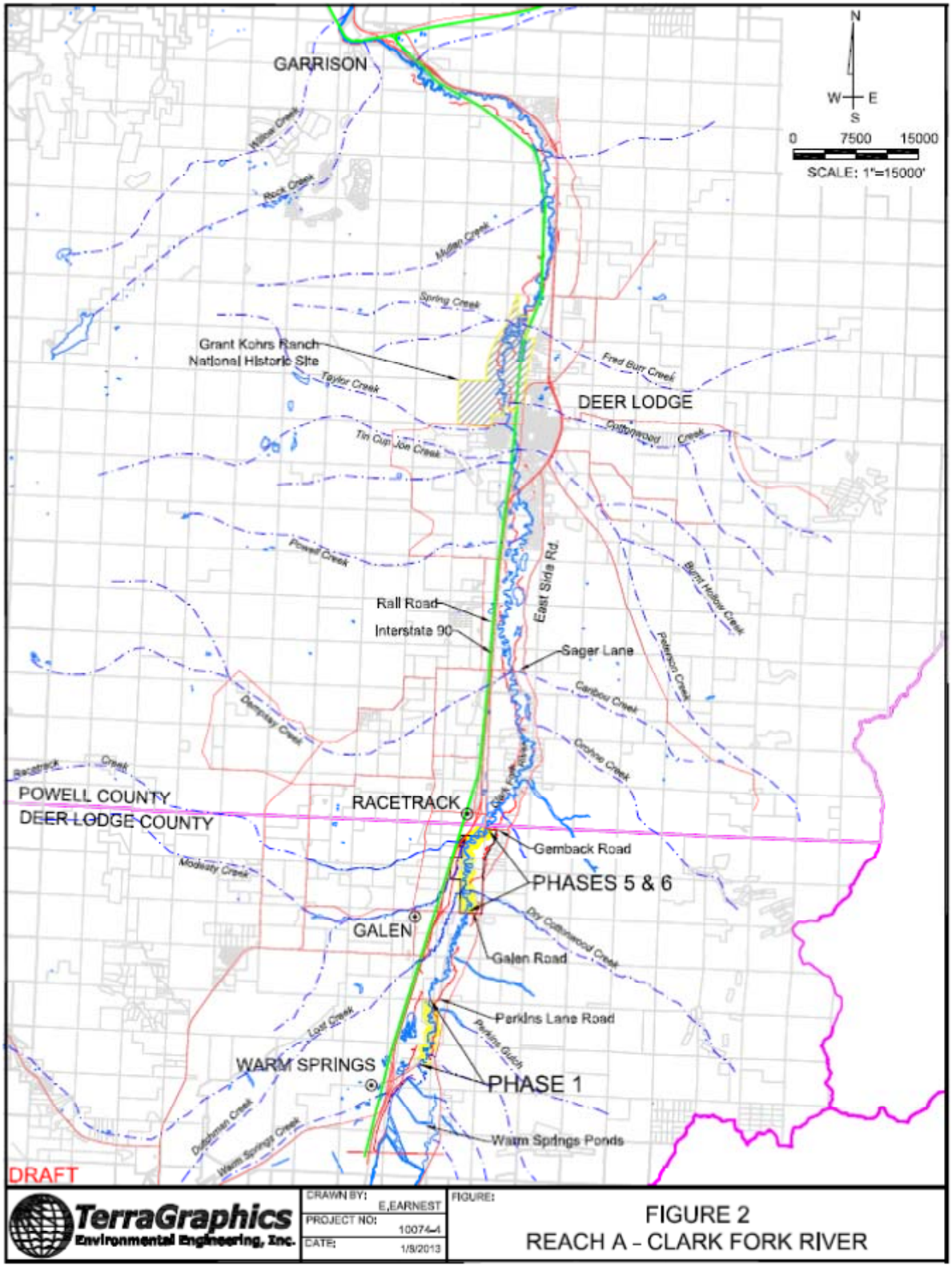


Figure 2. Phases 5 and 6 Location Map in Reach A (modified from CDM and AGI, 2010)

Section 2.0 Existing Conditions Investigation, Analysis, and Data Collection

Comprehensive discussions of prior studies and existing site conditions for Phases 5 and 6 are included in the DSR and GHH (TerraGraphics, 2012a, 2012b). The following sections summarize the pertinent data from these reports as they relate to the basis of design. Additional investigations, analyses, and data collection conducted outside the scopes of work for the DSR (August 2012) and GHH (July 2012) are also presented in the following sections including groundwater monitoring, vegetation assessment, and surveying.

2.1 Geomorphic Investigation

Since the mid-1850s, the geomorphology of this reach has been impacted by tailings aggradation on the floodplain, attenuation of flows in Warm Springs Ponds, land use practices, and a likely reduction in beaver populations. As a result of these changes, the CFR channel is entrenched, resulting in a reduced frequency of floodplain inundation, increased stress to and mortality of existing vegetation, conversion of riparian vegetation to upland species, and increased in-channel flow and associated erosive stress. The physical and chemical impacts of the contaminants have reduced bankline vegetation densities, which has reduced the integrity of these banks and allowed for increased rates of tailings recruitment through bank erosion. Floodplain processes have been further impacted by alterations to the dynamic variability, frequency, and magnitude of high-energy flows as caused by Warm Springs Ponds. The current geomorphology of this reach is a meandering, single thread, sinuous river with an aggraded floodplain, active alternating cut banks and point bars, topographically defined avulsion paths, riffle-pool sequences, and a gravel bed in a broad alluvial valley. The upstream half of Phase 5 is distinguished by a wider floodplain with numerous meander scars and evidence of relatively frequent overbank flooding. This flows into a narrower reach as the Dry Cottonwood Creek alluvial fan encroaches on the east side, limiting migration and partially confining flows between it and low floodplain terraces on the west. The Phase 6 floodplain remains narrower, with flows confined to the active channel and floodplain tabs between the western floodplain terrace and remnants of the same terrace on the east side. A channel remnant on the eastern floodplain area in Phase 6 records a historic avulsion in the reach that occurred between the time of the General Land Office (GLO) survey and the 1950s.

Geomorphic parameters of this site are summarized in Tables 3 through 6.

Table 1. Geomorphic Metrics

Feature	Phase 5	Phase 6	Phases 5 and 6
River Length (ft)	11,850	11,282	23,132
Valley Distance (ft)	5,235	5,854	10,786
Channel Slope (ft/ft)	0.0015	0.0017	0.0016
Number of Meander Bends	20	13	33
Average Meander Wavelength (ft)	524	901	654
Average Radius of Curvature (R_c) (ft)	151	248	189
Average Belt Width (ft)	326	530	406
Sinuosity	2.3	1.9	2.1
Average Channel Forming Flow Width (W_{cf}) (ft)	61.9	73.1	67.2
Average Rc/W_{cf}	2.7	3.4	3.0

Table 2. Mean Riffle Pebble Count Gradations

Average Pebble Diameter (inches)		
D_{16}	D_{50}	D_{84}
0.8	1.6	2.6

D = diameter; subscript indicates percentage of pebbles with a diameter less than the stated value

Table 3. Channel Forming and Channel Capacity Flow Rates

Flow Condition	Recurrence Interval	Flow Rate (cfs)
Channel Capacity Flow*	5 year	1000-1200
Channel Forming Flow**	1.5 year to 2 year	500-700

* Channel Capacity Flow – the specific discharge of water and sediment that a channel can carry at the top of the channel banks just before floodplain inundation begins.
** Channel Forming Flow – the theoretical discharge of water and sediment that maintains dynamic equilibrium and forms the stream bed and banks.

Table 4. Migration Rates

Migration Feature	Migration Rate (1947–2011)	
	Average Rate (ft/yr)	Maximum Rate (ft/yr)
Cut Bank Erosion	0.4	0.9
Point Bar Deposition	0.5	0.9

2.2 Hydrologic Analysis

The headwaters of the CFR upstream from this site include Silver Bow Creek which is routed through Warm Springs Ponds prior to its confluence with Warm Springs Creek marking the beginning of the CFR. The Phases 5 and 6 site begins at Galen Road, approximately 7.8 river miles downstream of the confluence with Warm Springs Creek and ends at Gemback Road, approximately 12.3 miles downstream from the confluence. The project reach is joined by Modesty Creek, which flows from the west out of the foothills of the Flint Creek Range, and Dry Cottonwood Creek, which flows from the east out of the eroded hills of the Boulder Batholith to join the CFR. The hydrology for Phases 5 and 6 was developed as part of the Geomorphology and Hydrology of Reach A Report (CDM Smith and AGI, 2013) and the peak flows for various recurrence intervals entering the site are summarized in Table 5.

Table 5. Peak Flow Summary

Return Interval (years)	Clark Fork River Near Galen Peak Flow (cfs)
2	584
5	961
10	1,216
25	1,535
50	1,757
100	1,893

cfs = cubic feet per second

2.3 Hydraulic Analysis

The existing hydraulic conditions in Reaches 5 and 6 were modeled with HEC-RAS (USACE, 2010) using the estimated peak flows for the 2-year, 10-year, and 100-year return interval events. Tabulated outputs from the model for the channel and overbank areas are included in Appendix A, Hydraulic Analysis. Floodplain inundation maps, cross-section locations, and detailed output from the models for the existing conditions are also included in the GHH Report. Summary tables of the reach averaged hydraulic parameters for the 2-year, 10-year and 100-year events used for analysis of, and comparison to, the proposed conditions are included in Table 6 through Table 8.

Table 6. 2-Year Existing Conditions Reach Averaged Hydraulic Parameters

Location	Flow (cfs)	Velocity (ft/s)	Shear Stress (lbs/sq ft)	Particle Size at Incipient Motion (in)	Hydraulic Depth (ft)
Left Overbank	8	0.3	0.02	0.08	0.3
Channel	675	3.4	0.30	1.2	3.2
Right Overbank	4	0.4	0.03	0.12	0.3

Table 7. 10-Year Existing Conditions Reach Averaged Hydraulic Parameters

Location	Flow (cfs)	Velocity (ft/s)	Shear Stress (lbs/sq ft)	Particle Size at Incipient Motion (in)	Hydraulic Depth (ft)
Left Overbank	94	0.6	0.05	0.19	0.5
Channel	1,148	4.0	0.39	1.6	4.2
Right Overbank	66	0.7	0.05	0.19	0.5

Table 8. 100-Year Existing Conditions Reach Averaged Hydraulic Parameters

Location	Flow (cfs)	Velocity (ft/s)	Shear Stress (lbs/sq ft)	Particle Size at Incipient Motion (in)	Hydraulic Depth (ft)
Left Overbank	479	0.6	0.10	0.39	1.0
Channel	1,729	4.7	0.46	2.0	5.3
Right Overbank	410	1.1	0.12	0.39	1.0

2.4 Floodplain Material and Borrow Investigation

The floodplain material in Phases 5 and 6 reflects the lateral reworking and sorting of materials delivered to and derived from within the reach. During test pit operations to characterize the extent of the contamination, excavations on the channel margins consistently encountered a coarse pebble–fine cobble horizon at the same general elevation as the channel bed. These materials reflect a concentration of coarse materials in the bank toe during lateral reworking of the floodplain. Overlying fine sediments that are commonly thinly laminated reflect overbank floodplain deposition of finer grained suspended loads. Bounding terraces in Phases 5 and 6 are typically a few feet above the active floodplain and quite fine grained, reflecting historical

floodplain deposits as well as colluvial sheetwash from the valley margins. These geologic units are described below and are shown in the GHH Report as excerpted from Berg and Hargrave (2004).

Alluvium – Gravel, sand, silt, and clay along active channels of modern rivers, creeks, and intermittent streams.

Alluvial terrace deposit, youngest – Deposits on irregularly shaped, unpaired terraces 3 to 6 feet above the modern floodplain that consist of 3 to 6 feet of well to poorly sorted rock clasts derived from Tertiary and older strata.

As part of the design investigation, borrow area test pits were excavated and assessed to identify potential floodplain backfill sources for both fine- and coarse-grained alluvial deposits. The locations of the potential borrow areas are shown on Figure 31 and locations of the borrow area test pits are shown in Appendix B on the Borrow Areas Test Pit and Piezometer Location Map. Test pits TP 1 through TP 8 were located in the general vicinity of the potential borrow areas. The test pits were excavated to a depth of approximately 10–12 feet and separate soil samples were taken of the overlying fine-grained material and the deeper coarse-grained material. The fine- and coarse-grained samples were submitted to a laboratory for testing of the parameters and by the methods listed in Tables 11 and 12, and the results of the testing are included in Appendix B, Borrow Area and Groundwater Investigation.

Table 9. Coarse-Grained Alluvium

Parameter	Test Method
Total Metals for As, Pb, Cu, Zn, Cd	Method SW 3050
Sieve Analysis	ASA Mono. #9, Part 1, Method 15-2.2
Specific Conductance	ASA Mono. #9, Part 2, Method 10-3.3
pH	ASA Mono. #9, Part 2, Method 10-3.2

Table 10. Fine-Grained Alluvium

Parameter	Test Method
Total Metals for As, Pb, Cu, Zn, Cd	Method SW 3050
Sieve Analysis	ASA Mono. #9, Part 1, Method 15-2.2
Specific Conductance	ASA Mono. #9, Part 2, Method 10-3.3
pH	ASA Mono. #9, Part 2, Method 10-3.2
Organic Matter	ASA Mono #9 29-3
Total Nitrate, P, and K	ASA Mono #9 33-3:8
Total Kjeldahl Nitrogen	ASA Mono #9 31.3
Calcium carbonate	USDA 60, Method 23c
Sodium Absorption Ratio	USDA Handbook 60, 6010
Herbicides	USEPA SW-846 8151A

2.5 Contamination Characterization

The results of the characterization are included in the DSR. The DSR summarized the nature and extent of the contamination deposited on the floodplain at the site. Soil was denoted as contaminated when the sum of the contaminants of concern (COCs) exceeded 1,400 milligrams per kilogram (mg/kg) or when arsenic exceeded 620 mg/kg in the surface soils. The COCs are arsenic, cadmium, copper, lead, and zinc (As, Cd, Cu, Pb, and Zn). The 1,400 mg/kg value is not a cleanup standard, but rather is used as a benchmark to gauge contamination within the phases as part of Remedial Design. The 1,400 mg/kg combined COC value is viewed with respect to its vertical and lateral extent, and its location, in order to ascertain whether the material represents a significant loading source. In general, test pit locations were spaced 125 feet apart on a north–south and east–west grid pattern. Additional sample locations were identified outside of the 125-foot grid system based on 2006–2007 RipES polygons, vegetation, visually identified tailings, topography, or geomorphic features. Field personnel collected soil samples at 6-inch vertical intervals over the total depth of the test pit and screened the samples in the field using X-ray fluorescence (XRF) prior to submitting the samples to the laboratory for testing. The soil intervals were denoted as contaminated or not contaminated based on the laboratory results. These results are shown in Appendix C on a revised set of Test Pit Depth of Contamination Results Maps, TP 1 through TP 5. These maps were originally included in the GHH Report (TerraGraphics, 2012b) showing COCs exceeding 800 mg/kg. The revised maps in Appendix C reflect COCs exceeding 1,400 mg/kg. The maps show 147 acres exceeding either the 1,400 mg/kg combined COC benchmark or the 620 mg/kg arsenic level.

2.6 Existing Streambank Conditions

Existing streambank conditions are defined in this section along with a general discussion of the location and features of each streambank type.

2.6.1 Uncontaminated Streambanks

Uncontaminated streambanks are typically those that were too high for historical flood inundation and tailings deposition. In Phases 5 and 6, they form both stable and actively eroding banklines. Where actively eroding, these banks typically support upland top-of-bank vegetation, whereas stable banklines typically support woody riparian vegetation. The majority of the uncontaminated banks are along outer meander bends located in Phase 6 where the river is confined between low floodplain terraces located on both sides of the river. Eroding Bank and Pool Location Maps (EBPL 1 through 5) in the GHH report show the location of eroding banks with no tailings observed and where no tailings exist on the adjacent floodplain.

Figure 3 shows a cut bank into the eastern floodplain terrace of Phase 6. The following characteristics are visible in the photograph:

- Upland vegetation on the low terrace surface, indicative of hydrologic disconnection between the river and floodplain.
- Homogeneous fine-grained alluvial deposits throughout the bank.
- Bank swallow nests along the mid-section of the bank.
- Capillary fringe from the river’s water surface to the lighter color soil just below the mid-section of the bank.

Figure 3. Cut Bank at Floodplain Terrace with No Tailings

2.6.2 Riparian Vegetation Supported Streambanks

Streambanks that are significantly reinforced by riparian vegetation typically have visible tailings exposures or tailings contamination on the adjacent floodplain. In addition to evidence of contamination, these banks commonly support mature, well-rooted, woody vegetation growing between base flow and the 2-year water surface elevation (WSE) or the existing top of bank. Riparian supported streambanks are found throughout the project but are primarily located along straight sections and point bars. They generally have either low to un-measureable erosion rates or are depositional.

Figure 4 shows a streambank along a straight section with intermittent eroding banks with visible tailings and riparian vegetation. The following characteristics are visible in the photograph:

- An eroding section with tailings visible in the upper portion of the bank.
- Riparian vegetation on the floodplain on either side of the eroding section.
- Mix of herbaceous and woody riparian vegetation from the water surface to the floodplain surface.
- Undercut banks supported by riparian vegetation on the left side of the photo.

Figure 4. Straight Bank with Intermittent Tailings and Riparian Vegetation

Figure 5 shows a straight section of streambank, adjacent to a contaminated floodplain, with no visible tailings and continuous riparian vegetation. The following characteristics are visible in the photograph:

- Continuous mix of herbaceous and woody riparian vegetation along the bankline from the water surface to the floodplain surface.
- Riparian vegetation on the floodplain.

Figure 6 shows a streambank along a contaminated point bar with no visible tailings. The following characteristics are visible in the photograph:

- Continuous riparian vegetation along the bankline from the water surface to the floodplain surface.
- Vegetation on the point bar is the “vegetated bar” community as described in Section 2.8.3.

Figure 5. Straight Bank with No Visible Tailings and Riparian Vegetation

Figure 6. Point Bar

2.6.3 Tailings-stratified Streambanks

Tailings-stratified streambanks are vertical eroding banks with tailings visible in the upper portion of the streambank and present on the adjacent floodplain, and with upland herbaceous vegetation at the top of the bank and on the adjacent floodplain. Tailings-stratified streambanks vary in location but mostly occur along cut banks of outer meander bends in Phase 5 where floodplain terraces do not exist.

Figure 7 shows a tailings-stratified streambank in Phase 5 along an outside meander bend with contamination present on the floodplain and visible in the upper portion of the bank. The following characteristics are visible in the photograph:

- Continuous vertical eroding bank with overhanging (slumping) upland vegetation.
- Tailings contamination (tan colored silty sand) in the upper 12 to 18 inches.
- Historical floodplain surface (dark brown/black silt and clay) just below the tailings.
- Willows sprouting from the historical floodplain surface.
- Fine-grained gravel alluvium below the historical floodplain surface extending to the water surface.
- Clay sill bank toe just below the water surface.

Figure 7. Cut Bank with Visible Tailings on Floodplain

2.6.4 Structurally Affected Streambanks

Structurally affected streambanks are outside meander bends located adjacent to irrigation ditch embankments and the abandoned railroad embankment or where irrigation intake structures exist. There are four outside meander bends adjacent to irrigation ditches: one at the Alvi Beck

Ditch, one at Whalen Ditch (Figure 8, Whalen Ditch Embankment), and two at West Side Ditch; and one outside meander bend adjacent to the abandoned railroad embankment. There are three intake structures, one for each ditch listed above. Except for the streambank along Whalen Ditch (Figure 8), the streambanks are sloped, partially rip rapped, and vegetated.

Figure 8 shows a vertical eroding streambank in Phase 6 that is eroding into the Whalen Ditch embankment. The bank height is approximately 10 to 12 feet with the upper 6 to 8 feet consisting of embankment fill over the historical floodplain.

Figure 8. Cut Bank at Whalen Ditch Embankment

2.7 Groundwater Monitoring

During the summer of 2012, groundwater elevations were obtained from 40 piezometers installed within the study area. Between May 24, 2012, and June 15, 2012, 1-inch and 2-inch diameter piezometers were installed in test pits completed with an excavator. 1-inch piezometers were installed in locations designated for future water level monitoring only and 2-inch piezometers were installed in locations designated for future groundwater sampling and water level monitoring. The piezometers were installed at 6 transects along the project reach; the locations are shown in Appendix B on the Borrow Area Test Pit and Piezometer Location Map.

Immediately following installation, the new piezometers were developed using a surge block and over-pumping to remove fine-grained sediments near the screened portion to ensure proper hydraulic connection with the local aquifer. The top-of-casing elevations were surveyed on August 15, 2012, by a DEQ-contracted surveyor (Brown and Associates).

Static water levels were obtained from each of the piezometers during three monitoring events on June 18, 2012; August 1, 2012; and August 29, 2012. Average depth to groundwater throughout the study area was 2.33 feet below ground surface (bgs) on June 18, 2012, 3.28 feet bgs on August 1, 2012, and 3.59 feet bgs on August 29, 2012. Piezometer groundwater elevations for the 2012 monitoring events are presented in Figure 9. The groundwater elevations are shown relative to the transect station where they are located. Summary tables of all groundwater elevations and depths to water for each monitoring event are included in Appendix B Borrow Area and Groundwater Investigation.

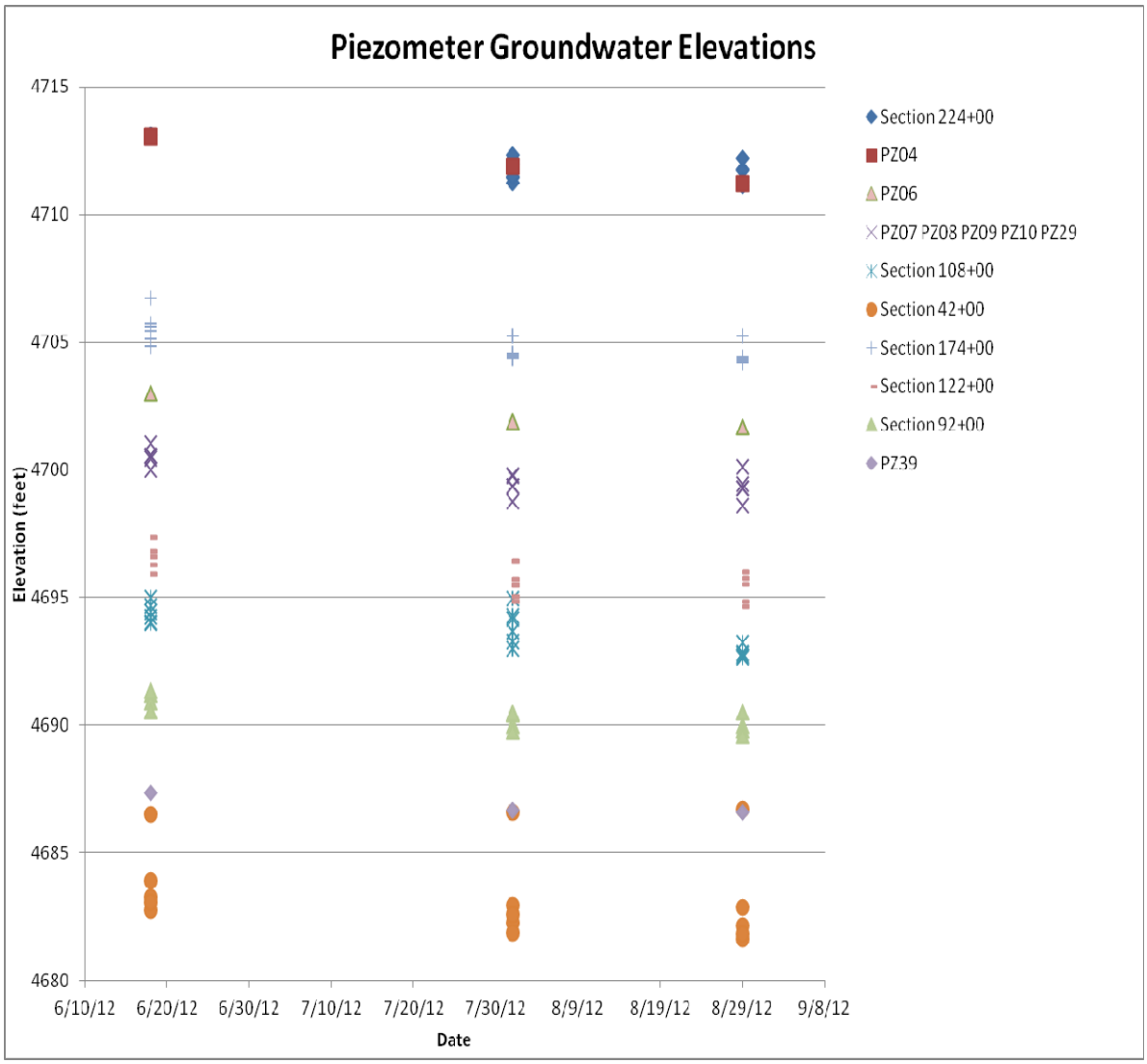


Figure 9. Piezometer Groundwater Elevations

The potentiometric surface of the alluvial aquifer and inferred groundwater flow direction within the study area for the three monitoring events conducted in 2012 is shown on the Phases 5 and 6 Water Table Map in Appendix B. The water table contour lines are inferred from groundwater levels in the 40 piezometers installed during this investigation, but may not account for local

flow variations near the river, Dry Cottonwood Creek, or ditches. In general, groundwater flow direction is toward the CFR in a downstream direction (north-northeast). Average groundwater hydraulic gradients ranged from 0.0032 ft/ft on June 18, 2012, to 0.0029 ft/ft on August 29, 2012, as measured between piezometers PZ01 and PZ40.

2.8 Vegetation Assessment

This section includes a description of vegetation within the project area, organized by previous vegetation assessments, historical vegetation, and existing vegetation. Methods and data sources used to map and analyze existing vegetation patterns are described, and a discussion section explains how vegetation patterns were interpreted and used to support design criteria.

2.8.1 Previous Assessments

Vegetation assessments for portions of the CFROU, including Phases 5 and 6, have been completed by various agencies and researchers to assist with remediation efforts.

Previous studies have shown that vegetation along the CFR is variable. Smith et al. (1998) state that, while some streambanks and floodplain areas are covered by phytotoxic slickens, willows (*Salix* spp.) re-grew after the 1908 flood of record in areas where tailings have been covered by levy sands. Griffin and Smith (2002) examined the density and distribution of floodplain vegetation to assess the vulnerability of floodplain erosion during overbank flow events. The results of their analysis showed that 74 percent of the floodplain tabs (floodplain areas between meander bends) have less than 40 percent of their surface covered by shrub canopy, and an average of 29 percent of the tab surface areas are covered by shrub canopy. Tailings and historical grazing practices have suppressed vegetation development, and few younger age classes of shrubs are present (Griffin and Smith, 2002).

Wetland and riparian areas were mapped in the Upper Clark Fork watershed as part of the U.S. Fish and Wildlife Service (USFWS) National Wetlands Inventory (NWI) (USFWS, 2005). Wetlands are classified using the Cowardin classification system (Cowardin et al., 1979) and riparian areas are classified using the USFWS riparian classification system (USFWS, 2005). The NWI data set was used to identify the location and extent of wetland and riparian areas in Phases 5 and 6 to better guide vegetation community mapping.

To support development of the ROD, USEPA assessed vegetation and wetlands including the following activities: distinguishing tree- and shrub-dominated areas as polygons; mapping jurisdictional wetlands to be used as a baseline for evaluating wetland credits that may become available as part of Remedial Activities; and distinguishing and mapping three broad categories of vegetation condition using RipES with the thought that plant community composition and structure might correlate with degree of contamination (USEPA, 2004). In 2006–2007, USEPA performed further RipES mapping. Results from these assessments are in the form of GIS data layers developed by USEPA and its contractors as part of developing the ROD.

2.8.2 Historical Vegetation

Historical reports of the vegetation and CFR channel within the Deer Lodge Valley indicate that the channel was narrow and deep with densely vegetated streambanks (Smith et al., 1998). GLO survey notes completed in 1869 describe areas along the Deer Lodge River (former name for the

CFR) in Phases 5 and 6 as having dense willow (*Salix* spp.) and alder (*Alnus* spp.) thickets, as well as cottonwood (*Populus* sp.) stands present (BLM, 2012). The only timber recorded in the GLO notes along the river is scattered cottonwoods. Historical vegetation communities and variable topography within the floodplain may have been influenced by beaver dams (Smith et al., 1998). Both springs and beaver impoundments would have supported a much wetter floodplain that included dense willow thickets, sloughs, marshes, and aspen swamps (BLM, 2012). Prolonged saturation from beaver dams may explain peat development in areas along the CFR.

Smith and Griffin (2002) suggest that the historical conditions, including variable topography and densely vegetated streambanks and floodplain, influenced the distribution of deposited tailings following large flood events in the early 1900s. Dense vegetation on the channel margin slowed overbank flows and promoted deposition on the channel edges, creating natural levees that slope away from the channel. Conveyance of flood flows over these natural levees into the adjacent floodplain drove deposition of suspended material as flow velocities slowed on the floodplain surface. Variations in tailings thickness reflect deposition on topographically irregular ground.

Within the project area, deposition of up to several feet of tailings on the CFR floodplain in the early 1900s resulted in the formation of elevated streambanks and reduced floodplain access (Smith et al., 1998; Smith and Griffin, 2002). While stream channel entrenchment is commonly the result of channel incision, in this case entrenchment was caused by rapid floodplain aggradation resulting from tailings deposition prior to the activation of Warm Springs Ponds as a sediment trap. Within Phases 5 and 6, tailings are deepest in areas along the channel margins and point bars, especially in Phase 5 where the floodplain is lower than in Phase 6 and not confined by floodplain terraces, and in areas that were depressions prior to the early 1900s flood events (areas such as oxbows, side channels, backwaters, and other low-elevation floodplain areas). Existing plant communities in these areas tend to have wetland characteristics because their elevation is low relative to the water table. Tailings have been deposited more recently as point bar features reflecting post-flood reworking of the contaminants.

2.8.3 Existing Vegetation

To support preliminary design and refine remedial actions, DEQ completed site-specific vegetation assessments and compared these results with contamination data from soil pits (Section 2.5) and geomorphic features identifiable from aerial imagery and detailed topography provided by LiDAR (Light Detection and Ranging) elevation data. These site-specific vegetation assessments showed that observed vegetation patterns weakly correlate with contamination thickness and concentration (Table 11). Variations in plant community composition and structure are driven partly by contamination but more strongly by geomorphic position, elevation relative to river-influenced hydrology, and land use.

2.8.3.1 Vegetation Evaluation Methods

Existing vegetation communities were evaluated using two methods. Field mapping first identified the composition and location of existing vegetation communities within Phases 5 and 6. Later, spatial analyses of the resulting vegetation community mapping combined additional data layers to further characterize and determine patterns of vegetation establishment.

Existing vegetation communities were mapped by Geum during the 2010 and 2011 growing seasons, and were refined in 2012. Vegetation communities were mapped in the field using the following spatial data for reference:

- 2009 National Agriculture Imagery Program (NAIP) imagery (USDA FSA, 2009)
- 2011 aerial photography (Microsoft, 2011)
- National Wetlands Inventory mapping including wetlands and riparian areas (USFWS, 2005)
- Deer Lodge County Area Soil Survey (USDA NRCS, 2012)
- Modeled WSEs prepared by TerraGraphics
- Elevations relative to the 2-year water WSE using processed LiDAR data collected between August 6, 2011, and August 11, 2011, by Fugro Horizons, Inc. (2011) and post processed by DJ&A, P.C.

During field mapping, the extents of distinct vegetation communities were delineated over aerial photographs of the project areas. Within each vegetation community, species lists were generated and information on topography and hydrology was collected for examples of each vegetation community. A global positioning system (GPS) point was recorded and photographs were taken at each location where data were collected. Based on this information, descriptive plant community categories were developed according to dominant plant species composition and structure, geomorphic position, elevation relative to river hydrology, and land use (Table 11).

Information obtained from field mapping of the vegetation communities was later used to digitize a spatial data layer using ArcMap 10 (ESRI, 2011) that could be combined with other project area spatial data for further analysis. Additional data layers included the 2-year WSE elevation derived from LiDAR elevation data and flow models, and depth of soil contamination derived from soil pit data collected by TerraGraphics (Section 2.5).

Half a foot above the 2-year WSE was used to determine areas that are currently connected to river hydrology, termed “hydrologically connected” for this plan. Based on previous floodplain projects and observed natural conditions, this elevation corresponds with conditions and processes required to establish and sustain riparian vegetation such as soil moisture, nutrient transport, scour and deposition, and seed availability. As such, half a foot above the 2-year WSE is estimated to be a reasonable maximum elevation corresponding to locations with sufficient hydrologic connectivity to sustain native riparian plant communities. These areas either receive frequent overland flow from the channel or have groundwater present in the rooting zone during significant portions of the growing season. To quantify existing floodplain hydrologic connection, the area of surfaces at or below half a foot above the 2-year WSE was calculated for each mapped vegetation community to indicate those areas that are currently connected to river hydrology (Table 11).

Soil pit data were interpolated using an inverse distance weighted (IDW) method in ArcMap 10 (ESRI, 2011) to generate a raster representing the depth of contamination where the summed concentration of COCs equals or exceeds 1,400 mg/kg throughout the project area.

The ArcMap tool “Zonal Statistics by Table” was used to determine the minimum, maximum, and average elevation of each plant community relative to the 2-year WSE, and the minimum, maximum, and average depth of tailings contamination by vegetation community. This tool

"…summarizes the values of a raster within the zones of another data set" (ESRI, 2011). In this case, the raster values used were elevations relative to the 2-year WSE and the depth of contamination, and the zones used to summarize these data were the vegetation communities. The findings of the vegetation community mapping and data analyses are described in the next section.

2.8.3.2 Vegetation Evaluation Results

Approximately 247 acres were mapped and 18 vegetation communities were characterized within the limits of soil sampling for Phases 5 and 6 (Table 11). Figure 10 and Figure 11 show the results of the vegetation community mapping in Phases 5 and 6, respectively. Sixteen of the communities are within the spatial limits of soil sampling. Two vegetation communities, Aspen Stand and Willow/Birch – Aspen Overstory, are outside of the sampling area, but are included because they represent vegetative potential within the project area. The most extensive vegetation communities within the project area floodplain are Willow/Birch (93.7 acres), Upland Herbaceous (71.2 acres), and Agriculture (18.8 acres). Other vegetation communities comprise small areas within the project area and are often associated with dominant vegetation communities.

Analyses overlaying vegetation communities with soil contamination thickness (Figure 12 and Figure 13) show that the Bare Ground vegetation community had the greatest average depth of contamination (2.2 feet), followed by Vegetated Bar (2.0 feet) and Willow/Birch (1.5 feet). These communities generally are present on meander tabs and point bars, and within the channel migration zone (CMZ).

Analyses overlaying vegetation communities with elevations relative to 0.5 feet above the 2-year WSE (Figure 14 and Figure 15) show that only 15.7 acres (6.4 percent) of the mapped vegetation communities are hydrologically connected to the river. Even dominant vegetation communities including Willow/Birch, Upland Herbaceous, and Agriculture only have a small percentage of area considered hydrologically connected to the river. Vegetation communities that do not occupy large areas within the floodplain, including the Vegetated Bar, Emergent Marsh, and Willow/Birch – Depression communities, occur on lower elevation geomorphic features, and therefore higher proportions of their total areas are within the elevation range corresponding to hydrologic connection.

Table 11. Existing Vegetation Community Descriptions. (4 pages)

Community Type (Acres)	Community Type Description	Elevation (feet) relative to 2-year WSE			Depth of Contamination >1,400 mg/kg (feet)			Hydrologically Connected Area[1] (acres)	Geomorphic Feature	Land Management Effects
		Min	Max	Ave	Min	Max	Ave			
Willow/Birch (93.7 acres)	Willow and/or birch dominated canopy. Understory can include upland vegetation such as gooseberry and rose, or wetland herbaceous vegetation such as sedges.	-3.8	8.7	1.8	0	5.0	1.5	5.6	Generally within the belt width; meander tabs, tributaries, or ditches; occasionally small patches further from the channel	Impacted by cattle, many higher elevation shrubs heavily browsed; shrubs at lower, wetter elevations have significant soil pugging from cattle use
Upland Herbaceous (71.2 acres)	Dominated by upland species such as wild rye, redtop, and wheat grasses. Lacks shrubs and trees. Dry weed species often present.	-3.2	9.6	2.8	0	4.0	0.4	1.1	Outer meanders and high terraces; occasionally elevated areas on meander tabs	Often hayed or grazed
Agriculture (18.8 acres)	Cultivated land including pasture grasses and alfalfa.	-0.5	10.3	4.9	0	2.5	0.5	0	Floodplain	Often irrigated, hayed, or grazed

Table 11. Existing Vegetation Community Descriptions. (4 pages)

Community Type (Acres)	Community Type Description	Elevation (feet) relative to 2-year WSE			Depth of Contamination >1,400 mg/kg (feet)			Hydrologically Connected Area[1] (acres)	Geomorphic Feature	Land Management Effects
		Min	Max	Ave	Min	Max	Ave			
Wet Meadow (15.5 acres)	Dominated by wetland species primarily in temporarily or seasonally flooded wetlands.	-1.4	7.9	2.5	0	3.5	0.7	0.2	Abandoned meander channels and low elevation areas in floodplain; irrigated hay fields	Often irrigated, hayed, or grazed
Bare Ground (9.2 acres)	Areas of exposed substrate with minimal vegetative cover. When present, species include salt grass.	-1.6	6.7	1.6	0	4.0	2.2	0.5	Generally on low meander tabs	None observed
Emergent Marsh (7.2 acres)	Dominated by wetland species found in semi-permanently to permanently flooded wetlands.	-2.0	6	0.7	0	3.7	1.1	4.0	Abandoned meander channels and oxbows in floodplain and meander tabs	None observed
Low Shrub – Upland Herbaceous (7.1 acres)	Areas of low growing shrubs including snowberry, Wood's rose, and gooseberry intermixed with areas of upland herbaceous species including redtop and wild rye.	-2.8	5.2	2.2	0	3.0	0.7	0.1	Variable	Some areas are grazed while others have recently been excluded from grazing

Table 11. Existing Vegetation Community Descriptions. (4 pages)

Community Type (Acres)	Community Type Description	Elevation (feet) relative to 2-year WSE			Depth of Contamination >1,400 mg/kg (feet)			Hydrologically Connected Area[1] (acres)	Geomorphic Feature	Land Management Effects
		Min	Max	Ave	Min	Max	Ave			
Low Shrub (6.3 acres)	Dense low growing shrubs including snowberry, Wood's rose, and currant. No herbaceous understory. Lacks willow/birch overstory.	-1.3	8.5	3.3	0	3.5	0.6	0.1	Variable	Recently excluded from grazing
Berm (5.1 acres)	Disturbed or infrastructure areas.	-2.0	11.9	3.7	0	4.0	0.8	0.6	Variable	Highly modified
Vegetated Bar (4.0 acres)	Recently deposited sediment, now vegetated with wetland plants and often colonizing willows.	-4.1	3.4	0.6	0.2	4.0	2.0	2.0	Point bar	None observed
Willow/Birch –Cottonwood Overstory (2.9 acres)	Willow and/or birch dominated canopy with black cottonwood in the overstory.	-1.6	3.6	1.1	0	3.5	1.2	0.5	Meander tabs	Impacted by cattle
Willow/Birch –Depression (2.3 acres)	Willow and/or birch dominated canopy. Understory dominated by wetland species such as sedges.	-4.1	9.2	1.2	0	3.5	1.2	0.8	Depressions, often old meander tabs or oxbows; occasionally low swales	Areas outside of riparian fencing are used for agriculture, including livestock grazing and hay production

Table 11. Existing Vegetation Community Descriptions. (4 pages)

Community Type (Acres)	Community Type Description	Elevation (feet) relative to 2-year WSE			Depth of Contamination >1,400 mg/kg (feet)			Hydrologically Connected Area[1] (acres)	Geomorphic Feature	Land Management Effects
		Min	Max	Ave	Min	Max	Ave			
Cottonwood Stand (0.7 acres)	Black cottonwood stand with an understory dominated by upland herbaceous vegetation.	0.1	5.3	3.3	0	2.4	1.1	0	Meander tabs	Some areas are grazed while others have recently been excluded from grazing
Willow/Birch –Decadent (0.6 acres)	High percentage of decadent willows and/or birch.	0.4	2.3	1.3	0.5	1.9	1.1	0	Meander tabs	Heavily browsed by cattle
Island (0.4 acres)	Vegetated island in active river channel.	-2.0	2.6	1	NA	NA	NA	0.2	Vegetated islands in channel	None observed
Salt Grass (0.1 acres)	Salt grass is dominant vegetative cover.	-0.9	4.9	3.8	0	0.4	0.2	0	Meander tabs; isolated upland saline areas	None observed
Willow/Birch –Aspen Overstory (1.4 acres)	Willow and/or birch dominated canopy intermixed with aspens. Understory is often dominated by wetland herbaceous vegetation such as sedges.	-0.3	4.4	2.4	NA	NA	NA	0	Along abandoned channel; low areas	Some areas are grazed while others have recently been excluded from grazing
Aspen Stand (0.3 acres)	Aspen stand.	-0.8	3.0	1.2	NA	NA	NA	0	Floodplain	None observed

[1] Areas located at or below 0.5 feet above the 2-year WSE are considered hydrologically connected to the river.

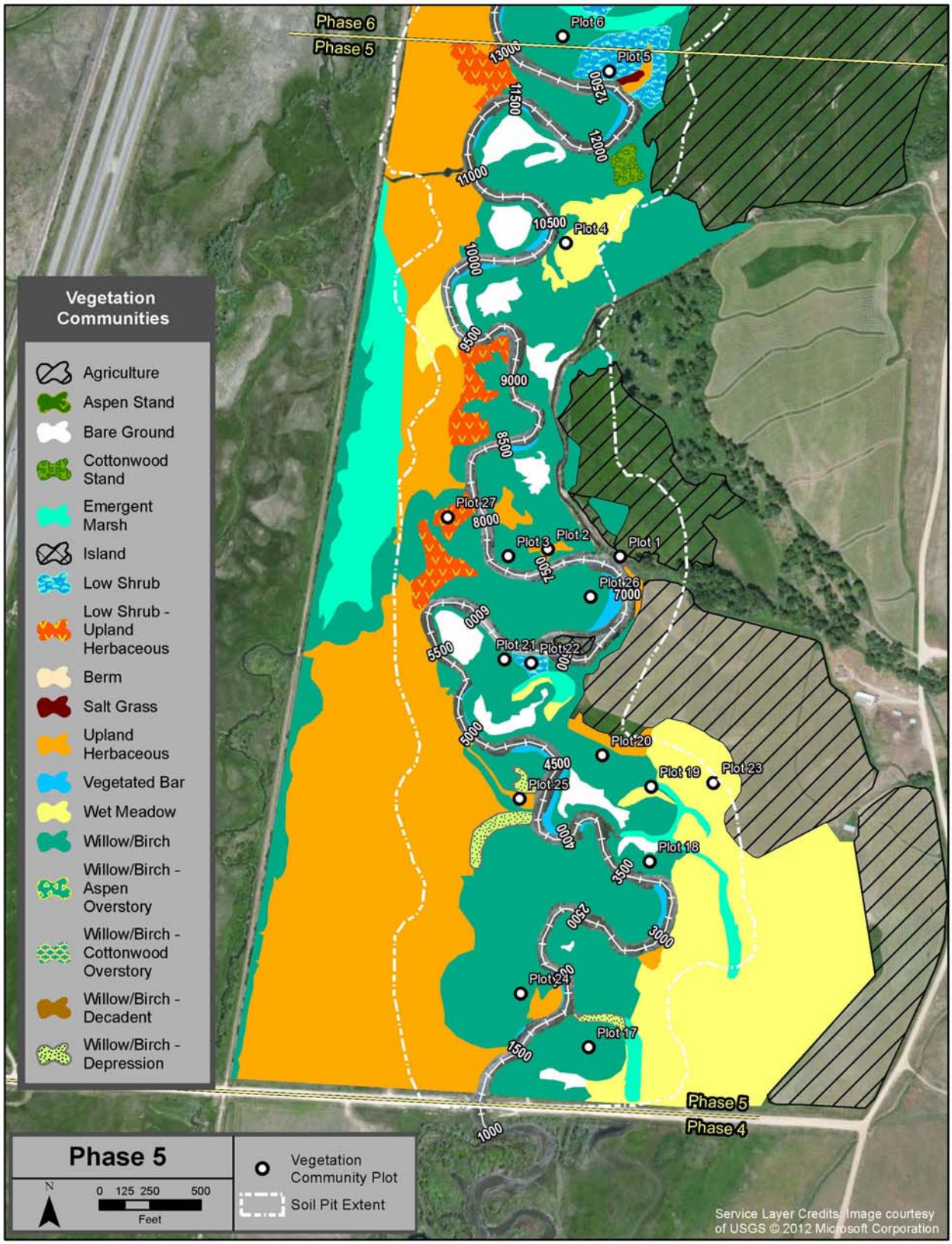


Figure 10. Existing Vegetation Community Distribution in Phase 5.

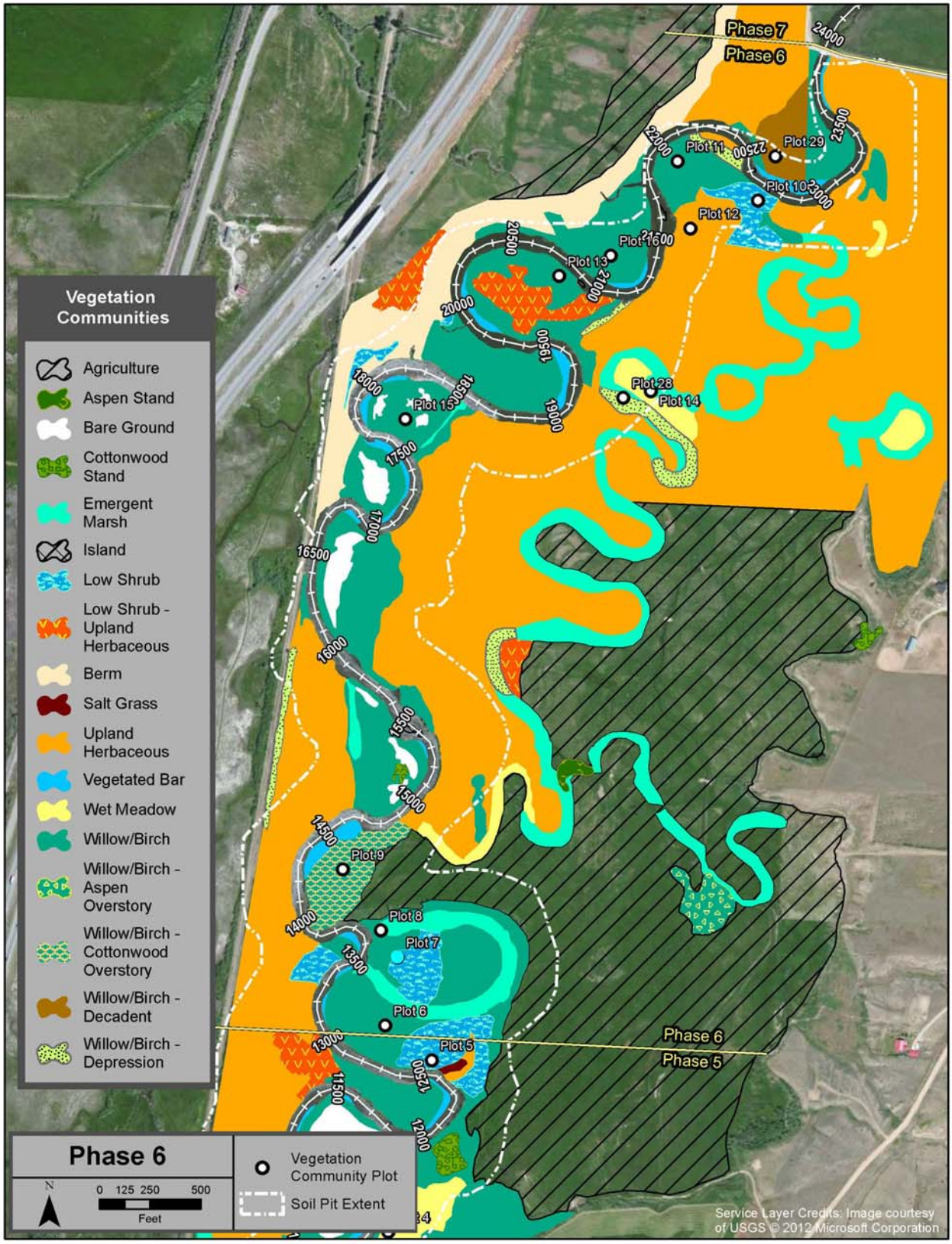


Figure 11. Existing Vegetation Community Distribution in Phase 6.

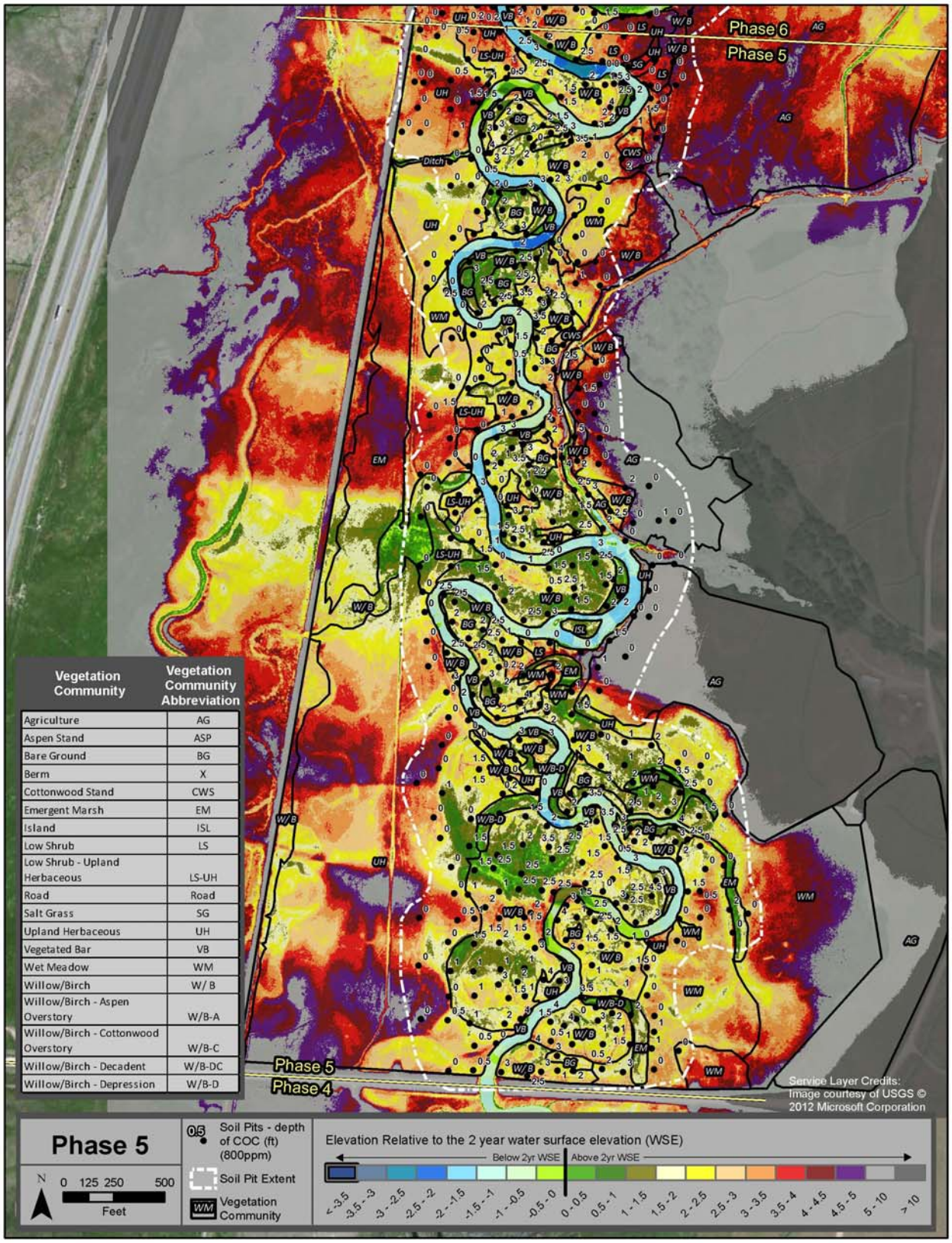


Figure 12. Phase 5 Vegetation Communities and Existing Ground Elevations relative to the 2-year Water Surface Elevation.

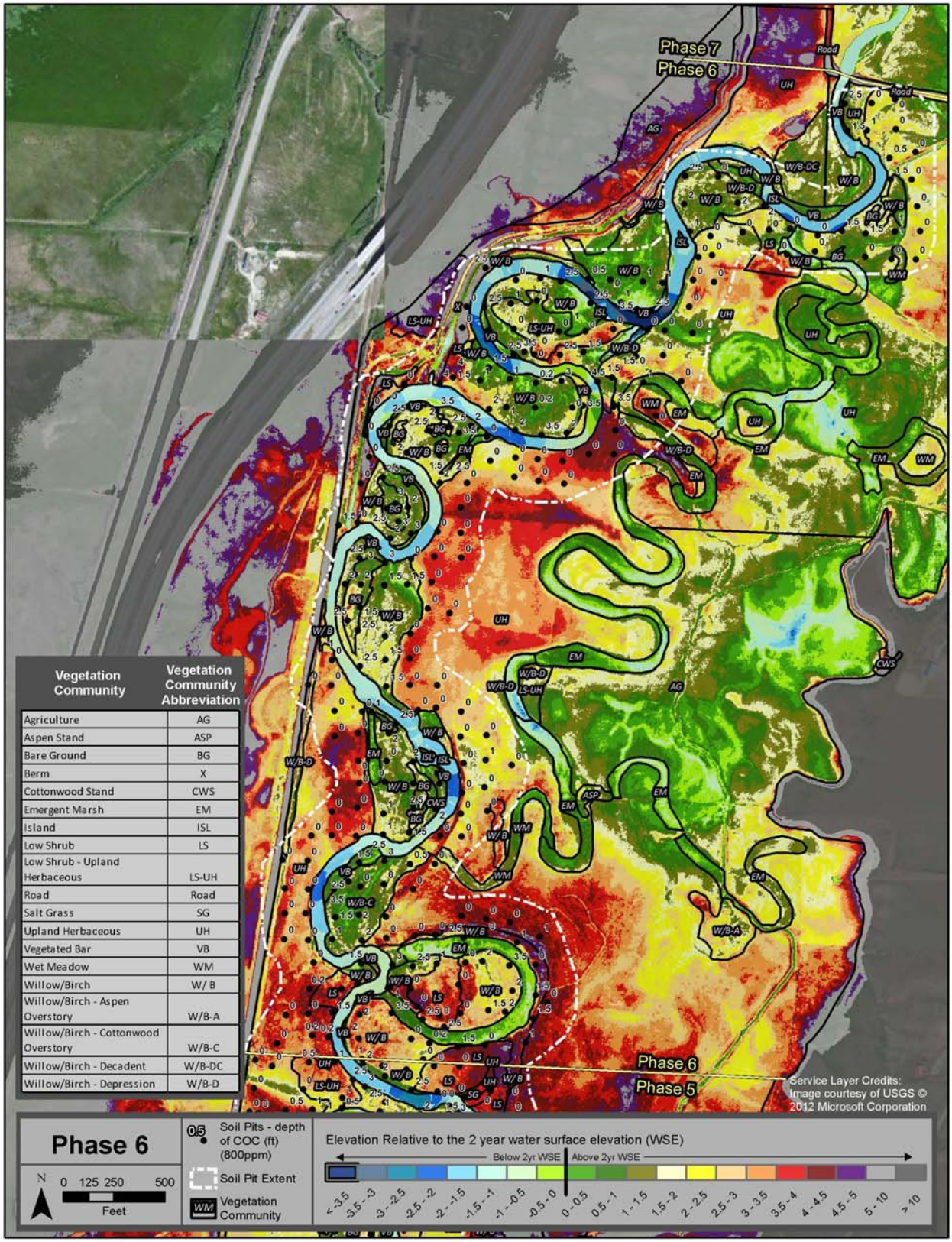


Figure 13. Phase 6 Vegetation Communities and Existing Ground Elevations relative to the 2-year Water Surface Elevation.

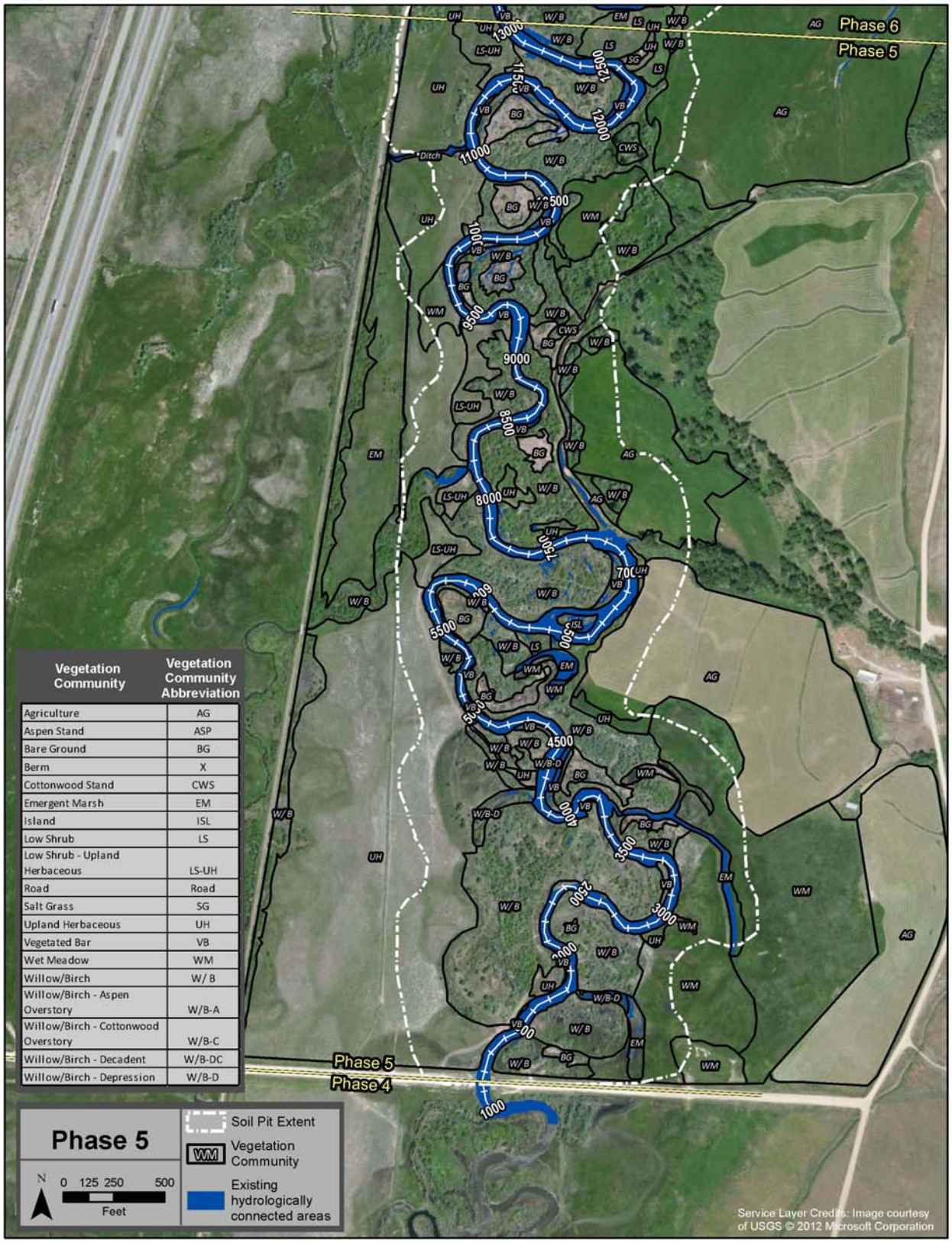


Figure 14. Phase 5 Existing Areas Connected to River Hydrology.

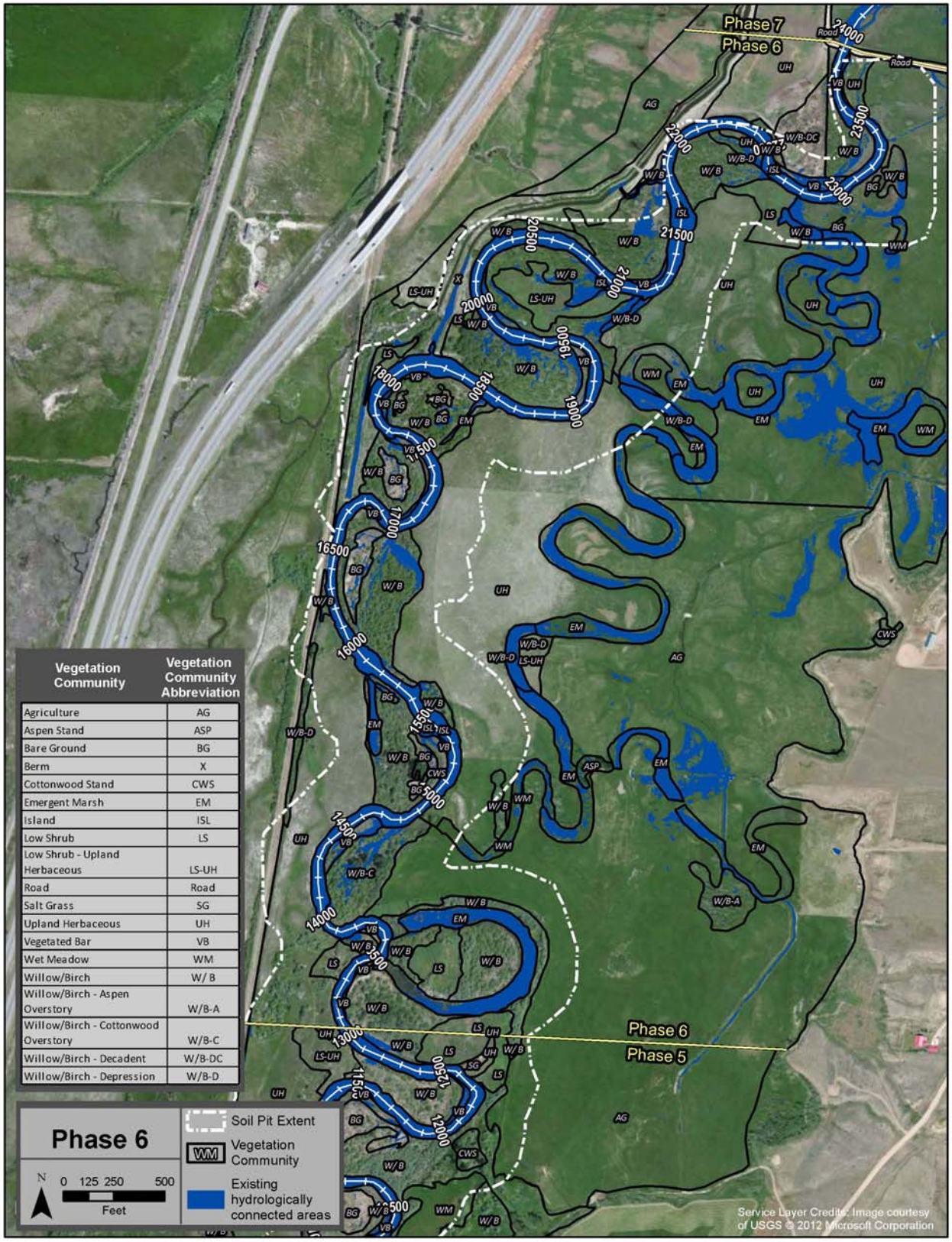


Figure 15. Phase 6 Existing Areas Connected to River Hydrology.

2.8.4 Riparian Vegetation and Floodplain Function

Existing vegetation communities at the site were mapped and analyzed in order to describe vegetation relative to contamination based on repeatable visual patterns. Few apparent patterns were observed that linked the composition and structure of vegetation communities to contamination. However, relationships were observed between vegetation structure and composition, geomorphic position, hydrology relative to the river channel, and land use.

Within the project area, the most common vegetation community is Willow/Birch (93.7 acres, 38 percent of mapped vegetation communities within soil sampling extents). This community is characterized by a willow (*Salix* spp.) and/or birch (*Betula occidentalis*) dominated overstory with an understory that includes herbaceous or low shrub species. The Willow/Birch vegetation community is on average 1.8 feet above the 2-year WSE, with an average depth of contamination of 1.5 feet. Willow/Birch occupies a broad range of elevations with mature shrubs that range from vigorous to decadent. However, there is no apparent relationship between the degree of contamination and condition of this community.

Historically, Willow/Birch areas were likely hydrologically connected to the river channel, but tailings deposition has caused these areas of the floodplain to aggrade and become hydrologically disconnected, with only 5.6 acres (6.0 percent) of the area being at or below 0.5 ft above the 2-year WSE. Existing willows and birches are likely the result of vegetative regrowth from live roots and branches buried under deposited tailings. New plants are unable to colonize many of these areas from seed because the elevated geomorphic position results in a lack of river flows that scour and deposit substrate needed for willow and cottonwood regeneration. Some human-caused disturbances, such as berm construction, have resulted in bare alluvial surfaces that are supporting some natural willow reproduction.

The Willow/Birch – Decadent vegetation community, characterized by a high percentage of decadent mature willow and birch, is located on average 1.3 feet above the 2-year WSE, with an average depth of contamination of 1.1 feet. Because elevation and tailings thickness are within the range of the Willow/Birch vegetation community, this community's degraded condition is best explained by obvious impacts from livestock grazing, rather than a difference in contamination levels. The Willow/Birch – Cottonwood Overstory community is a minor floodplain component characterized by a willow and birch dominated shrub canopy with black cottonwoods (*Populus balsamifera*) in the overstory.

The Upland Herbaceous vegetation community is also a major component within the assessed area, occupying 71.2 acres (29.0 percent). This community lacks tree and shrub species and is characterized by upland herbaceous species such as wild rye (*Elymus* sp.), redtop (*Agrostis gigantea*), and wheat grasses. These areas are on average 2.8 feet above the 2-year WSE, with an average depth of contamination of 0.4 feet. The Agriculture vegetation community is a minor component occupying 18.8 acres (7.7 percent) that consists of irrigated, cultivated land with pasture grasses and alfalfa (*Medicago sativa*). Vegetation composition in both communities is primarily driven by land use including grazing and hay production.

The Wet Meadow vegetation community comprises 15.5 acres (6.3 percent) of the assessed area and is characterized by plant species found in temporarily or seasonally flooded wetlands. While it is one of the wetter vegetation communities, it occurs on higher surfaces (the average elevation is 2.5 feet above the 2-year WSE). Whereas some Wet Meadow areas are influenced by river

hydrology, other areas may be wet because of irrigation or groundwater seepage from upland slope toes. These areas have an average depth of contamination of 0.7 feet. This community is primarily influenced by land management including irrigation, grazing, and haying practices.

The Emergent Marsh community comprises 7.2 acres (2.9 percent) of the assessed area and is located within abandoned meander channels, depressions, and oxbows. This community is characterized by plant species primarily found in semi-permanently to permanently flooded wetlands. The Willow/Birch – Depression community occupies 2.3 acres (0.9 percent) of the assessed area within swales, oxbows, and depression features and is characterized by a willow and/or birch overstory and an understory dominated by sedges (*Carex* spp.). Both communities are located at lower elevations relative to the 2-year WSE but on average have more than 1 foot of contamination. Low elevation features such as these may have greater depths of contamination due to tailings deposited during flood events. Prior to these analyses, it was assumed that the integrity of vegetation would decline with greater contamination depths. However, the Emergent Marsh and Willow/Birch – Depression communities appear to be ecologically functioning (vigorous, dense riparian shrubs and/or abundant sedges, rushes and other herbaceous wetland species are present and appear healthy) even though they have some of the highest average contamination depths. Approximately 4 acres (55.3 percent) of Emergent Marsh and 0.8 acres (35.5 percent) of Willow/Birch – Depression are considered to be connected to river hydrology. This supports that idea that geomorphic position and hydrology influence the composition and structure of plant communities more than tailings thickness.

The Bare Ground vegetation community, with sparse to no vegetation, often has visibly contaminated soil as evidenced from metal salts that accumulate on the soil surface. Previous studies have identified these areas as severely impacted areas (slickens). These areas comprise approximately 9.2 acres (3.8 percent) of the assessed area and typically are present on low meander tabs close to the channel. Vegetation is sparse, possibly because tailings are slightly thicker than in other vegetation communities (average depth of contamination of 2.2 feet) and elevations are relatively high; therefore, the effects of thick contamination are less likely to be buffered by anaerobic, saturated conditions. The Saltgrass (*Distichlis spicata*) vegetation community only comprises 0.1 acres (0.1 percent) of the project area and is found around Bare Ground vegetation communities.

The Low Shrub – Upland Herbaceous vegetation community is characterized by areas of low growing shrubs including snowberry (*Symphoricarpos occidentalis*), Woods' rose (*Rosa woodsii*), and gooseberry/currant (*Ribes* spp.) intermixed with areas of upland herbaceous species. The Low Shrub vegetation community consists of dense, low growing shrubs similar to the Low Shrub – Upland Herbaceous community but lacks patches of upland herbaceous species. Both communities are located relatively high compared to the 2-year WSE and have relatively low levels of contamination. These low levels of contamination may be attributed to a historical lack of connection with river hydrology.

The Vegetated Bar vegetation community is a minor floodplain component (4 acres, 1.6 percent) that occurs on point bars and is composed of wetland herbaceous species and young willows. This community is on average 0.6 feet above the 2-year WSE and has the second greatest average contamination depth of 2.0 feet. This level of contamination may be attributed to vegetated bars being recently formed depositional features that accumulate mobilized, contaminated sediment from eroding banks during flood events. Island communities are located in the active river channel and are on average 1.0 feet above the 2-year WSE. Soil pit data were

not collected in this community so it is unknown if they are also accumulating contaminated depositional material.

The Cottonwood Stand vegetation community is a very minor component of the project area (0.7 acres, 0.3 percent). This community is characterized by an overstory dominated by black cottonwood and an understory dominated by upland herbaceous vegetation.

Within Phases 5 and 6, floodplain aggradation has resulted in a floodplain that is largely disconnected from the river channel, thereby affecting the composition and structure of vegetation communities compared to historical conditions. Currently, only 8 percent of the mapped floodplain and associated riparian vegetation within the project area are estimated to be hydrologically connected to the CFR in Phases 5 and 6. Areas that are currently connected to river hydrology are able to perform ecological functions including sediment and nutrient transport and storage, flood water storage, food web support, and aquatic habitat support. Areas not connected to the river channel are unable to provide similar ecological functions.

2.9 Topographic Survey

The site topography was surveyed in three stages: an initial ground survey of the river and banks, an aerial LiDAR survey of the floodplain topography, and a second ground survey of site surface features and property lines. Dan Brown and Associates set survey control before any other survey activities commenced. TerraGraphics performed the initial ground survey of the river and banks to investigate the existing geomorphic and hydraulic conditions and to collect topographic data for hydraulic modeling and design. Survey data were collected at regular cross-section intervals spaced at approximately 500 feet relative to the stream direction, and were also collected to identify the locations and characteristics of pools, inset floodplain surfaces, bed features, and river planform. Each channel cross-section was surveyed perpendicular to the assumed flow path and extended beyond the top-of-bank elevation. Aerial LiDAR data were collected between August 6, 2011, and August 11, 2011, by Fugro Horizons, Inc. and post processed by DJ&A, P.C. Because the LiDAR survey cannot obtain data below water and to improve the accuracy along the river, the LiDAR data were merged with initial ground survey points to create a project area surface of the ground topography. A second ground survey of the site was performed by Dan Brown and Associates to obtain the location of site features such as fences, irrigation ditches, headgates, and other structures. Additionally, Dan Brown and Associates provided the location of property lines based on county records and plats.

Section 3.0 Basis of Design

3.1 Design Concept

Section 2.0 provided information on groundwater, riparian vegetation, geomorphic stability, contaminant sampling, ownership, infrastructure, land use, and site-specific remedy requirements. As the information makes clear, Phases 5 and 6 exhibit extensive contamination within the CMZ, dominating the floodplain system. The Phases 5 and 6 polygons within the CMZ meet the classification of severely impacted areas. In addition, certain areas outside the CMZ exhibit extensive contamination where the thickness is greater than or equal to 2 feet. These outside the CMZ polygons also meet the classification of severely impacted areas. Lastly, certain discrete areas in addition to these two sets of polygons demonstrate arsenic levels above 620 mg/kg, and are also in the 2-year WSE, and therefore meet the classification of severely impacted areas.

Therefore, the objectives of the project described in this preliminary design document are to 1) remove severely impacted areas, 2) provide geomorphic stability during reestablishment of riparian vegetation after construction, and, ultimately, 3) revegetate through the establishment of plant communities capable of stabilizing soils against wind and water erosion, thus reducing transport of COCs to groundwater and surface water, and compliance with ARARs or replacement standards, in perpetuity.

The primary sources of contamination in Reach A are concentrated tailings deposits and tailings mixed with soil along the river banks and on the floodplain. These contaminant sources directly impact plants, terrestrial wildlife, aquatic organisms, and humans through uptake and ingestion. Effects of tailings deposition include but are not limited to degraded vegetation communities, stands of dead willows, and areas devoid of vegetation. These impacts are caused by acid generating potential of tailings during oxidation and phytotoxicity of metals in the soil. In addition to these geochemical impacts, tailings aggraded on the floodplain have physically perched the floodplain above the normal hydrologic regime of the river, causing reduced floodplain inundation frequency and duration, reduced riparian vegetation access to groundwater, and concentrated in-stream flows. Contaminants have been physically recruited into the channel by bank erosion, and some of those reworked contaminants have been deposited within in-channel depositional features such as point bars and low bank-attached bars. In addition to these processes, metals also move through the soil column or are dissolved in the water during fluctuating periods of oxidizing and reducing conditions and can be taken up by plants. Until the contaminants are removed, these conditions will persist within the river system and metals will be available for biologic uptake.

In order to accomplish the objectives for this project, the Design relies on a combination of the following remedial strategies.

1. To offset and reduce the impacts from the tailings contamination:
   - Remove the severely impacted areas from the floodplain
   - Dispose at the BP ARCO Waste Management Area.
2. To provide system stability during reestablishment of the floodplain after removal:

- Topographically reconnect the floodplain and river, allowing for increased groundwater access for riparian vegetation, and increased frequency and duration of floodplain inundation. This reconnection is absolutely critical to meet remedial goals and performance standards in the ROD.
- Reconstruct the floodplain as a topographically diverse, hydrologically connected surface that will support a permanent vegetative cover including robust woody riparian and wetland species.
- Revegetate the reconstructed floodplain with appropriate native riparian species.
- Reinforce floodplain areas that are at a higher risk of erosion using specific substrate gradations, bank treatments, and topographic grading strategies.
- Preserve those streambanks that are at a lower risk of accelerated erosion.
- Stabilize actively eroding streambanks as necessary with bioengineered treatments designed to manage erosion and bankline migration during the period of floodplain vegetation establishment.

In the long term, these strategies are intended to collectively meet the following requirements:

- Prevent or reduce unacceptable risk to ecological (including agricultural, aquatic, and terrestrial) systems degraded by contaminated soil.
- Minimize direct contact with arsenic, thus reducing the potential risk of human exposure to acceptable risk-based levels.
- Prevent or inhibit ingestion of arsenic-contaminated soils/tailings where ingestion or contact would pose an unacceptable health risk.
- Remediate contaminated soils to be compatible with the existing and anticipated future land use with minimal future maintenance activities.
- Improve agricultural production by reducing or eliminating phytotoxic conditions, thus providing for multiple land uses.
- Minimize wind erosion and movement of contaminated soils onto adjacent lands, thus eliminating human, agricultural, and wildlife exposure.
- Provide geomorphic stability to streambanks, thus minimizing release of COCs to the river.
- Minimize surface water erosion and COC transport to surface water through methods described in the Selected Remedy.
- Comply with surface water standards.
- Minimize transport of COCs to groundwater.
- Return contaminated shallow groundwater to its beneficial use within a reasonable time frame.
- Comply with State groundwater standards, including nondegradation standards.

- Prevent groundwater discharge containing arsenic and metals that would degrade surface waters.

3.1.1 Desired Post-remediation Condition

The desired post-remediation condition to meet ROD requirements includes the following characteristics:

- Human health risks have been addressed. Streambanks are stabilized until floodplain vegetation is established, after which erosion occurs at rates typical of the geomorphic setting.
- Overall trends in channel planform reflect a dynamic equilibrium condition (see Section 3.1.2 Performance Targets).
- The floodplain is largely uncontaminated by mine waste within the CMZ.
- The floodplain is reconnected to river hydrology, evidenced by overbank flows and frequencies and relatively shallow groundwater conditions.
- A mosaic of native riparian and wetland plant communities and age classes is present on the floodplain and in the riparian zone.

3.1.2 Performance Targets

This section describes performance targets established in two monitoring plans that have been developed for the CFROU. One plan, the *Interim Comprehensive Long-Term Monitoring Plan for the Clark Fork River Operable Unit* (Atkins, 2011), addresses surface water, groundwater, in-stream sediments, and aquatic biota including macroinvertebrates and fish. This plan provides a framework for monitoring the CFROU as remedial activities are implemented to evaluate the environmental effectiveness of these remedial actions. Specific performance targets have been developed for surface water and groundwater, but not for sediments and aquatic biota. Performance targets are described in detail in Atkins (2011).

A second plan, the *CFR Reach A, Phase 1 Geomorphology and Vegetation Monitoring Plan* (Monitoring Plan) (DEQ, 2012), provides a framework to evaluate physical- and vegetation-related components of the CFR and its floodplain that will be influenced directly by remedial actions. Effectiveness monitoring described in this plan will evaluate progress toward achieving project goals and objectives related to geomorphology and vegetation. The focus will be on collecting data that can be used to establish and measure performance targets for remedial activities.

Performance targets—values that indicate if the project is accomplishing goals and objectives—are presented in terms of monitoring metrics that have target ranges or values. Monitoring metrics are selected for their ability to measure, consistently and objectively, whether desired processes and functions are being achieved. Monitoring locations, schedules, and methods will be established in a site-specific monitoring plan to be developed for CFROU Reach A Phases 5 and 6, which will be similar to those in the Monitoring Plan for Phase 1. The following sections describe general performance targets and monitoring metrics for geomorphology and vegetation components.

3.1.2.1 Geomorphology Performance Targets

The two time frames used to evaluate geomorphology-related performance targets are as follows:

- Short-term (0 to 15 years): The short-term time frame incorporates channel and floodplain adjustments during the period of vegetation establishment. The objectives for this time frame focus on overall channel and floodplain stability.

- Long-term (after 15 years): The long-term time frame reflects normal channel processes within a revegetated, lowered floodplain condition that may include a higher level of dynamism typical of non-entrenched, unarmored river systems.

Specific monitoring metrics are shown in Table 12. The Monitoring Plan (DEQ, 2012) provides an in-depth discussion on how geomorphology performance targets were developed for Phase 1 and these values will be refined for Phases 5 and 6 before monitoring begins.

Table 12. Geomorphology Monitoring Metrics.

Objective	Monitoring Metrics
Channel Dimensions	• Cross-section area • Bankfull width • Bankfull depth • Width/depth ratio
Slope and Sinuosity	• Channel Slope • Sinuosity
Bank Erosion and Channel Migration	• Bank erosion rate • Channel migration rate
Floodplain Connectivity	• Bankfull discharge • Bankfull / bank height ratio • Floodplain inundation extent
Floodplain Stability	• Floodplain channel morphology (cross-section area, width, depth, slope, continuity)

3.1.2.2 Vegetation Performance Targets

The CFR Reach A Phase 1 Monitoring Plan describes how vegetation performance targets were developed based on four vegetation-related objectives: streambank vegetation, floodplain vegetation, noxious weeds, and wetlands (DEQ, 2012).

The time frames used to evaluate vegetation performance targets are as follows:

- Short-term (0 to 5 years) is the post-construction period when floodplain vegetation is immature and the site is being colonized by pioneer species.

- Mid-term (5 to 15 years) is the period when vegetation installed during project implementation has developed functioning root systems such that any maintenance irrigation is no longer required. In addition, the site is beginning to be colonized by plants originating from seed or other propagules coming from established plants, either on or off site. Mature vegetation is present but sparsely distributed throughout the site. Vegetation is becoming a primary factor in floodplain stability during this timeframe.

- Long-term (after 15 years) is the period when areas of mature vegetation are well distributed and self-sustaining on the floodplain, and the channel can migrate and change at normal rates without compromising project objectives.

Specific vegetation monitoring metrics and associated performance targets are shown in Table 13.

Table 13. Vegetation Monitoring Metrics and Associated Performance Targets.

Objective	Monitoring Metric	Performance Target Value
Streambank Vegetation	• Woody canopy cover	Short-term: 40% canopy cover on treated streambanks by year 5. Mid-term: 60% or greater canopy cover on treated streambanks by year 10. Long-term: Canopy cover varies with normal channel migration rates but is greater than 80%.
Floodplain Vegetation	• Plant survival and density • Woody canopy cover • Native canopy cover	Short-term: Native species comprise greater than 80% of the total vegetative cover. Total cover is greater than 20% by Year 1, 50% by Year 3, and 80% by Year 5. Average canopy cover of woody vegetation in the floodplain is 30% by Year 5. Planted woody species have 80% or greater survival after the first growing season and woody plant density is not decreasing in subsequent years. Mid-term: Native species comprise greater than 80% of the total vegetative cover. Total canopy cover is 80%, allowing for some bare patches of non-contaminated substrate deposition, and open water. Canopy cover of woody vegetation in the floodplain is 50% by Year 10. Long-term: The floodplain is composed of a mosaic of native riparian and wetland ecological types, non-contaminated depositional features, and open water that supports a full range of ecological functions and processes.
Noxious Weeds	• Weed canopy cover	Short-, mid-, and long-term: Less than 5% canopy cover of noxious weeds is present.
Wetlands	• Wetland delineation • Function Effective Wetland Area (FEWA)	Short-, mid-, and long-term: There is no net loss of wetlands meeting U. S. Army Corps of Engineers (USACE) criteria from pre-project conditions. After 5 years, the site meets the reference wetland FEWA score of 2.3 developed for the CFROU.

3.1.3 Design Concept Summary

The CFR floodplain in the project area is disconnected from the river's normal hydrologic regime due to a tailings-aggraded floodplain that does not allow overbank flooding until approximately the 5-year to 10-year event. The elevated floodplain has resulted in perching of the floodplain surface above groundwater, diminished rates and patterns of riparian succession, increased sediment recruitment from high streambanks (including re-entrainment of contaminants), and reduced floodwater storage. Removing contaminated materials, lowering the floodplain, and reconnecting the floodplain to the River's hydrologic regime are absolutely necessary if the Design is to achieve the ROD's goals and performance standards.

The design concept for Phases 5 and 6 calls for the removal of severely impacted areas, reconstruction of the floodplain after removal to its lower elevation within a range from near base flow to the 2-year WSE, and streambank and floodplain stabilization through revegetation.

The materials to be removed within Phases 5 and 6 are (1) those tailings-contaminated soils with metals concentrations exceeding 1,400 mg/kg for the sum of the COCs within the 100-year CMZ, (2) tailings-contaminated soils outside the CMZ with metals concentrations exceeding 1,400 mg/kg for the sum of the COCs where contamination depths exceed 2 feet, and (3) those tailings-contaminated soils with metals concentrations exceeding 620 mg/kg for arsenic. Removal of contaminated soils within the Channel Migration (buffer) Zone is necessary to reduce significant contaminant loading to the Clark Fork River through surface flows, establish healthy self-sustaining vegetation capable of stabilizing remaining contamination against wind and water erosion, and reduce input of COCs to groundwater and consequently the risks to human health and the environment. The removal of additional tailings-contaminated soils beyond the CMZ boundary supports strategies to reconnect portions of the floodplain with the river's hydrology, thus restoring normal floodplain function. Removing tailings and rebuilding a lower floodplain will increase areas of hydrologically connected floodplain and provide a shallower water table. This will make it possible to sustain a range of riparian and wetland plant communities and floodplain functions, which will in turn provide the necessary stability to the floodplain and streambanks.

Floodplain stabilization practices will be incorporated into the reconstructed floodplain surface and streambanks to enhance stability and help maintain existing channel form and pattern during the period of vegetation establishment. The 10-year flood event was used as the basis for establishing protective measures for short-term stability of the floodplain surface. Proposed measures utilize redundant stabilization methods, which include strategic floodplain grading, enhanced floodplain roughness, incorporation of coarse substrate, and bioengineered streambank reinforcements. Over the long term, the objective will be dynamic stability, where the river channel and floodplain will be expected to effectively convey incoming water and sediment loads, shift spatially in response to natural disturbances, and maintain a balanced distribution of age classes and plant communities within a shifting floodplain mosaic. This dynamic stability will be supported through the recovery of a self-sustaining, robust riparian corridor on the reconstructed floodplain surface.

Floodplain surfaces will be constructed to support natural recruitment of willows and other riparian and wetland plant species. This will be achieved by using substrate with appropriate texture given geomorphic position, and by building surfaces at elevations that provide access to the water table during the growing season and are subject to surface flows during flood events

that bring nutrients and sediment to support floodplain vegetation growth. Planting of the floodplain and streambanks will occur in areas where plants have a high likelihood of survival. These locations include low areas such as wetlands and constructed swales, and within bioengineered streambank structures constructed of coir, which has high water-holding capacity. Plant communities are designed to correspond closely with geomorphic surfaces; for example, different plant communities will develop on point bar surfaces vs. wetlands due to differences in substrate, shear stress, groundwater elevation, and ground surface elevation.

Streambank stabilization treatments along passive margins, transitions, and portions of outside bends will consist of a series of bioengineered streambank stabilization practices that correspond to their geomorphic position, vegetation composition, and degree of contamination. Actively eroding banks on outside bends in the vicinity of avulsion paths will be reinforced and super-elevated to reduce the frequency of overbank flooding while vegetation reestablishes on the adjacent floodplain. Banks with existing robust woody vegetation will be preserved to the extent possible. Passive margins will be preserved or redeveloped as point bars. A suite of bank reconstruction and revegetation treatments will be applied that correspond to these different bank conditions and planform locations. Bank treatments use a combination of locally salvaged wood, biodegradeble materials, alluvial backfill, and live plant material such as willow cuttings.

Other activities to be conducted in support of the remedial action include dewatering, road construction, and borrow area development and reclamation. Dewatering is needed to facilitate removal of tailings from the floodplain and to control surface water runoff. Temporary roads that will be constructed for hauling tailings and borrow materials will be reclaimed at the end of the project unless otherwise requested by the landowner. The borrow area will also be reclaimed and revegetated after removal of the borrow materials. Best management practices (BMPs) will be implemented to control erosion during construction.

The remedial action implementation process, criteria developed to implement this design concept and analyses of the proposed design are presented in the following sections.

3.2 Remedial Action Process

This section builds on the previous sections and describes the process by which Phases 5 and 6 remedial action will then be determined. The steps in the Phases 5 and 6 process, explained in the sections below, include:

1. Identify areas within the floodplain where contaminated soils are present. Contaminated soils are denoted as soils where the sum of COCs (arsenic, cadmium, copper, lead, and zinc) is greater than or equal to 1,400 parts per million (ppm [measured as mg/kg]).
2. Identify the CMZ, which is defined as the portion of the floodplain that demonstrates a high potential for contaminant recruitment over the next century, either through bank erosion or channel avulsion processes. All contaminated soils will be removed within the CMZ, except for areas where historic structures, cultural resources, locally rare vegetation communities, or stabilizing bank vegetation exists.
3. Identify areas outside the CMZ where the depth of contaminated soils is greater than or equal to 2 feet. Within these areas, all contaminated soils will be removed, except for

areas where historic structures, cultural resources, or locally rare vegetation communities exist.

4. Identify remaining areas outside the CMZ where the arsenic concentration exceeds the cleanup level of 620 mg/kg (as determined by the land use). Within these areas, all contaminated soils will be removed, except for areas where historic structures, cultural resources, or locally rare vegetation communities exist.
5. All areas will be evaluated to determine if Institutional Controls (ICs) or BMPs are needed to address future potential contaminant pathways.

3.3 Components of the Decision Process

This section provides definitions and descriptions of the different components within the decision process.

3.3.1 Floodplain Areas with Contaminated Soils

Contaminated soils are denoted as soils where the sum of the COCs (arsenic, cadmium, copper, lead and zinc) is greater than or equal to 1,400 mg/kg or where arsenic exceeds 620 mg/kg in surface soils.

3.3.2 Channel Migration Zone

Direct recruitment of tailings via bank erosion has been shown to be a significant source of metals loading in Reach A. To address these threats a CMZ is identified which defines a corridor near the river that is at risk of continued direct entrainment of contaminants by fluvial processes. The CMZ is defined by evaluating historical rates of change for geomorphically similar reaches of the CFR. A yearly erosion rate is determined for each eroding bank, and the 90th percentile migration rate value per year for all measurements is then extrapolated to a 100-year migration distance, which is expressed as an erosion buffer measured from the current location of the streambank. This buffer, specific to each phase, will be applied to the recent banklines on both banks to allow for future channel movement resulting from bendway migration, bendway compression, and stochastic processes such as woody debris lodging and associated channel movement. Based on historical analysis, this buffer is anticipated to accommodate the vast majority of channel movement via lateral bankline migration over the next century, thereby reasonably addressing the risk of entrainment due to incremental bank erosion. The application of a consistent buffer width to both active and passive channel margins allows for new bendway development over the next century that would not be captured by near-term migration trends.

In addition to channel migration processes, tailings recruitment can also occur due to channel avulsion, or rapid relocation of the channel into a new thread. Avulsions are most common across bendway cores where elevations are low and floodplain channels are present. Avulsion paths are included within the CMZ where they extend beyond the erosion buffer. Collectively, the lateral migration entrainment risk (bank migration buffer) and avulsion entrainment risk (avulsion paths) effectively define the meander belt that is at demonstrable risk of alluvial turnover during the next century.

3.3.3 Contamination Depth Greater than or Equal to 2 Feet

Within the project area for each Phase, test pits are excavated and soil contamination is characterized according to methods described in Sampling and Analysis Plans completed for each phase. Depth of contaminated soils is identified in each test pit based on sample results taken from 6-inch intervals along the profile of the test pit. All test pits with contaminated soils present to depths of 2 feet or deeper outside the CMZ are identified.

3.3.4 Locally Rare Vegetation Communities

Locally rare vegetation communities include all mature cottonwood stands and wetlands with high native diversity. Areas with patches of mature cottonwoods (*Populus balsamifera ssp. trichocarpa*) will be preserved regardless of contamination depth and location relative to the CMZ. Cottonwoods are rare in the CFR floodplain in Reach A upstream from Deer Lodge, so these mature stands provide habitat and seed sources that would take 25 to 50 years to replace with newly planted or naturally recruited trees. Areas outside the CMZ that have wetland characteristics and are dominated by native species may be left intact even if contaminated soils are 2 feet deep or deeper if they are sites of locally rare and high-value vegetation communities. An area has wetland characteristics if it is hydrologically connected to the river (elevation is at or below 0.5 feet above the 2 year WSE).

3.3.5 Arsenic Cleanup Level

The land use and corresponding maximum arsenic concentrations requiring remedial action are shown in Table 14 below as identified in the ROD (USEPA/DEQ, 2004; pages 2–39).

Table 14. Maximum Arsenic Concentrations by Land Use

Land Use	Concentrations
Residential	150 ppm
Recreational	680 ppm (children at Arrowstone Park and other recreational scenarios)
	1,600 ppm for fishermen, swimmers, and tubers along the river
Rancher/Farmer	620 ppm

3.3.6 Waste Removal and Over-excavation

Contaminated soils will be removed as described above, with an additional 6 inches of over-excavation. Over-excavation is a common construction practice. The 6-inch over-excavation is included to account for the inherent variability within the floodplain where tailings were deposited and practical limitations with regard to characterization. Contaminated soils that are removed will be hauled for disposal to the Opportunity Ponds waste management area. As projects are implemented, the need for over-excavation will be re-evaluated, and this step may be reduced or eliminated depending on the results of this evaluation.

3.3.7 Evaluation of Institutional Controls and Best Management Practices

Prior to completion of Remedial Action, all areas with remaining tailings/impacted soil will be evaluated to determine whether ICs or BMPs are needed to address potential future contaminant pathways. ICs include the following:

- Deed restrictions and/or county zoning regulations to prevent land use changes or future residential development where contamination is left in place
- Groundwater use controls to prevent use or domestic consumption of contaminated groundwater until groundwater cleanup levels are obtained
- Education Program
- Best Agricultural Management Practices where contamination is left in place
- Maintenance and Monitoring

3.3.8 Restoration in lieu of Remedy

No State Restoration in lieu of Remedy is included in the design.

3.4 Application of Project Remedial Action Decision Process

3.4.1 Extents of Contamination

Areas within the floodplain where contaminated soils are present were identified during site characterization, and the results are included in the DSR (TerraGraphics, 2012a). Contaminated soils where the sum of COC concentrations is greater than or equal to 1,400 mg/kg are shown on the Test Pit Depth of Contamination Maps, TP1 through TP 5 in Appendix C.

3.4.2 Channel Migration Zone Analysis

The 100-year bank migration buffer and avulsion pathways were identified and combined to develop the CMZ for the project. This combination of bank migration and avulsion pathway erosion addresses the risks of contaminant entrainment for the vast majority of channel movement and floodplain erosion over the next century. Bank migration and avulsion pathway analyses for this site are discussed below. The CMZ removal boundary for this site is shown on Figure 16.

3.4.2.1 Bank Migration

Bank migration was measured on all banklines that displayed in excess of 20 feet of movement since 1947. Vectors were collected at approximately 20-foot station frequencies on eroding banks to capture the range of migration distances expressed at a given site. A total of 99 measurements were collected, and each migration vector was attributed by length. Summary results of these measurements are listed in Table 15.

Table 15. Results of Migration Rate Analysis

		Phase 5	Phase 6	Total
Number of Measurements		57	42	99
1947–2009 Migration Distance (ft)	Mean	32.9	35.3	33.9
	90th Percentile	50.8	54.6	52.0
	Maximum	64.0	74.0	74.0
1955–2011 Migration Rate (ft/yr)	Mean	0.5	0.6	0.5
	90th Percentile	0.8	0.9	0.8
	Maximum	1.0	1.2	1.2
100-Yr Migration Distance (ft)	Mean	52.3	56.0	53.9
	90th Percentile	80.6	86.7	82.5
	Maximum	101.6	117.5	117.5
Basis of Buffer Selection				90th Percentile 100-Year Migration Distance (ft)
100-Year Migration Buffer				**83 ft**

The mean measured migration rate in Phases 5 and 6 is 0.5 feet/year (ft/yr). In developing a bank migration buffer, the 90th percentile migration rate value for all measurements (0.8 ft/yr) was extrapolated to a 100-year migration distance. This resulted in an 83-foot-wide 100-year bank migration buffer that was applied to the digitized 2009 banklines on both banks.

3.4.2.2 Avulsion Pathways

Because contaminated areas were present within all avulsion pathways, all bendway cores were included with the bank migration buffer to delineate the CMZ.

3.4.2.3 Historic Structures and Cultural Resource Preservation Areas

Only one historic cabin was observed on the site within the removal boundary; it will be protected in place.

3.4.2.4 Mature Black Cottonwoods

Two stands of mature black cottonwoods were identified within the CMZ. Preservation areas are discussed in further detail in Section 3.10.4. No preservation is necessary where removals occur outside the CMZ because no mature black cottonwoods were identified in those areas.

3.4.3 Contamination Depth Greater than or Equal to 2 Feet

Depth of contamination was identified in each test pit based on sample results taken from 6-inch intervals along the profile of the test pit. Sample results showing contamination in the 18-inch to 24-inch interval represent a contaminated depth equal to 2 feet. The areas between test pits with contamination equal to or greater than 2 feet and test pits with contamination less than 2 feet were delineated using an inverse distance weighted interpolation algorithm. The resulting polygons represent the plan extents of removals for all contamination equal to or greater than 2 feet in depth and are shown on Figure 17. These areas were overlain upon the CMZ and any areas outside the CMZ were added to the removal boundary. No mature black cottonwoods or wetlands with high native diversity were found outside the CMZ with tailings depths equal to or greater than 2 feet. The resulting removal boundary included all test pits with contamination greater than or equal to 2 feet in depth as indicated by the sum of the COC values exceeding 1,400 mg/kg at the site.

3.4.4 Arsenic Contaminated Areas

Phases 5 and 6 encompass the reach of river through Dry Cottonwood Creek Ranch, currently operated as part of a 2,300-acre working cattle ranch. As such, the rancher/farmer land-use scenario's action level for arsenic in soil is 620 mg/kg. After identification of the preliminary removal boundary based on the combination of contamination within the CMZ and contamination greater than 2 feet outside the CMZ, the remaining test pits exterior to this area were evaluated for arsenic concentrations using soil samples from the top 12 inches. Only laboratory results for arsenic were evaluated and no XRF arsenic readings were used. Most of the surficial arsenic results exceeding 620 mg/kg were captured in the combined CMZ and Contamination Greater than 2 Feet preliminary removal boundary. Of the test pits remaining outside this preliminary removal boundary, four areas were identified with an average arsenic concentration exceeding 620 mg/kg as shown on Figure 18 and Figure 19. These four areas were identified because each encompassed an exposure area of nearly an acre or more for a total of 5 acres, and two or more test pit surface soil arsenic results exceeded 620 mg/kg (only the 0–2 or 0–6 inch sample results were included in the calculation of an average surface soil concentration). The observed arsenic results for the 6–12 inch depth within these areas were generally below the 620 mg/kg action level.

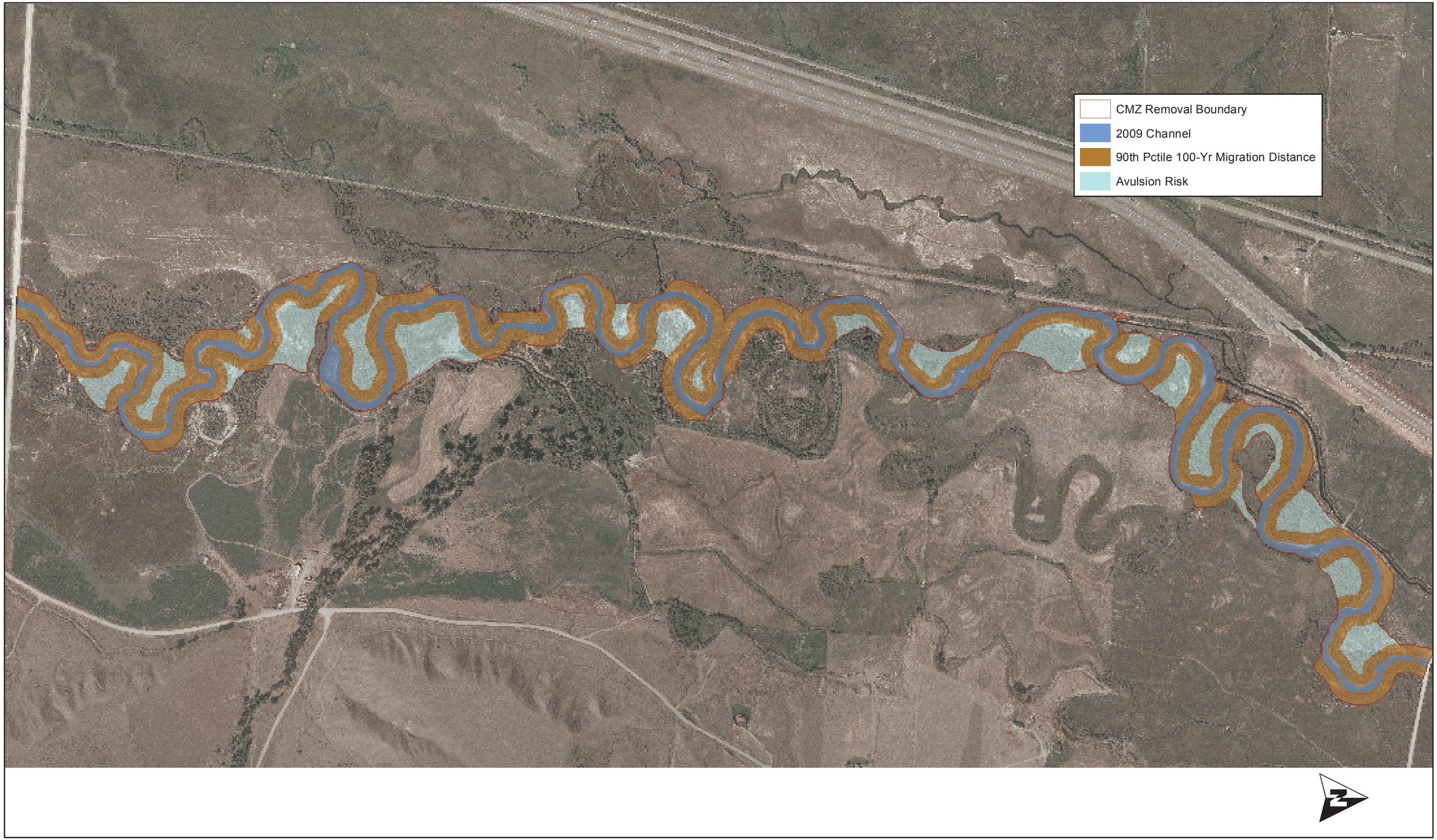
In addition to the four areas discussed above, eight individual test pits with surface arsenic concentrations exceeding 620 mg/kg exist adjacent to the preliminary removal boundary: Phase 6: Pits 235 and 004; Phase 5: Pits 504, 353, 312, 268, 299, and 815 (Figure 18 and Figure 19). However, these are individual test pits and results from other adjacent test pits are below 620 mg/kg. These results do not form an exposure area with multiple contaminated test pits and multiple sample results averaging greater than 620 mg/kg. Consequently these particular test pits are not included within the removal boundary.

3.4.5 Feasibility of In-Situ Treatment for Arsenic Exceedances

In-situ treatment is not deemed cost-effective for the arsenic exceedances due the relatively small areas of arsenic contamination in the vicinity of larger areas designated for removal. Additionally, due to the proximity of groundwater to the treatment elevation, these areas would likely be saturated or partially saturated during remedial actions, thereby making *in-situ* treatment unimplementable. Soils in areas where arsenic contamination exceeds the land-use scenario's action level will be removed.

3.4.6 Institutional Controls

Contamination will remain at this site upon completion of Remedial Action, including remedial action related to this Preliminary Design Plan. ICs will be evaluated upon completion of Remedial Action to address future potential contaminant pathways.



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File: AGI_Phase_5_6_Fig_17_CMZ	Projection: NAD83 MT State Plane Feet	Project Name: Clark Fork River Operable Unit Phases 5&6	This map was produced using information obtained from several different sources that have not been independently verified. These sources have also not provided information on the precision and accuracy of the data. Information on this map is not a substitute for survey data.
Print Date: April 26, 2013	Project Manager: Matt Culpo/J. Mickey		
Project Number: 10074-3 MDEQ CRF Investigation - TO #26	Cartographer: Karin Boyd		

1:7,410
1 inch = 617 feet
0 500 1,000 Feet

Figure 16
100-Year Channel Migration Zone Removal Boundary

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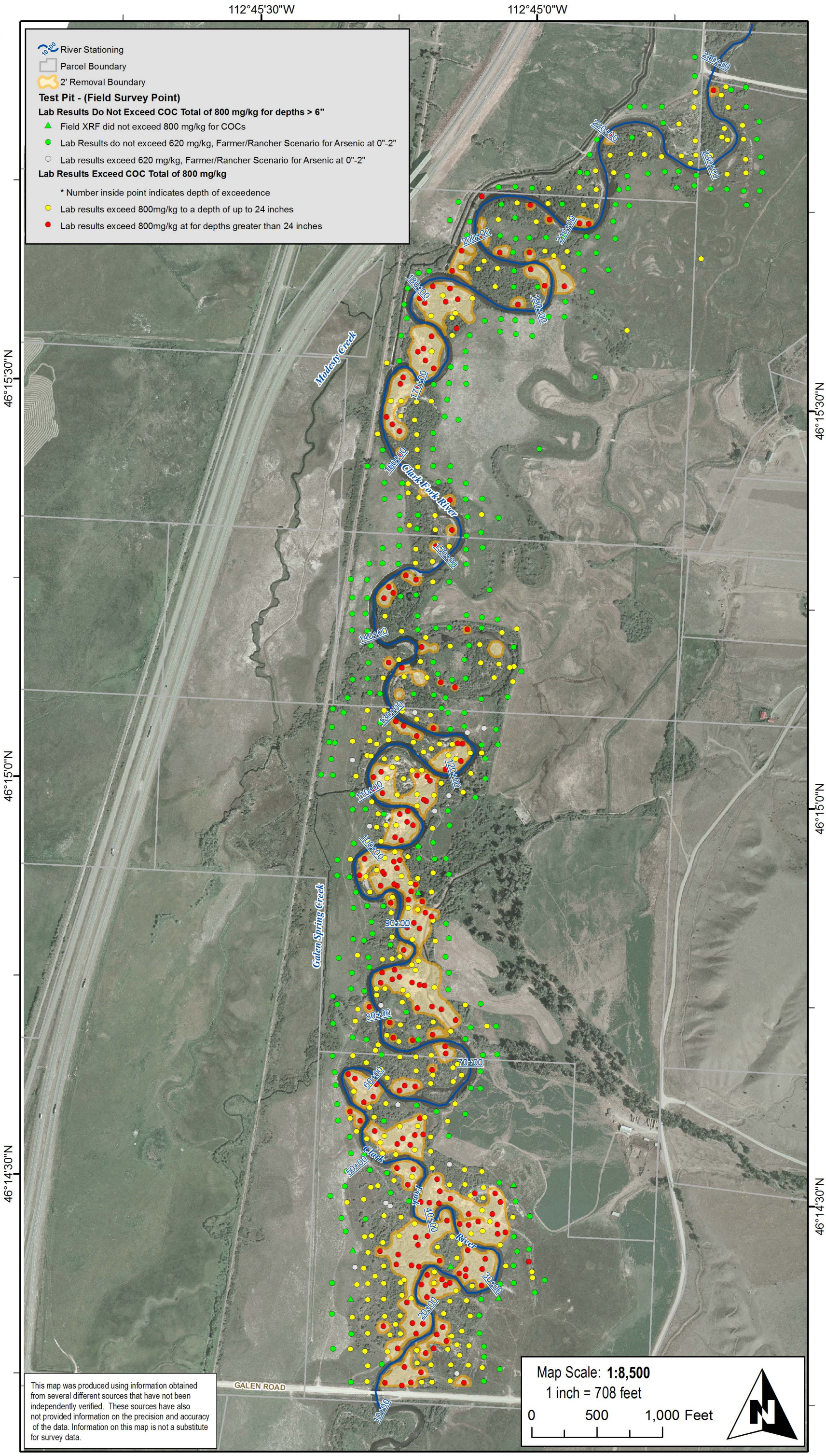

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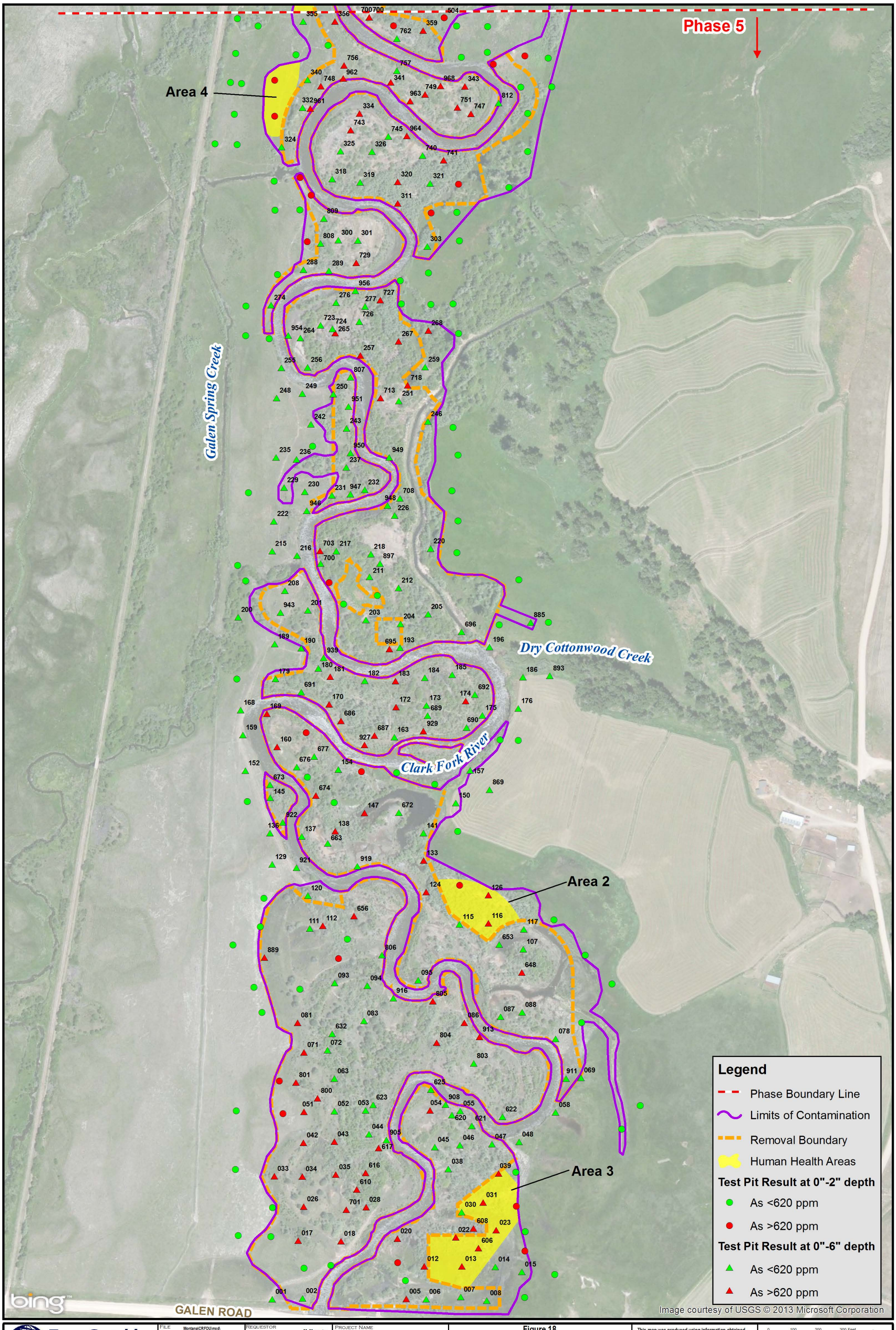
TerraGraphics Environmental Engineering, Inc. www.TerraGraphics.com	File: Montana\CFROU\mxd\2C_20130419	Map Projection: NAD83 UTM12N	Project Name: Clark Fork River Operable Unit Phases 5 & 6 Part 1, Floodplain Investigation	Figure 17 Contamination Depth Greater than 2ft Map (2011 Aerial Image)
	Print Date: July 29, 2013	Project Manager: M. Culpo		
	Project Number: 10074-3 MDEQ - CFR Investigation - TO #26	Cartographer: B. Bailey		



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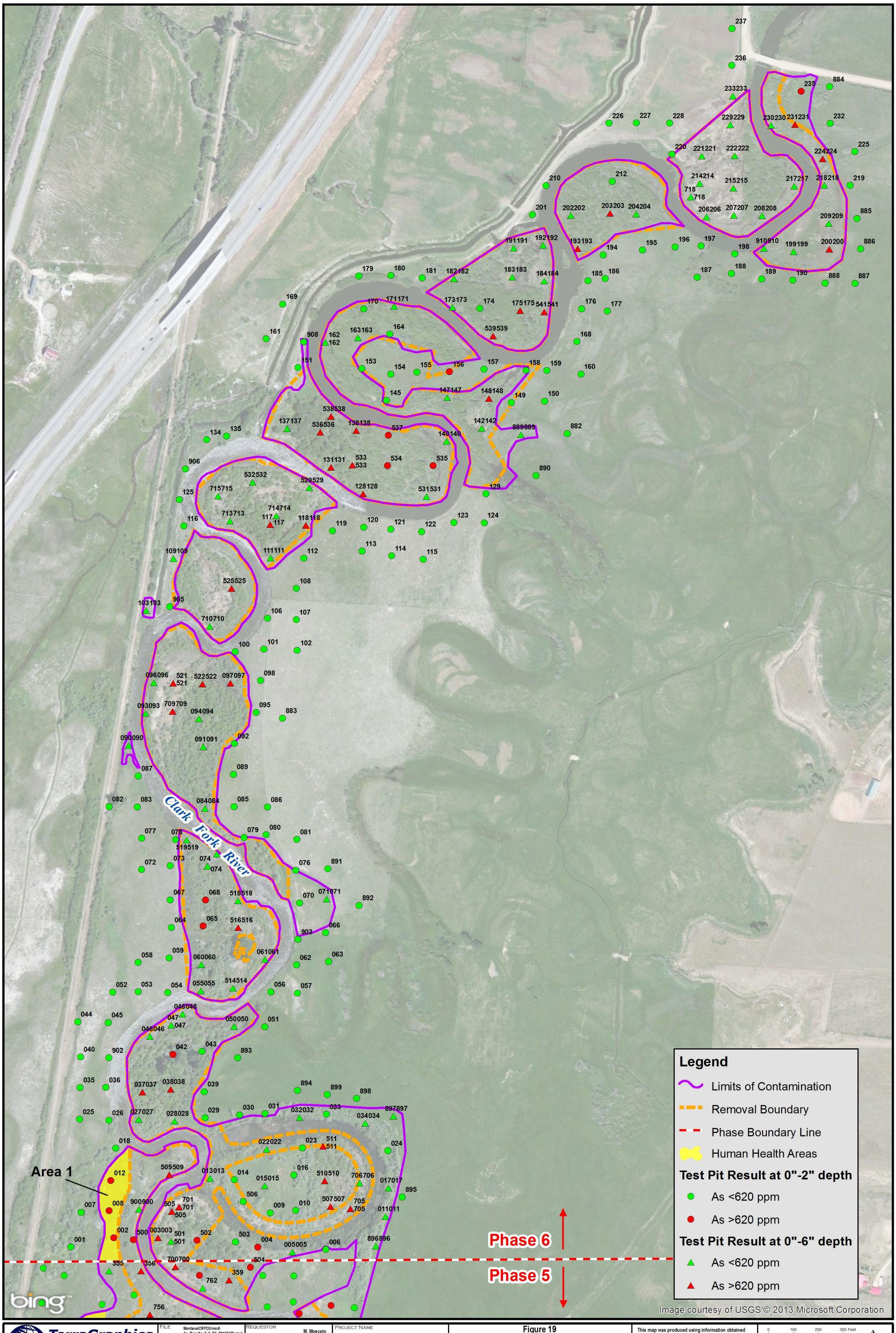
File	Montana\CRFOU\mxd\As_Results_2_6_P5_20130419.mxd	Requestor	M. Moscato
Print Date	July 29, 2013	Project Manager	S. Spalinger
Project Number	10047	Cartographer	B. Bailey

Project Name: Clark Fork River

Figure 18
Clark Fork River Phase 5 Test Pits
Total Arsenic Laboratory Results
0 - 2" and 0 - 6" Depths

This map was produced using information obtained from several different sources that have not been independently verified. These sources have also not provided information on the precision and accuracy of the data. Information on this map is not a substitute for survey data.

0 100 200 300 Feet
1 in = 333 ft
Scale = 1:4,000
Projection: NAD 83 Montana State Plane



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File	Montana\CRFOU\mxd\As_Results_2_6_P6_20130108.mxd	Requestor	M. Moscato
Print Date	July 29, 2013	Project Manager	S. Spalinger
Project Number	10047	Cartographer	B. Bailey

Project Name: Clark Fork River

Figure 19
Clark Fork River Phase 6 Test Pits
Total Arsenic Laboratory Results
0 - 2" and 0 - 6" Depths

This map was produced using information obtained from several different sources that have not been independently verified. These sources have also not provided information on the precision and accuracy of the data. Information on this map is not a substitute for survey data.

0 100 200 300 Feet
1 in = 333 ft
Scale = 1:4,000
Projection: NAD 83 Montana State Plane

3.4.7 Project Removal Depth, Area, and Volume

Application of the decision process to this project resulted in a removal boundary for Severely Impacted Areas within Phases 5 and 6. The removal boundary is shown on Excavation Plan, Sheets 9 though 12 of the Preliminary Design Plans contained in Appendix E. Table 16 presents a summary of removal quantities. Depths were estimated based on excavation exit criterion of 1,400 mg/kg combined COCs benchmark and 6 inch over-excavation. The Phase 5 and 6 estimated total area and volume of contaminated soils are 147 acres and 488,000 cubic yards, respectively. The Phases 5 and 6 estimated remedial action removal area and volume are 114 acres and 402,000 cubic yards.

Table 16. Summary of Contamination and Removals

Contamination Category Descriptions	Area and Volume	
Total Contamination Area	147	acres
Total Contamination Volume	488,000	cubic yards
Removal Area	114	acres
Removal Volume	402,000	cubic yards

3.5 Floodplain Treatment Criteria

The 2-year flow event was used as a criterion for the onset of overbank flooding, and the floodplain will be designed for stability up to the 10-year event. The reconstructed floodplain surface after removal is designed to inundate 30 percent of the 100-year floodplain during a 2-year flood event. Within the excavation boundary, design floodplain elevations vary from approximately 2.5 feet below the 2-year WSE to about 0.5 feet above the 2-year WSE, depending on geomorphic location. Elevations of the floodplain along the streambanks vary from 1 foot above base flow to about 0.5 feet above the 2 year WSE. To reduce the frequency and duration of overbank flooding on outside bends or along overland flow routes, avulsion paths, and bendway cores, the floodplain elevation is graded up to the higher end of the elevation range in these areas. In more passive areas, floodplain grading elevations are lower to capitalize on opportunities for habitat diversification. This configuration provides a balance between short-term and long-term stability, which will allow for reestablishment of riparian vegetation as well as long-term deformability.

The following design criteria were applied to the various geomorphic features of the floodplain and incorporated into the flood treatments:

Floodplain Topography – General shaping of the floodplain surface will convey overland flows in excess of the 2-year event. Shaping will also be designed to convey water from off-site sources such as groundwater seepage or surface runoff and to store water in passive areas along the river or in depressions outside the CMZ. The following are included in floodplain grading.

- Construct slopes that range from flat to a maximum slope of 10 horizontal to 1 vertical (10:1) except at the edge of the removal boundary where the slope may approach 3:1.
- Grade identified potential avulsion paths to prevent channelized flow and promote sheet flow or divergent surface flow conditions.
- Super-elevate the top of banks on outside bends to 0.5 feet above the 2-year WSE, and grade a wide, flat surface on the meander tab behind.

Microtopography – Small depressions and ridges throughout the floodplain will provide erosion resistance, promote sediment sorting, and enhance sediment and seed trapping for plant establishment and a source of organic material. Following are plans for integration of micro-topographic features in the floodplain surface.

- Construct small furrows and ridges throughout the floodplain, varying up to plus or minus 0.5 feet.
- Include some larger depressions (swales) up to 0.25 acres, at least 30 feet from the main channel and in passive areas. Swales are between 1.0 and 2.5 feet deep relative to the adjacent ground surface.
- Install containerized native plants in swales within the Floodplain Riparian Shrub cover type.

Buried and Partially Buried Woody Debris – Salvaged willows and birch cut above ground from within the removal boundary will be partially buried on the floodplain or buried within reconstructed streambanks. This will reduce velocities at the soil/water interface on the floodplain and increase the stability and complexity of reconstructed banks. Both buried and partially buried wood can trap sediment and other woody debris, ultimately degrading as long-term stability is achieved.

Avulsion Paths – Bendway cores that show potential for post-remedy bendway cutoff through either the presence of developing chutes under existing conditions or relatively high ratios of channel length to avulsion path length will be addressed using the following techniques.

- Grade outside bend banklines to 0.5 feet above the 2-year WSE where avulsion risk is identified to reduce frequency of overbank flow across bendway core.
- Broadly grade bendway cores to promote overbank sheet flow versus flow concentration through swale features.
- Include microtopography (described above) through bendway core and potential avulsion path. Concentrate buried wood to increase roughness through bendway core.
- Incorporate coarse alluvial backfill on bendway core to reduce erosion potential and inhibit formation of an avulsion path.

Wetlands – Larger areas set outside the CMZ will be saturated either seasonally or permanently. These areas will support hydrophytic plants and will in time develop hydric soils. Plans for wetland construction include the following elements.

- Construct wetland areas ranging in size from 0.25 to 1 acre.
- Slope wetland margins to a maximum slope of 10:1 or flatter when possible.
- Construct wetlands to intersect the groundwater table for at least part of the year, with a bottom elevation approximately equal to that of the adjacent river base flow.
- Construct wetlands that imitate natural features such as oxbows or abandoned channels and include irregular shapes and variable depths.

Gravel Alluvium – Alluvial soil ranging in size from sand to 10-inch cobbles, from on-site borrow sources to be used as base material in floodplain reconstruction, will provide resistance to overland flow erosion and enhance natural recruitment of floodplain sediment and seeds. Alluvium will be placed according to the following.

- Place alluvium on the floodplain surface where erosion risks are elevated through potential avulsion paths. Apply on-site alluvial material that is resistant to erosion under channel shear stress conditions up to the 10-year event.
- Place alluvium at elevations ranging from approximately base flow up to about the 2-year WSE.
- Alluvium placed on the floodplain surface as an erosion-resistance measure will be up to 1 foot deep and underlain by either gravel or fine-grained material.
- Place alluvium in passive locations where depositional and colonizing depositional cover types exist.

Vegetative Backfill – Vegetative backfill is fine-grained alluvial soil obtained from on-site borrow sources, generally found from existing grade to 3–6 feet below grade, ranging in texture from loamy clay, silt, or sand to loam and containing organics. This material is intended to support plant growth because it will retain nutrients and water and promote capillary rise of about 2 feet or greater (McCarthy, 1988). Vegetative backfill will be placed according to the following.

- Vegetative backfill may be placed on the surface where stability risks are low, such as passive margins and wetlands and at elevations above the 2-year WSE.
- Vegetative backfill may be placed over gravel alluvium or, for the full depth of the reconstructed floodplain, from the bottom of excavation to the finished grade.
- The depth of placement will range from 12 inches to 24 inches depending on the vegetation cover type.

3.6 Streambanks Treatment Criteria

Existing streambanks are divided into three treatment groups: Group 1 (point bars), Group 2 (banks capable of supporting short-term planform stability) and Group 3 (banks not capable of supporting short-term planform stability). Short-term planform stability is necessary so floodplain vegetation has enough time to become established and begin providing erosion resistance and roughness during flood events. After this establishment period, increased lateral bank movement is acceptable because this supports the long-term project objective of a dynamic river and floodplain environment that supports a shifting mosaic of geomorphic features and associated riparian vegetation communities. In addition to the three groups, which cover most streambank treatment scenarios, some banks require special treatment to protect infrastructure, some areas have split flow conditions, and other areas require no treatment. Figure 20 is a decision pathway that provides criteria for assigning a bank to one of the three treatment Groups or other categories. Example treatments are shown in Figures 21 through 24.

The decision pathway shown in Figure 20 addresses the following scenarios:

If infrastructure is present, adjacent banks or banks approaching infrastructure (particularly bridges) will be treated to provide stability as needed. Typical infrastructure includes irrigation diversions, roads, bridges, or utility crossings.

Areas with high risk of avulsion are present in project reaches as shown on Figure 25 and Figure 26. Where banks are located at the potential return point of an avulsion path, these banks are at risk of head cutting during a flood event, and this has the potential to compromise short-term planform stability. These potential avulsion return points are assigned to Group 3 where banks are reconstructed to support short-term planform stability.

If the avulsion risk described above is not present, streambanks are evaluated for the presence of contaminated sediments in the adjacent floodplain, using soil pit data described in Section 2.5. If no contamination is present in the adjacent floodplain, for example where the river is migrating into a terrace that is above the elevation where contaminated sediments deposited, no streambank treatment is needed.

If contaminated sediments are present in or adjacent to the bank and the bank is a depositional feature such as a point bar or is located where a depositional feature should form, the bank is assigned to Group 1.

If the bank is not a point bar, and it is at a split flow feature such as an island or entrance to a secondary channel, it may receive a bifurcation treatment, which will vary depending on the specific site conditions and associated risks.

If the bank is not located at a split flow feature, it is evaluated for its ability to support short-term planform stability. Examples of banks that are not capable of providing short-term planform stability include outer meanders with high rates of lateral movement, some banks along straight reaches with unstable toe materials or limited vegetation, and avulsion return points as described above. These banks are assigned to Group 3.

Group 3 banks are split according to whether stable toe materials are present (stable toe materials are able to withstand forces associated with a 10-year flow). If existing toe materials are stable, the upper bank is constructed on these existing materials; otherwise, a stable toe is constructed as part of the bank treatment.

If banks are capable of supporting short-term planform stability the bank is in Group 2. Short-term planform stability assumes that a stable toe is present. These banks may be located in a position along the planform where hydraulic stresses are not causing the banks to erode, such as well-vegetated streambanks and passive margins.

Group 2 banks are split according to whether stabilizing woody vegetation is present on the bank. Stabilizing woody vegetation is defined as at least 50 percent cover of willows or birches growing from between base flow and the 2 year WSE, with gaps less than 10 feet between woody vegetation along the bank. Where the bank contributes to planform stability and supports woody vegetation that can be preserved with adjacent tailings removal, the vegetation will be preserved. Upper-bank woody vegetation may also be supplemented, and the upper bank may be reconstructed, depending on site characteristics.

If stabilizing woody vegetation is present, that vegetation will be preserved, and the bank treatment will focus on tying the reconstructed floodplain surface to the existing vegetated bankline. If stabilizing woody vegetation is not present, is sporadically present, or is present only in the lower portion of the streambank (1 foot below the 2 year WSE or lower), the bank treatment will include preserving the toe and lower bank and reconstructing the upper bank. These treatments would include a live vegetation component incorporated in the upper bank.

There may be some banks that are predominantly Group 2 but have small sections of unstable toe or bank material. These banks may be classified as Group 2 or Group 3 during the final design process, depending on whether the design team perceives a risk to short-term planform stability

Once the banks have been categorized into the groups or other categories as shown in Figure 20, the design criteria in Table 17 are applied. Example treatment details from CFROU Draft Final Phase 1 Remedial Action Construction Plans dated May 2012 (CDM Smith 2012) are shown in Figures 21 to 24.

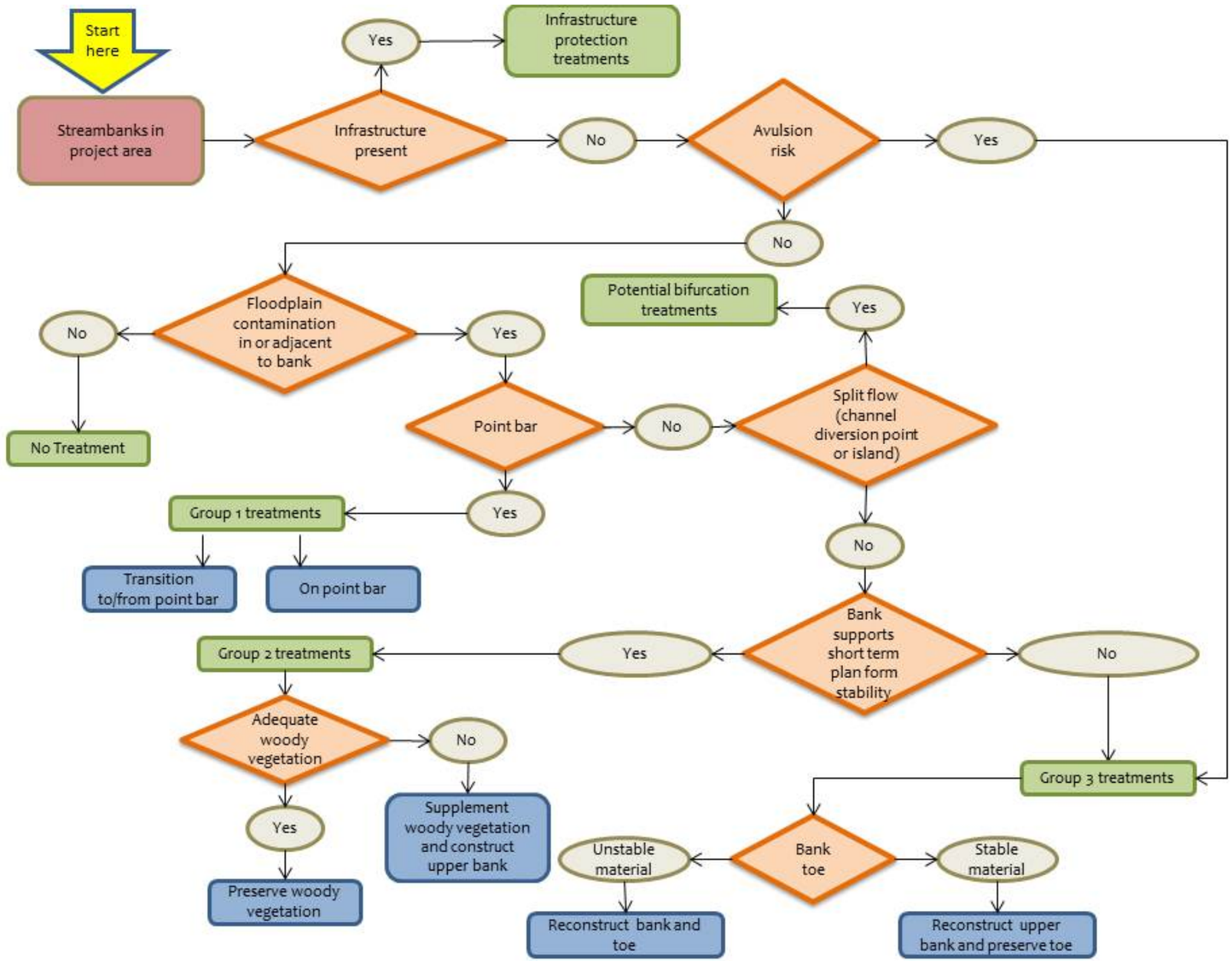


Figure 20. Streambank Decision Pathway

Table 17. Streambank Design Criteria for Contaminated Banks

Streambank Treatment Category	Design Intent	Design Bank Height	Toe Design	Bank Design	Sub-groups	Example Treatments
Group 1 Figure 21	Define point bar shape; transition to Group 2 treatments; provide appropriate substrate for willow and cottonwood recruitment	Base flow to 0.5 ft below 2 year WSE	No toe treatment – Placed material gradation is subject to floodplain stability criteria	Point bar shaping and possible revegetation	Transition to/from point bar	1-Brush Trench
					On point bar	2-Point Bar Regrading
Group 2 Figures 22 and 23	Preserve existing stable planform while floodplain vegetation establishes; tie banks to floodplain remediation; define upper bank where needed; preserve existing woody vegetation where present	0.5 ft below to 0.5 ft above 2 year WSE	Existing toe material is stable and will not be replaced	Reconstruct portion of bank above stable toe or existing lower bank vegetation; preserve existing woody vegetation if present	Woody vegetation present on lower and upper bank	2-Preserve Vegetation
					Woody vegetation either not present or only present on lower bank	1-Willow Cutting Behind Bank 1-Single Vegetated Soil Lift 2-Single Vegetated Soil Lift, Gap in Bank Vegetation
Group 3 Figure 24	Support stable planform while floodplain vegetation establishes; preserve existing functional bank toes; tie banks to floodplain remediation	0 to 0.5 ft above 2 year WSE	Toe material either preserved or sized for 10-year flood event	Reconstruct entire bank using biodegradable materials and live vegetation; construct stable toe if needed	Toe is stable	1-Double Vegetated Soil Lift
					Toe is not stable	2,1-Double Vegetated Soil Lift with Bank Toe Protection Construction
Bifurcation	Define side channel entrance or island shape while vegetation establishes	Variable	Toe material either preserved or sized for 10-year flood	Depends on type of split flow situation	No sub-groups	-Woody debris jam -Single Vegetation Soil Lift -Brush Trench -Double Vegetation Soil Lift with or without toe -Other as appropriate for situation
Infrastructure Protection	Protect infrastructure	Variable	Toe material sized to provide appropriate duration of stability	Bank construction materials protect infrastructure with appropriate duration	No sub-groups	-Rip-rap or other permanent stability treatment
No Treatment	Allow recruitment of sediment from uncontaminated banks where it will not conflict with planform stability objectives for Group 2 and Group 3 banks	Existing	No toe treatment	No bank treatment	No sub-groups	None

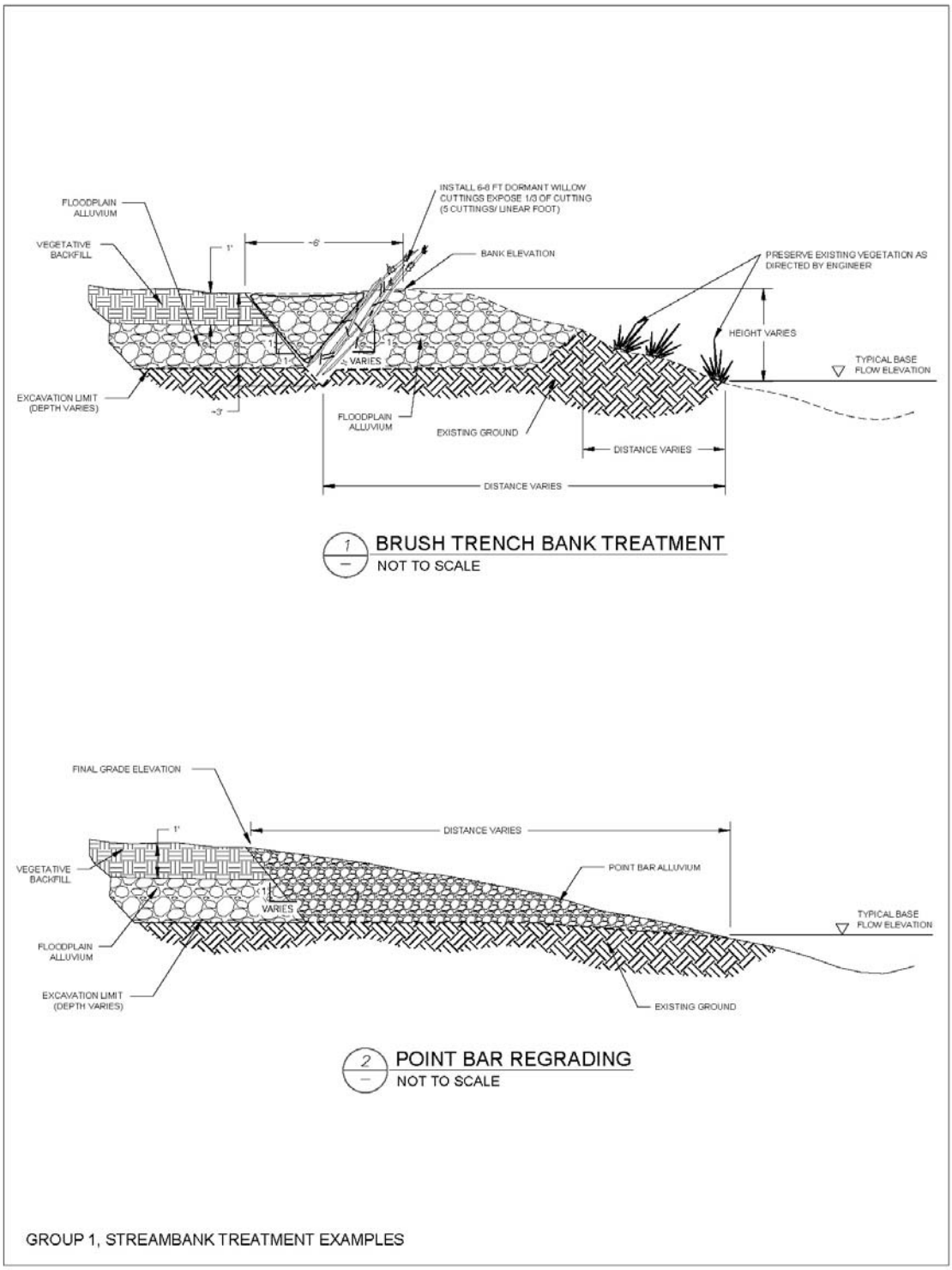


Figure 21. Streambank Treatment Examples, Group 1

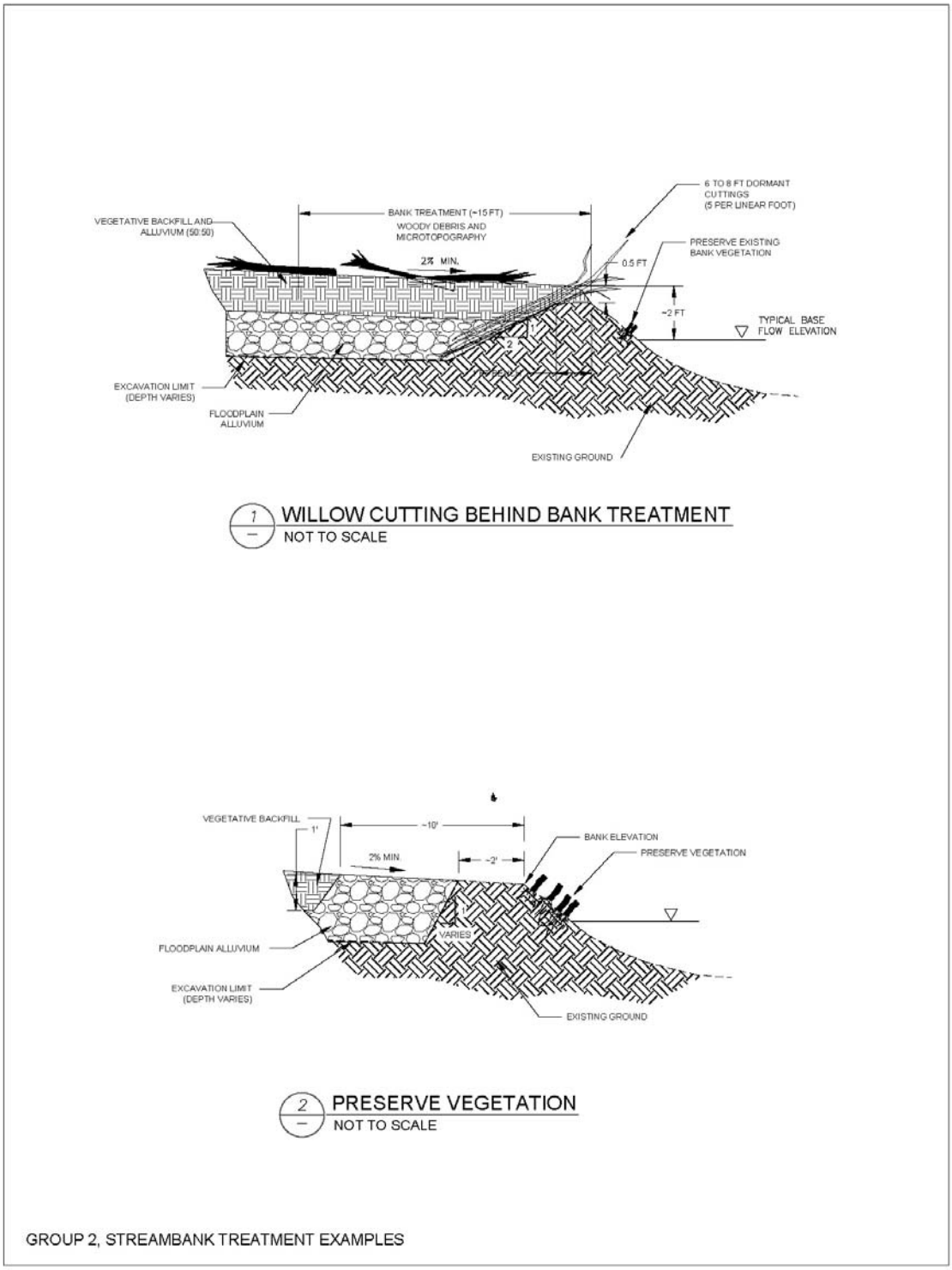


Figure 22. Streambank Treatment Examples, Group 2(a)

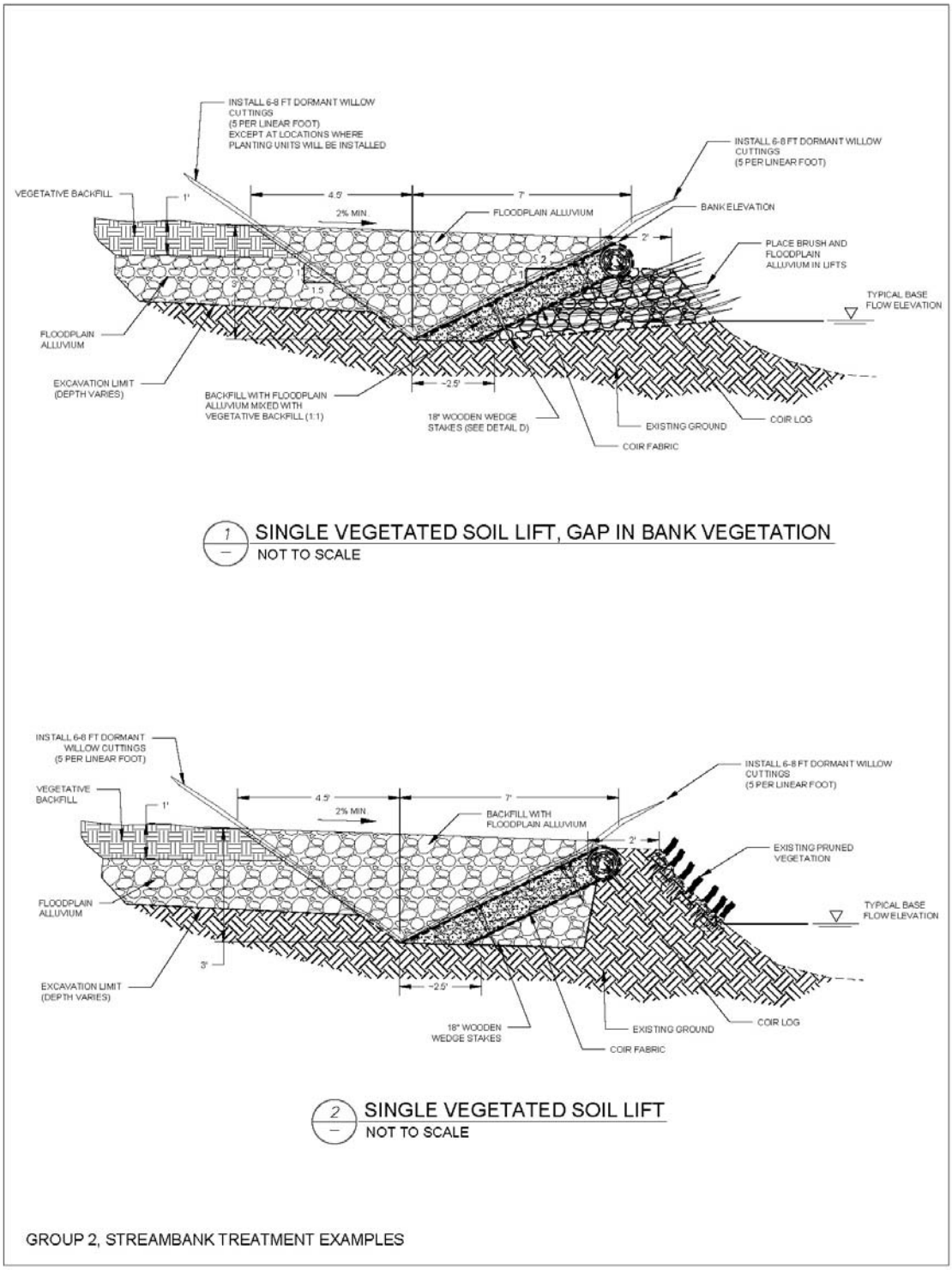


Figure 23. Streambank Treatment Examples, Group 2(b)

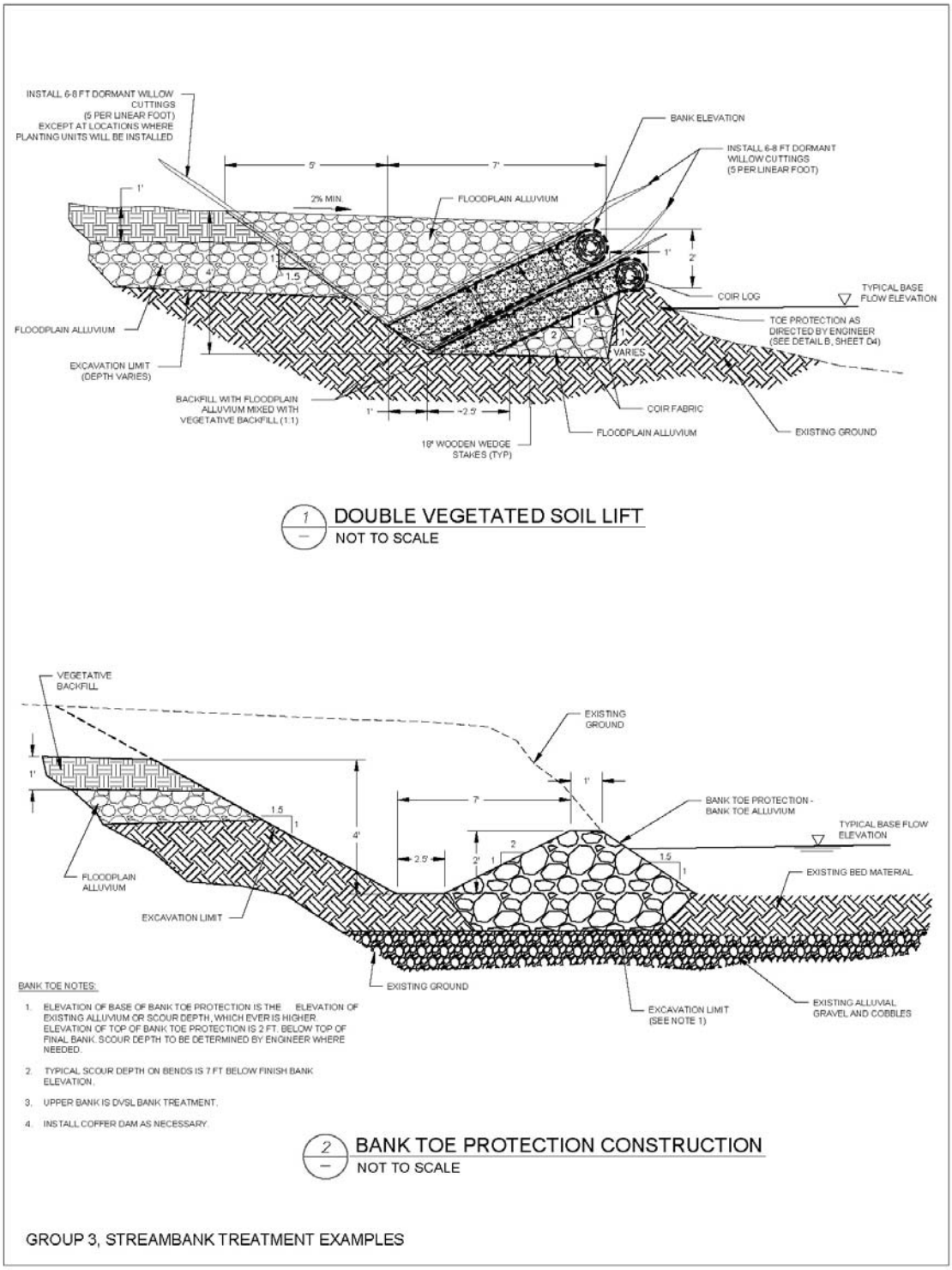


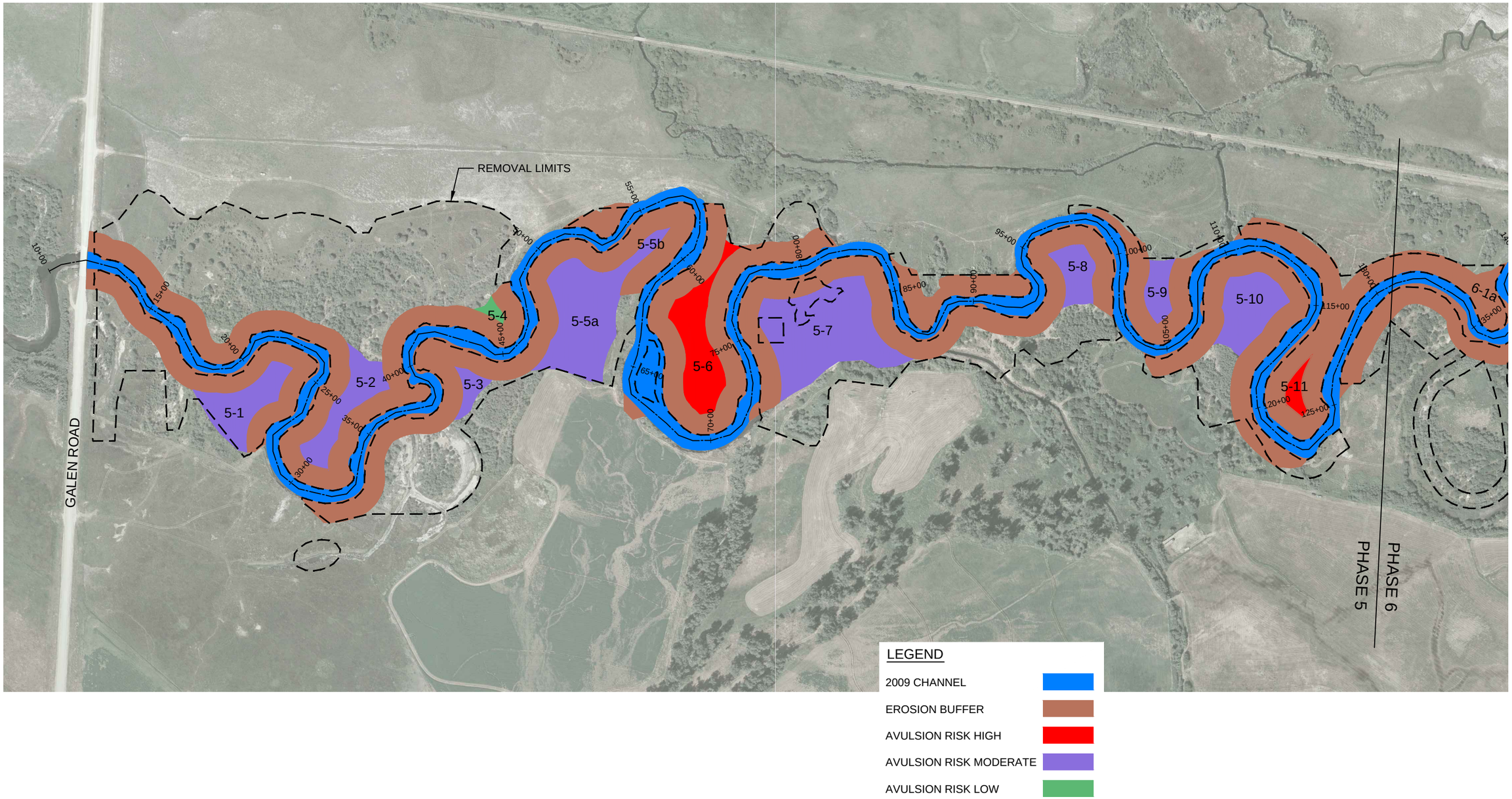
Figure 24. Streambank Treatment Examples, Group 3

3.7 Floodplain and Streambank Criteria Application Analysis

Based on application of the Streambank Treatment Criteria and the analyses contained in the following sections, streambank treatment groups and floodplain avulsion protection locations were preliminarily assigned to this reach. The location of the streambank treatment Groups 1 through 3 and high risk avulsion pathways are shown in Appendix E, Preliminary Design Plans on the Sheets C13 to C16, Proposed Grading and Streambank Location Plans.

3.7.1 Avulsion Pathway Analysis

Avulsion risk ratings were developed to help guide floodplain and bank treatment applications through meander bends. Potential avulsion areas were evaluated in terms of the "topographic advantage" that would be gained by channel relocation through a bendway core. Water surface profiles derived from LiDAR data were used to quantify current water surface slopes (Sc) through each meander bend in Phases 5 and 6. These slopes were then compared to the gradient of a potential cutoff chute (Sa) through the bendway core. The slope ratio (Sa/Sc) can be used as one indicator of avulsion potential; higher Sa/Sc values indicate a strong topographic driver for bendway cutoff. Additional information includes the presence of chute channels in the bendway core, evidence of sediment transport deficiencies in the upstream limb of the bend, and anomalously low channel slopes. Based on these combined criteria, four bends have been identified as having a high risk of avulsion based on channel planform (Figure 25 and Figure 26). Bendway 6-7 is especially prone to cutoff, due to both the high Sa/Sc ratio (6.6) and the very low channel slope through the bend (0.08 percent). Bendway 5-7 was given a moderate risk of avulsion due to the presence of the Whalen Ditch close to the bendway core that could potentially capture high flows and breach back to the main river downstream, creating an avulsion path.



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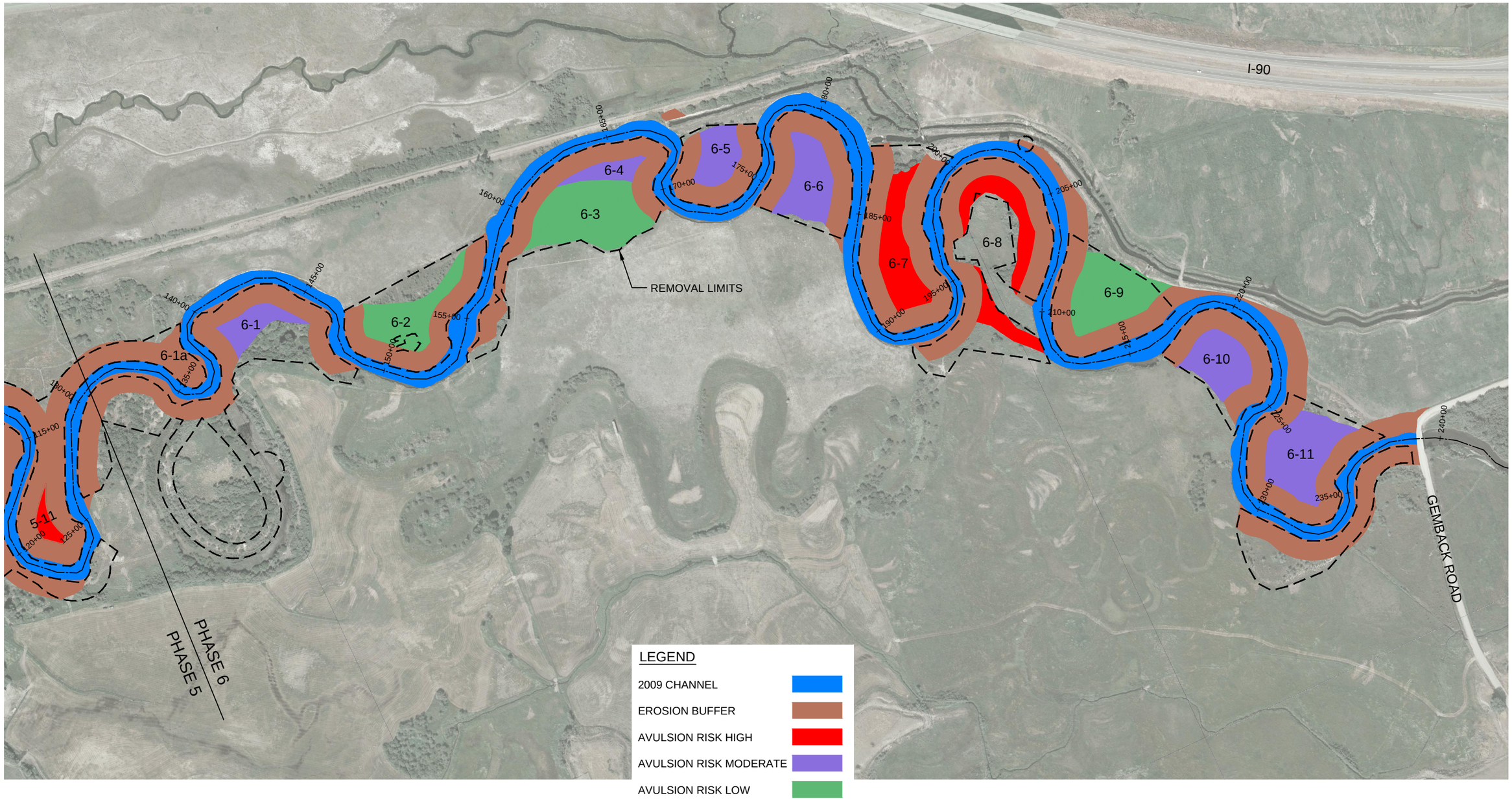
DRAWN: G D HOGGATT	PROJECT NO.: 12007	CLARK FORK RIVER OPERABLE UNIT, PHASE 5 & 6	RELATIVE AVULSION RISK PHASE 5
ENGINEER: M. CULPO	SCALE: 1" = 400'		
CHECKED:	APPROVED:		
DATE:	DATE:		

FIGURE 25



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ENGINEER: M. CULPO	SCALE: 1" = 400'
CHECKED:	APPROVED:
DATE:	DATE:

CLARK FORK RIVER OPERABLE UNIT, PHASE 5 & 6

RELATIVE AVULSION RISK PHASE 6

FIGURE 26

Table 18. Avulsion Potential Summary Data

Phase	Meander Reference	Channel Length (ft)	Avulsion Path Length (ft)	Channel Slope	Avulsion Path Slope	Sa/Sc	Risk	Comment
5	5-1	800	243	0.07%	0.23%	3.3	Mod	
5	5-2	1600	302	0.13%	0.67%	5.3	Mod	
5	5-3	400	164	0.37%	0.90%	2.4	Mod	
5	5-4	450	234	0.10%	0.20%	1.9	Low	
5	5-5a	1900	441	0.15%	0.67%	4.3	Mod	Long compound bend
5	5-5b	900	213	0.10%	0.43%	4.2	Mod	
5	5-6	1900	174	0.17%	1.83%	10.9	High	Deposition on upstream limb of bend
5	5-7	1400	717	0.22%	0.42%	2.0	Mod	Risk is from ditch capture
5	5-8	900	278	0.25%	0.80%	3.2	Mod	
5	5-9	750	254	0.11%	0.33%	3.0	Mod	
5	5-10	1300	290	0.14%	0.63%	4.5	Mod	
5	5-11	1350	111	0.17%	2.07%	12.2	High	Rapidly compressing
6	6-1a	450	112	0.15%	0.60%	4.0	Mod	All of bendway core in erosion buffer
6	6-1	1100	453	0.21%	0.50%	2.4	Mod	
6	6-2	1100	656	0.21%	0.35%	1.7	Low	
6	6-3	1100	661	0.16%	0.27%	1.7	Low	
6	6-4	500	201	0.20%	0.51%	2.5	Mod	Would abandon diversion structure
6	6-5	900	331	0.15%	0.40%	2.7	Mod	Rapid migration of upstream limb
6	6-6	1200	385	0.14%	0.45%	3.1	Mod	
6	6-7	1600	241	0.08%	0.51%	6.6	High	Low channel gradient
6	6-8	1600	278	0.15%	0.86%	5.8	High	Developed chute
6	6-9	1100	510	0.16%	0.35%	2.2	Low	
6	6-10	1000	391	0.17%	0.43%	2.6	Mod	
6	6-11	1300	362	0.15%	0.54%	3.6	Mod	

Sa = gradient of a potential cutoff chute
Sc = current water surface slope

3.8 Floodplain and Streambank Hydraulic Analyses

A HEC-RAS hydraulic analysis of the river and floodplain was performed for the 2-year, 10-year, and 100-year events using the reconstructed (design) floodplain surface. The results of the 2-year and 10-year events were used for the design of the floodplain and streambanks, and the 100-year event was used for design of structural components such as at bridges and irrigation structures, and near irrigation ditches. The 2-year event was used to evaluate the effectiveness of floodplain activation and the 10-year event was used to evaluate floodplain and streambank stability.

The reconstructed floodplain surface will be lower than the existing tailings aggraded surface, lowering the bankfull flow elevation and allowing more overland flow at each flooding event. This will result in slight increases in flow conveyance, velocity, and shear stress on the floodplain for all events above the bankfull flow but will also result in slight decreases for these conditions in the channel because the WSE for all events will be reduced. The results of the design analyses are shown in Table 19 to Table 21 and the output for each event from the hydraulic model is contained in Appendix A, Hydraulic Analysis.

Table 19. 2-Year Proposed Conditions Reach Averaged Hydraulics.

Location	Flow (cfs)	Velocity (ft/s)	Shear Stress (lbs/sq ft)	Particle Size at Incipient Motion (in)	Hydraulic Depth (ft)
Left Overbank	61	0.5	0.04	0.16	0.4
Channel	605	3.2	0.29	1.20	2.8
Right Overbank	58	0.7	0.05	0.19	0.6

Table 20. 10-Year Proposed Conditions Reach Averaged Hydraulics.

Location	Flow (cfs)	Velocity (ft/s)	Shear Stress (lbs/sq ft)	Particle Size at Incipient Motion (in)	Hydraulic Depth (ft)
Left Overbank	211	0.8	0.07	0.27	0.8
Channel	965	3.8	0.38	1.60	3.6
Right Overbank	180	0.8	0.08	0.31	0.8

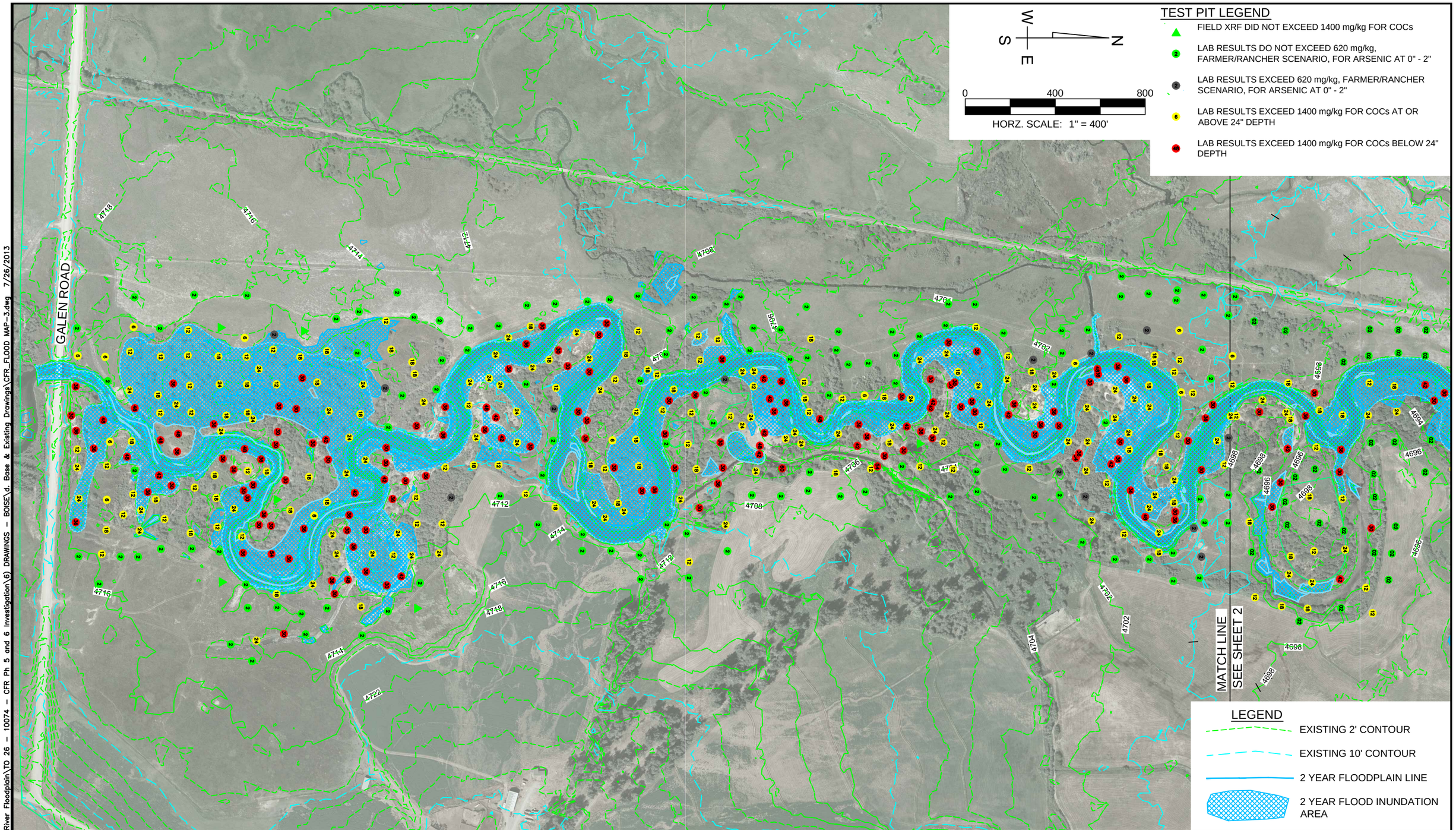
Table 21. 100-Year Proposed Conditions Reach Averaged Hydraulics.

Location	Flow (cfs)	Velocity (ft/s)	Shear Stress (lbs/sq ft)	Particle Size at Incipient Motion (in)	Hydraulic Depth (ft)
Left Overbank	430	0.9	0.12	0.47	1.1
Channel	1,314	4.2	0.46	1.79	4.3
Right Overbank	397	1.1	0.19	0.74	1.2

3.8.1 Floodplain Analysis

The floodplain grading and elevations were analyzed to evaluate floodplain inundation extent for the 2-year event and short-term stability during the 10-year event. An increase in floodplain inundation area during the 2-year event is essential to meeting the project objectives and desired post remediation conditions. Upon completion of the reconstructed floodplain, short-term stability is reliant on the floodplain treatments without the benefit of vegetation. Short-term stability is thus accomplished by applying the floodplain treatment criteria for floodplain grading, gravel alluvium, buried woody debris, and microtopography. Long-term floodplain stability will ultimately rely on reinforcement of the floodplain surface by riparian vegetation.

Under existing conditions, the effective flow area inundated outside the river banks during the 2-year event is minimal because the flows are largely contained within the banks of the river. Currently, the effective flow area inundated by the 2-year event outside the channel is estimated at 22 acres, which represents 12 percent of the 100-year effective flow inundation area. Upon completion of the removals and reconstruction of the floodplain at a lower elevation, the effective floodplain flow area inundated by the 2-year event increases to 52 acres, which represents 30 percent of the 100-year effective floodplain flow inundation area. Figure 27 and Figure 28 show the existing 2-year floodplain for Phases 5 and 6, respectively, and Figure 29 and Figure 30 show the proposed 2-year floodplain inundation areas.



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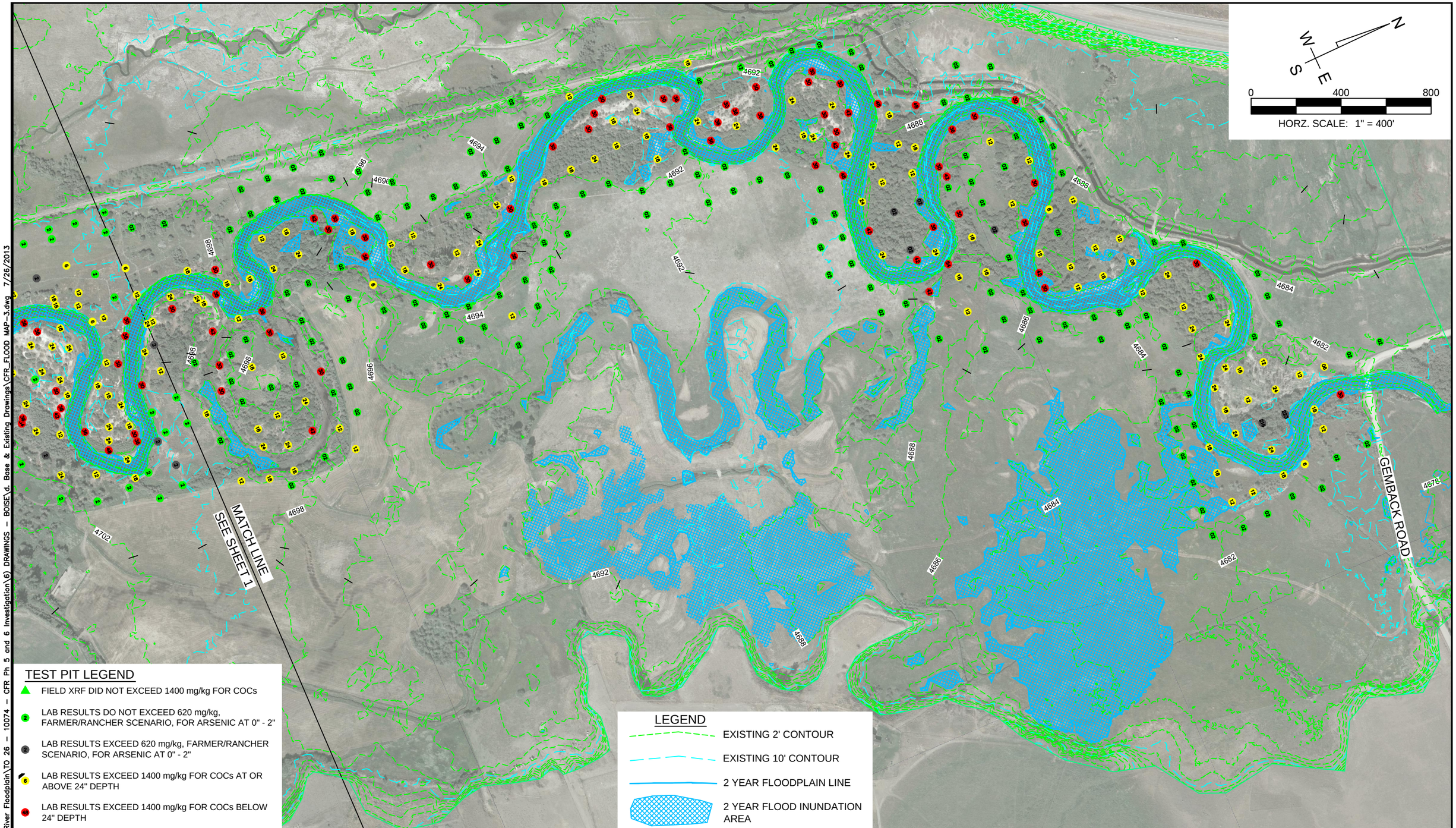
REVISED:	G. HOGGATT	DATE:	7/26/2013

CLARK FORK RIVER OPERABLE UNIT, PHASE 5 & 6

EXISTING 2 YEAR FLOODPLAIN INUNDATION MAP - PHASE 5

FIGURE 27



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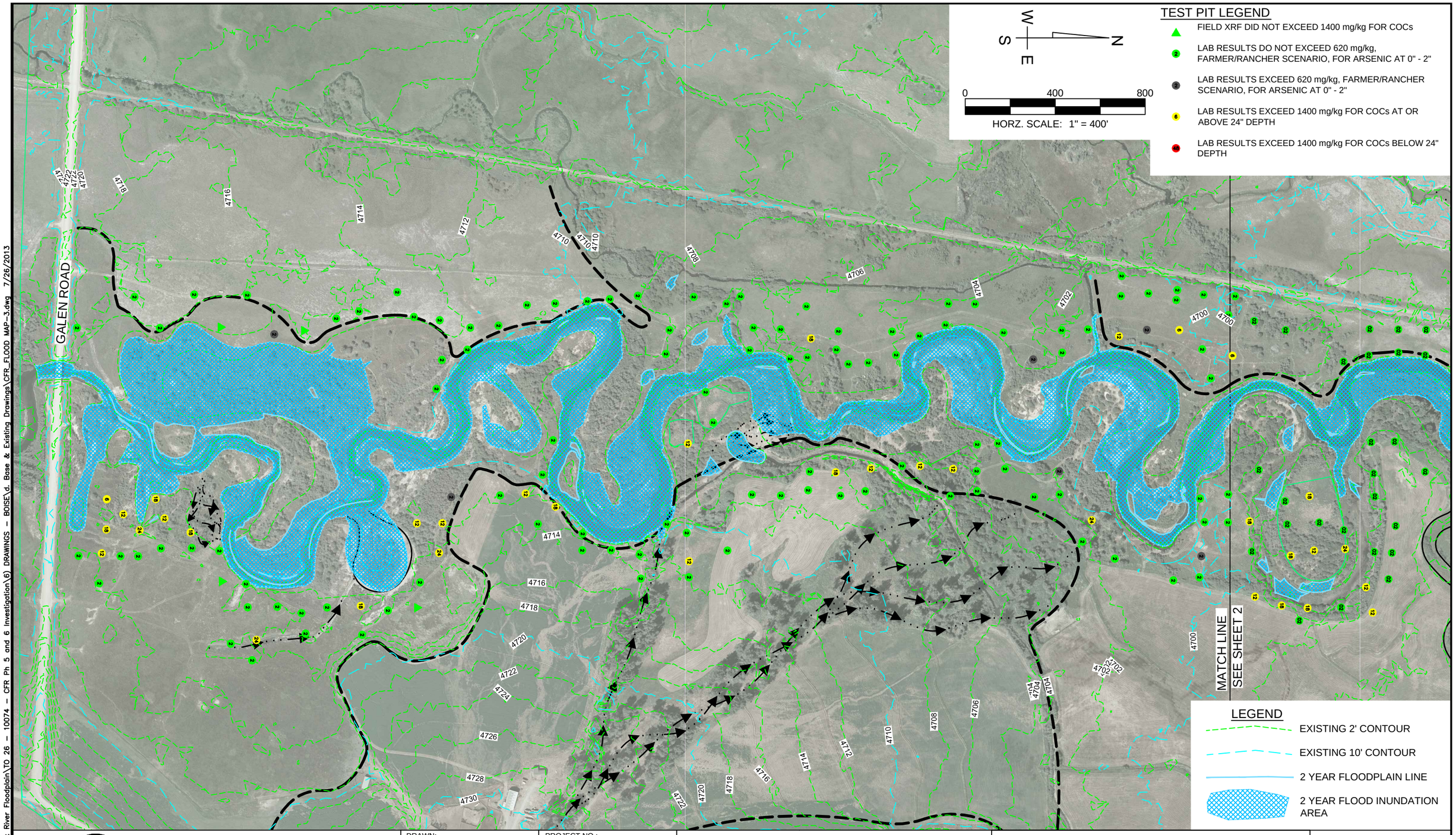
CLARK FORK RIVER OPERABLE UNIT, PHASE 5 & 6

EXISTING 2 YEAR FLOODPLAIN INUNDATION MAP - PHASE 6

FIGURE 28



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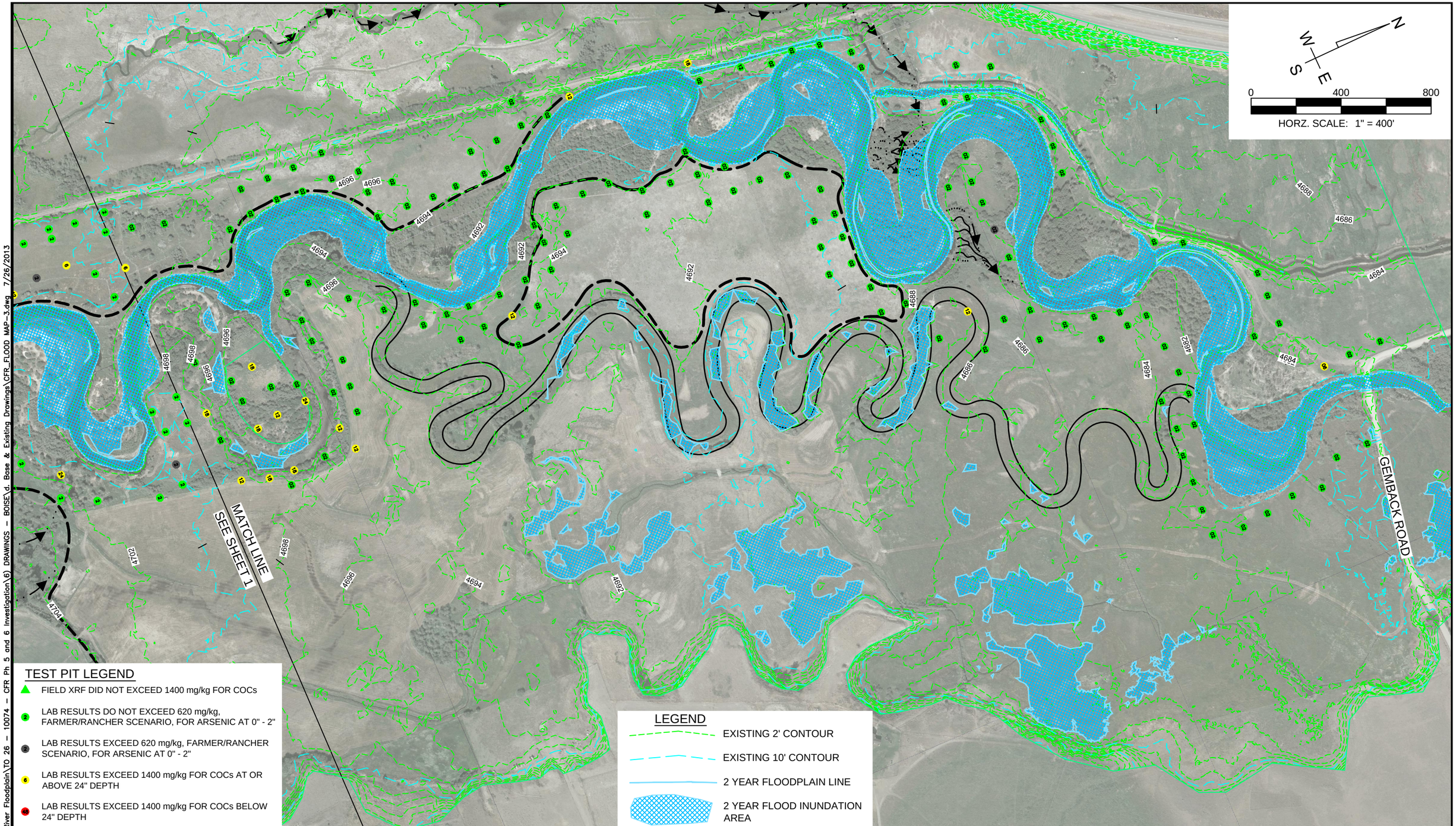
CLARK FORK RIVER OPERABLE UNIT, PHASE 5 & 6

PROPOSED 2 YEAR FLOODPLAIN INUNDATION MAP - PHASE 5

FIGURE 29



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CLARK FORK RIVER OPERABLE UNIT, PHASE 5 & 6

PROPOSED 2 YEAR FLOODPLAIN INUNDATION MAP - PHASE 6

FIGURE 30

The proposed floodplain grades were derived from an iterative process of estimating the proposed elevations using the existing condition WSEs, preparing a new HEC-RAS model using those proposed grades, and then comparing the new 2-year WSEs to the proposed floodplain grades to ensure compliance with design criteria. Tabular output from the HEC-RAS model showing the proposed 2-year WSEs is contained in Appendix A. Gradients along the floodplain surface are generally flatter than 10:1 except at the removal interface with existing ground. The proposed grading plan promotes sheet flow and diminishes concentrated flow and defined avulsion paths. The floodplain grading is shown in Appendix E, Preliminary Design Plans on Sheets C13 to C16, Proposed Grading and Streambank Location Plans.

Gravel alluvium will be applied to areas along the floodplain where short-term stability is a concern and as a cover type to assist with revegetation and long-term stability. Samples of this material collected from the proposed borrow areas were analyzed to develop typical size gradations. The resulting grain size distribution was compared to the incipient motion analysis using floodplain and channel shear stresses from the proposed 10-year floodplain model. Incipient motion analysis for the channel and floodplain indicates that at the 10-year flow condition, a 1.6-inch diameter particle is relatively stable in the channel and a 0.3-inch particle is relatively stable on the floodplain. The gradations from the borrow area samples show that the alluvial gravels range in size from sand to cobbles over 4 inches in diameter, and the fine-grained alluvium ranges from silt and clay to coarse sands. However, the alluvial gravel sample analysis excluded all particle sizes larger than about 4 inches, and field logs note cobbles in the borrow source material reaching 10 inches in diameter. Gradations and field logs are contained in Appendix B. The location of gravel alluvium to be placed on the floodplain and along the streambanks is shown in Appendix E, Preliminary Design Plans on Sheets C17 to C20 Revegetation Cover Types and on Figures 21 to 23 for Groups 1 through 3 Streambank Treatment examples.

Development of microtopography includes constructing a hummocky floodplain surface, partially burying woody debris, and incorporating larger depressions on the floodplain. Microtopography is combined with use of gravel alluvium to provide redundant features that will roughen and assist with short-term stability during out-of-bank flood events. The roughened floodplain surface will decrease velocities and is represented in the model by increasing Manning's n. The selected Manning's n for the floodplain under the proposed condition was estimated at 0.06 for analysis of short-term stability.

3.8.2 Streambank Analysis

The proposed reconstructed streambanks were analyzed to evaluate the adjacent floodplain grading relative to the streambank criteria, for top-of-bank elevations, and for stability during the 10-year event. Consistent with floodplain grading, the top-of-bank elevations vary relative to base flow and 2-year event WSEs. Final top-of-bank grading depends on geomorphic location and analysis of stability during the 10-year event. This design allows only 10 to 20 percent of the total flow to access the floodplain at the 10-year event. Several streambanks are located near or adjacent to irrigation ditch embankments and intake structures, which were analyzed for stability up to the 100-year flood event. Similar to the short-term floodplain stability, the reconstructed streambanks are reliant on the stabilizing properties of the materials and methods used without the benefit of vegetation. Long-term stability will ultimately rely on riparian

vegetation and the natural functions of the system except where structural elements are concerned.

Floodplain and streambank elevations were evaluated by initially applying the streambank treatments along the river based on geomorphic location, existing streambank conditions, and location of contamination where removals are planned. Active margins are eroding or in locations of higher stress while passive margins are largely depositional areas. Based on the initial application of treatments, the criteria for top-of-bank elevations were compared to the adjacent floodplain elevations and are shown in Appendix E, Preliminary Design Plans on the Sheets C13 to C16, Proposed Grading and Streambank Location Plans. These elevations were also cross-referenced to the WSEs from the HEC-RAS model output for proposed conditions during the 2-year event (Appendix A). For this analysis, the streambank elevations were consistent with the criteria, the adjacent floodplain elevation, and the proposed 2-year WSEs.

Short-term stability was evaluated for the active margins. Analyses of the historical bank migration rates and geomorphic streambank location, and a field evaluation of the existing bank conditions, were used to identify streambank treatment groups and identify preliminary locations where toe reconstruction is needed. A summary table of these analyses for eroding banks is contained in Appendix D. The preliminary planform locations of the streambank treatments are shown on the Preliminary Design Plans in Appendix E.

Gravel alluvium and cobbles provide a roughened floodplain surface along reconstructed streambanks, which will reduce velocities at the soil/water interface, and are increasingly resistant to movement during more frequent events, yet mobile within the range of normal system function. Gravel alluvium consists of a range of material sizes derived from native sources at the project site and is consistent with the material found adjacent to streambanks and within the bed substrate. The larger portion of the gravel alluvium and cobble backfill will range from approximately 3 to 8 inches in diameter. When compared to the incipient motion estimates, this range of material exceeds the critical diameter from reach average conditions for the 2-year event to the approximate maximum critical diameter for the 100-year event. Gradations for the gravel alluvium from the proposed on-site borrow areas are included in Appendix B.

Structural reinforcement of streambanks will be applied to areas where irrigation ditch embankments and intake structures exist in close proximity to actively eroding outer meanders. Based on the smallest particle size at incipient motion identified in the GHH Report of 5.4 inches for the 100-year event, structural reinforcement will generally consist of rip rap with a median diameter of 6 to 12 inches. Rip rap is angular and has interlocking properties that resist movement. To address long-term scour, rip rap will be keyed into the streambed or placed to form a bench along the bankline to fill developing scour holes.

3.9 Borrow Area and Backfill Material Criteria

Borrow materials will be needed to backfill excavated areas to the designed floodplain elevations. They will also be needed for temporary infrastructure such as haul roads, for streambank stabilization and surfacing of depositional areas, and as vegetative growth media. The primary types of borrow needed are a fine-grained vegetative backfill and a coarse-grained floodplain backfill. Sources for these materials include suppliers at gravel pits, off-site borrow areas including the Beck borrow area, and on-site borrow areas. On-site borrow areas have the

distinct advantage of being local, which will significantly reduce haul costs and will provide native backfill materials consistent with those found within the project boundary. With landowner approval, this project will utilize on-site borrow areas when available. Portions of these on-site borrow areas will be within the removal boundary. All contaminated soil within the footprint of the on-site borrow areas will be removed prior to development of the borrow sources. The potential on-site borrow areas are shown on Figure 31.

Approximately 150,000 cubic yards of vegetative backfill and 50,000 cubic yards of floodplain backfill are needed to reconstruct the floodplain to the design grades shown in Appendix E, Preliminary Design Plans on Sheets C13 to C16. Additional materials needed for the site include rip rap for streambank reinforcement at structures and cobbles for streambank toe stabilization.

Borrow area design grading will be prepared with landowner approval and included as part of the final design plans. Once floodplain backfill material is removed from the borrow areas, the majority of each area will remain below groundwater and will be contoured to create wetlands. The following design criteria will be applied to the reclaimed borrow areas:

- Maximum depth of 10 feet below seasonal high groundwater elevation.
- Minimum depth of 1 foot of fine-grained soil along the floor.
- Low gradient slopes around the perimeter.
- Variable depth throughout with all ground elevations below seasonal high groundwater.
- Complex, meandering edges and shaping to mimic natural features.
- Outside the 200-year channel migration buffer or approximately 166 feet from the river.
- Contouring to discourage direct overland flow paths to and from the main channel.

3.9.1 Vegetative Backfill

Vegetative backfill is available from fine-grained alluvial sources on site as shown on Figure 31 and from off-site sources that include the Beck Borrow Area, which is owned by the State. Vegetative backfill requirements are specified as part of the ROD. Table 22 presents the chemical and physical requirements for vegetative backfill on CFROU projects.

Table 22. Chemical and Physical Criteria for Vegetative Backfill.

Parameter	Value
pH	6.5 to 8.5
Arsenic (As)	<30 mg/kg
Cadmium (Cd)	<4 mg/kg
Copper (Cu)	<100 mg/kg
Lead (Pb)	<100 mg/kg
Zinc (Zn)	<250 mg/kg
Texture:	Sandy loam or finer; no clay
Coarse fragments (>2 mm diameter)	< 45% by volume
Maximum size	6 inches
Specific conductance	<4.0 dS/m
No weeds or weed seeds	

Notes: mg/kg –milligrams per kilogram dS/m – deciSiemens per meter mm – millimeter

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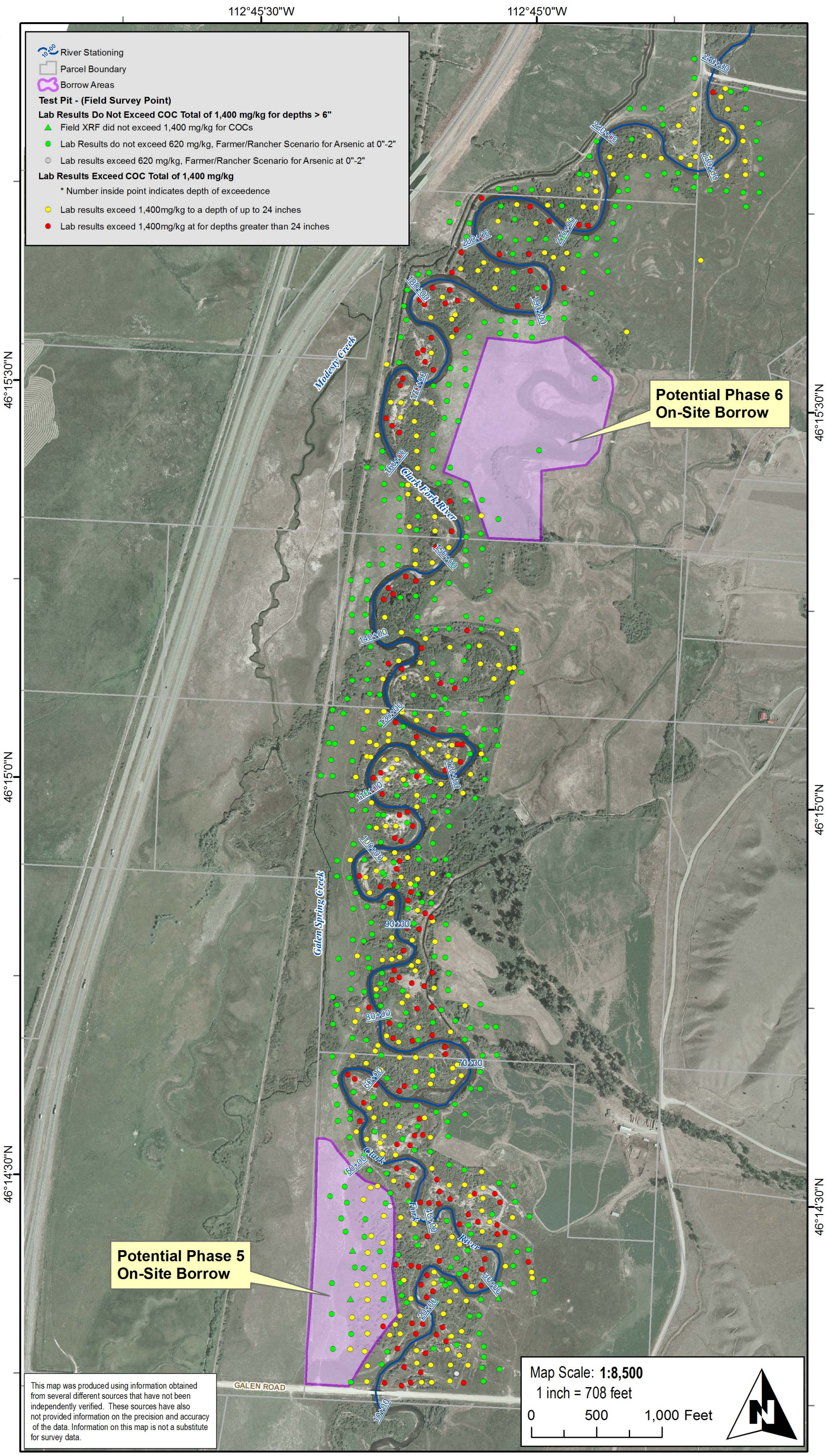

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TerraGraphics Environmental Engineering, Inc. www.TerraGraphics.com	File: Montana\CFROU\mxd\borrow_20130723	Map Projection: NAD83 UTM12N	Project Name: Clark Fork River Operable Unit Phases 5 & 6	Figure 31 On-Site Borrow Area Location Map (2011 Aerial Image)
	Print Date: July 29, 2013	Project Manager: M. Culpo		
	Project Number: 10074-3 MDEQ - CFR Investigation - TO #26	Cartographer: B. Bailey		

Resource availability and the chemical and physical properties of the vegetative backfill from on-site alluvial sources has been investigated for this report and is discussed in Section 2.4 Floodplain Material and Borrow Investigation, with the results of the investigation included in Appendix B; availability and properties of material at the Beck Borrow Area are documented in the *Beck Ranch Cover Soil Borrow Investigation* (PBS&J, 2008). Vegetative backfill meeting the project requirements is shown to exist at both the on-site sources and the Beck Borrow Area. On-site sources have limited capacity to meet the project needs because they exist at variable depth from 3 to 5 feet below existing ground. If on-site sources are exhausted, material from the Beck Borrow Area will be used.

3.9.2 Floodplain Backfill

Floodplain backfill is available from coarse-grained alluvial sources on site as shown on Figure 31 On-Site Borrow Area Location Map and from private off-site sources. Resource availability and the chemical and physical properties of the floodplain backfill from on-site alluvial sources has been investigated for this report and is discussed in Section 2.4, with the results of the investigation included in Appendix B. Floodplain backfill will be used below vegetative backfill, as a surfacing course on the passive margins and depositional areas, within the reconstructed streambanks, and as a surfacing course along the active floodplain margins. Analysis of the floodplain backfill meeting the project requirements for use within these areas is included in Section 3.8.1 Floodplain Analysis and Section 3.8.2 Streambank Analysis. In general, the findings of the investigation and analysis show that the coarse-grained alluvial resources are available of sufficient quantity at depths up to 12 feet and greater based on site geology. Additionally, the coarse-grained alluvial material is consistent with the existing bed substrate and streambank toe material and meets physical requirements necessary for short-term stability. Borrow depths greater than approximately 8–10 feet will be backfilled and covered with fine-grained material.

3.9.3 Rip Rap

Any rip rap needed for the site will be hauled in from off-site sources. Rip rap is only needed along streambanks near structures. These locations are identified in Section 2.6 Existing Streambank Conditions for structurally affected streambanks. Analysis for the size and extents of rip rap needed for structural reinforcement is discussed in Section 3.8.2 Streambank Analysis.

3.9.4 Cobbles

Cobbles are available from coarse-grained alluvial sources on site and from private off-site sources. Cobbles will need to be screened from the smaller material from both on-site and off-site sources. Cobbles will be used as toe material in the reconstructed streambanks where a stable toe does not exist and lateral bank movement is high. After the cobbles have been screened out, the remaining coarse-grained alluvium may not be used for streambank reconstruction or as a surfacing course along the active floodplain margins. The remaining coarse-grained alluvium may be used as a surfacing course in passive areas and as floodplain backfill within the bendway cores. Analysis for the design cobble gradation is included in Section 3.8.2 Streambank Analysis and availability from the on-site sources is shown in the results of the borrow investigation contained in Appendix B.

3.10 Vegetation Design Criteria

This section describes the vegetation design criteria for CFR Reach A, Phases 5 and 6, currently managed as a working ranch by the Clark Fork Coalition. The project area within the grading limits will be managed as a natural floodplain system, and other land use activities such as livestock grazing and hay production will be separated from the reclaimed area by fencing. The vegetation design emphasizes creating a self-sustaining mosaic of riparian and wetland plant communities on a floodplain surface that is hydrologically connected to the CFR. The design acknowledges that sediment transport and deposition, distribution of woody debris, flood events, water storage, and nutrient regimes all play a role in plant community development. Each design plant community (cover type) represents a starting point for the development of a dynamic riparian system that has the ability to respond to interconnected factors at both the local and watershed scales. Local factors that influence vegetation community development and succession in the floodplain include groundwater, woody debris accumulation, sediment distribution, and accumulation of organic matter or litter. Landscape-scale factors that influence vegetation development include flood regimes, climate patterns, valley type, and surface water-groundwater interactions. These communities are not meant to be static, but are intended to develop and change over time in response to natural floodplain processes. Figure 32 shows an example floodplain cross-section with the existing condition including tailings, the immediate post-reclamation condition, and the desired future condition once riparian vegetation has become established.

Because several plant communities can occur on similar geomorphic features, plant communities are grouped into seven broader floodplain cover types for the purposes of developing vegetation design criteria and treatments. These cover types are as follows: Exposed Depositional (non-vegetated), Colonizing Depositional (vegetated), Emergent Wetland, Riparian Wetland, Floodplain Riparian Shrub, Outer Bank Riparian Shrub, and Upland Transition. This section includes detailed descriptions of each of these cover types, strategies for each cover type, and descriptions of each revegetation treatment assigned to the cover types. Figure 33 and Figure 34 show the distribution of design cover types in addition to planting areas and other features discussed in the section for Phases 5 and 6, respectively.

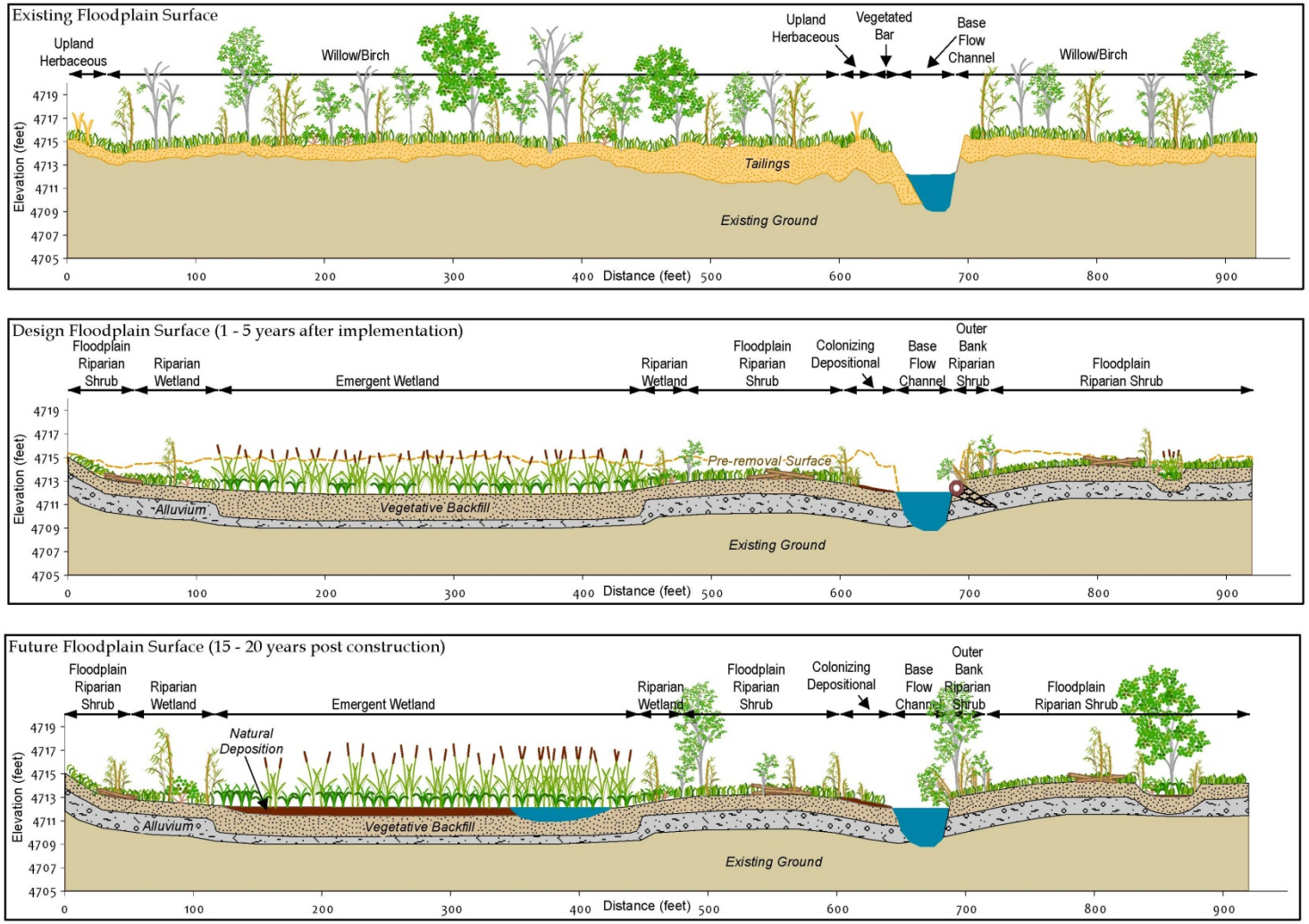

Figure 32. Example Cross-section of the Existing, Design, and Future Floodplain Surface.

Figure 33. Phase 5 Design Cover Types, Planting Areas, Swale Features, and the Example Valley Cross-Section Location.

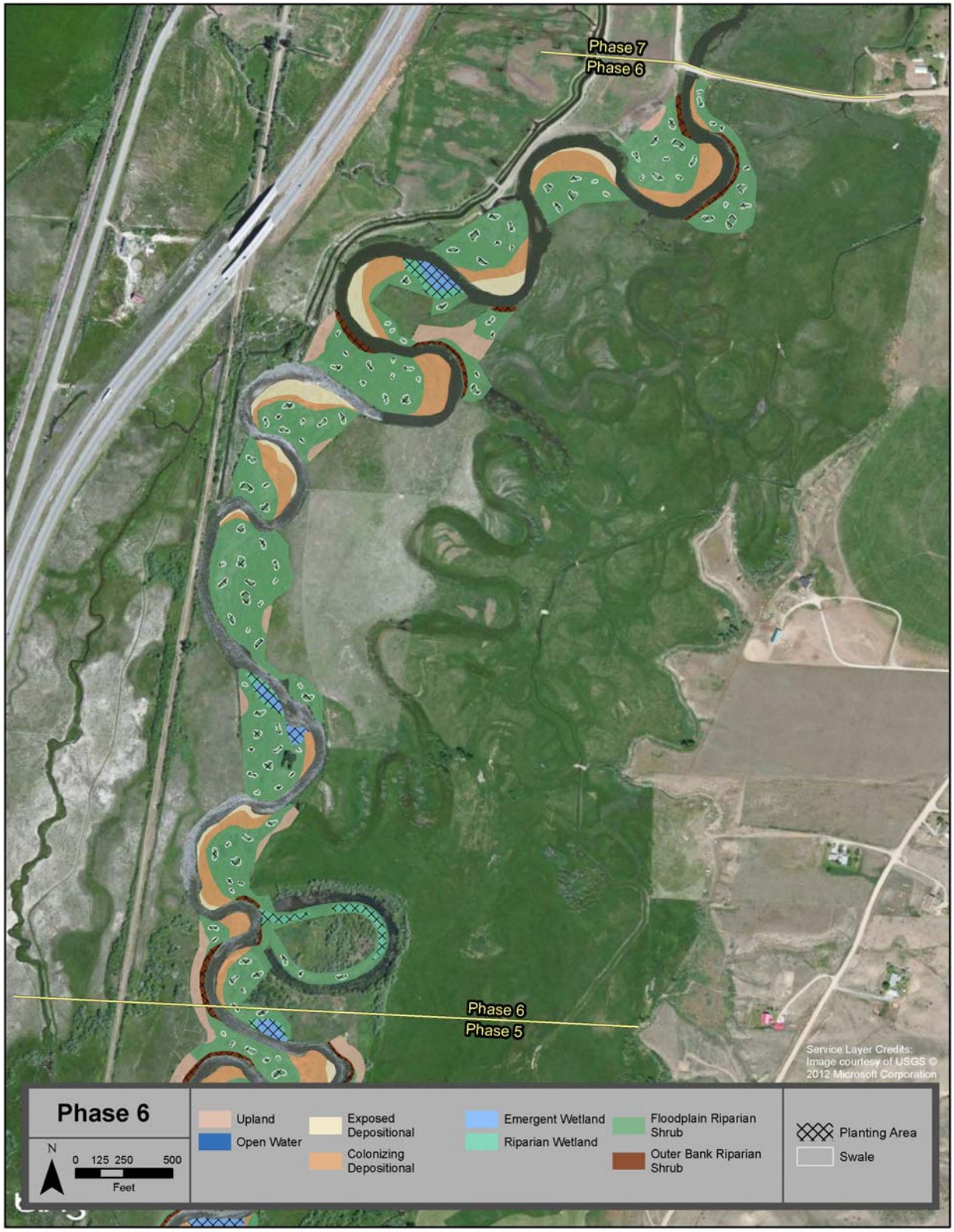

Figure 34. Phase 6 Design Cover Types, Planting Areas, and Swale Features.

Design criteria for each floodplain cover type were developed based on the following physical factors that influence the development of plant communities:

- Geomorphic feature: the location of the cover type within the floodplain
- Flood dynamic: the anticipated return interval for overbank flooding within the cover type
- Estimated distance to groundwater
- Elevation relative to the 2-year flow WSE
- Soil texture: Range of soil textures that can support development of desired plant communities within the cover type
- Soil depth: depth of soil before alluvium is reached.

Table 23 provides ranges for each of these factors by floodplain cover type. Design criteria for vegetation are closely tied to floodplain design criteria (Section 3.5), streambank reconstruction design criteria (Section 3.6), and design criteria for backfill (Section 3.9). The following discussion explains some of the rationale for vegetation design criteria within the project area for Phases 5 and 6.

Creating hydrologic connectivity between the channel and floodplain is necessary for floodplain cover types and related plant communities to develop so they can provide a wide range of floodplain functions and processes to meet remedial goals, in particular vegetation performance standards. Reconstructing the floodplain at the range of elevations specified in the design will result in this degree of hydrologic connectivity between the floodplain and channel. As a result, flows exceeding the 2-year return flow will deposit nutrients, sediment, and seeds on the floodplain, thereby creating and sustaining riparian vegetation. Floodplain topography that is part of this design also allows for surface connection to groundwater that transports additional nutrients to floodplain vegetation and develops complex food webs below ground (Brinson et al., 2005). Diverse topography will also support a wide range of plant communities in the floodplain.

As with other natural floodplain processes, riparian soil development and related nutrient exchange also depends on the floodplain and channel being hydrologically connected. Riparian systems generally receive nutrients from allochthonous sources such as dead leaves and woody debris brought from upstream (Vannote et al., 1980). Topographic diversity in the form of oxbows, connected side channels, wetlands, and smaller depressions provides pathways and sinks for allochthonous inputs of organic matter and promotes soil development. A significant portion of organic matter and nutrients is also delivered to the floodplain during flood events (Tabacchi et al., 1998). A high proportion of fine sediment in floodplain soils consists of soil particles or mineral sediments originating from the stream channel where they were coated with organics (Gregory et al., 1991). Because these are the dominant nutrient and organic matter input pathways in floodplain systems, the vegetation design does not call for import of organic material or nutrients in the form of compost or commercial fertilizers.

The appropriate substrate to support vegetation development includes cobble, gravel, and sand (alluvium) on exposed depositional and colonizing surfaces, and sandy loam to finer textured soils (vegetative growth media) on higher elevation floodplain surfaces and within wetlands. Vegetative growth media depth will be 12 inches within most cover types, which reflects the

typically shallow soils found on western Montana alluvial floodplains, where most fine-textured soil that accumulates on alluvium is made up of sediment trapped by established woody vegetation. The organic component of these soils is typically low (1.5 to 2.5 percent) because most organics are derived from either litter that has accumulated over a relatively short time frame or organics that have moved in through the water column and coated soil particles (as described above). Deeper vegetative growth media will be placed in wetland depressions because depressions with no outlets trap more sediment, resulting in a deeper mineral soil layer. Anaerobic conditions within these constantly-saturated features also result in relatively rapid accumulation of organic matter in soils because the organics do not decompose rapidly. Within designed wetlands, organic matter content in soils will likely trend toward 5 percent or greater.

Table 23. Design Criteria for Floodplain Cover Types.

Floodplain Cover Type	Geomorphic Design Feature(s)	Flood Dynamic (flood return interval)	Distance to Ground-water (feet)	Elevation Relative to 2-Year WSE (feet)	Soil Texture	Vegetative Backfill (inches to alluvium)
Exposed Depositional (Non-vegetated)	Non-vegetated portion of point bars	< 1 year	0 to 3	-2.5 to -1.0	Sand, fine to coarse gravel or cobble (alluvium)	0
Colonizing Depositional (Vegetated)	Vegetated portion of point bars	1 to 2 years	0 to 3	-1.0 to 0	Sand, fine to coarse gravel or cobble (alluvium)	0
Emergent Wetland	Passive margins along channel; wetlands, oxbows, and backwater areas	< 1 year	0 to 3	-2.5 to -1.0	Silt to sandy loam (vegetative backfill)	24
Riparian Wetland	Bankfull floodplain in backwater areas; edge of emergent wetlands and oxbows	1 to 2 years	0 to 3	-1.0 to 0	Silt to sandy loam (vegetative backfill) overlying gravel or cobble (alluvium)	12
Floodplain Riparian Shrub	Bankfull floodplain; low terrace	2 to 50 years	2 to 4	-0.5 to 2.5	Silt loam to sandy loam (vegetative backfill) overlying alluvium	12
Outer Bank Riparian Shrub	Streambanks along outer meanders	1 to 10 years	2 to 4	0 to 2.0	Silt loam to sandy loam (vegetative backfill)	12
Upland Transition	Slope transitions to higher terraces; high inclusions within CMZ	10+ years	3 +	2.0 +	Silt loam to sandy loam (vegetative backfill)	12

3.10.1 Integration with Floodplain Grading

The floodplain grading plan references modeled WSEs for key flows, including the 2-year WSE for creating connected floodplain surfaces and setting bank heights, and the 10-year flow for short-term streambank and floodplain stability. Much of the design floodplain will be constructed between 1 foot above the base flow elevation and 0.5 feet above the 2-year WSE. Floodplain surfaces 0.5 feet above the 2-year WSE and lower are considered to be connected to the river hydrology and able to support riparian and wetland plant communities. The floodplain grading plan development process is closely tied to the process of assigning floodplain cover types for revegetation. Some floodplain locations, such as streambanks on outer meander bends, require specific elevations to maintain the channel and floodplain and support specific vegetation communities, namely the Outer Bank Riparian Shrub cover type. Other floodplain locations allow for more variable elevations that will support the mosaic of riparian and wetland vegetation communities typically found in connected floodplains.

3.10.2 Design Criteria and Components by Cover Type

3.10.2.1 Exposed Depositional

3.10.2.1.1 Description

Within the project area, the Exposed Depositional cover type is located at low elevations along the inside of meander bends between base flow and approximately 1.5 feet above base flow. These areas are subject to frequent scour and often do not support vegetation, but they have the potential to recruit sediment and eventually become vegetated as they aggrade. This type of feature forms naturally from the sediment transport and deposition process, is composed entirely of exposed alluvial substrate such as cobble and gravel, and supports mostly scattered annual vegetation. Because these surfaces are subject to frequent disturbance, over the long term they tend to change shape and may be eliminated altogether. In some locations, once these features have matured, they may be colonized with willows (*Salix* species) or herbaceous vegetation that will trap fine sediments, thus creating more niches for other plant species to colonize. These areas may become higher over time as they continue to trap sediment and aggrade, causing them to encroach on the channel forming defined banks. Because these areas are so dynamic and unpredictable, no active revegetation treatments are proposed.

3.10.2.1.2 Strategy

The revegetation strategy for the Exposed Depositional cover type includes the following:

- Grading associated with floodplain construction to create surfaces with gradual slopes extending from base flow to below the 2-year WSE.
- Construction using floodplain alluvium consisting of fine to coarse gravel or cobble.

Table 24 summarizes the revegetation criteria and treatments for the Exposed Depositional cover type.

Table 24. Exposed Depositional Cover Type Criteria and Revegetation Treatments.

Exposed Depositional Cover Type	**Total Area = 3.5 acres** **Percent of Total Area = 2.8%**	
Treatment	**Criterion/Description**	**Treatment Area**
Grading	-2.5 to -1.0 feet relative to 2-year WSE	3.5 acres
Soil Texture	Sand, fine to coarse gravel or cobble (alluvium)	3.5 acres
Vegetative Backfill Depth	No vegetative backfill	N/A

3.10.2.2 Colonizing Depositional

3.10.2.2.1 Description

The Colonizing Depositional cover type occupies areas on point bars between the Exposed Depositional cover type and the 2-year WSE. These surfaces are partially vegetated, so they trap finer material than the Exposed Depositional cover type. Typical substrate in these areas consists of recently deposited sediments—patches of sand and silt over gravel and cobble. Successful natural recruitment of willows requires bare, moist, mineral-rich surfaces that are protected from scour so seedlings can survive beyond the first growing season. In addition to willows and other riparian trees and shrubs, annual and perennial herbaceous vegetation will develop on these surfaces. The bare patches created by scour and re-shaping also provide places for additional recruitment, resulting in a variety of age classes and diverse plant community structure. The Colonizing Depositional cover type is a transition between the Exposed Depositional surfaces that experience frequent re-sorting and the more stable Floodplain Riparian Shrub or Riparian Wetland cover type surfaces that experience lower magnitude and lower frequency floods. Over time, some areas within this cover type will continue to be re-shaped by the river. Other areas will become more stable and may transition to one of the other cover types such as Floodplain Riparian Shrub or Riparian Wetland.

3.10.2.2.2 Strategy

The revegetation strategy for the Colonizing Depositional cover type includes the following:

- Grading associated with floodplain construction to create surfaces at a higher elevation and, often, further away from the channel than the Exposed Depositional cover type.
- Construction using floodplain alluvium consisting of fine to coarse gravel or cobble.
- Placement of coarse woody debris and logs on the surface (microtopography) to provide safe sites where existing cottonwood and willow seedlings can survive frequent flooding, and to trap sediment and debris floating downstream, creating additional microsites where seeds can germinate and survive.
- Planting of herbaceous wetland plugs to encourage development of desired plant communities along the channel margins.
- Seeding with a two-stage seed mix. The seed mix will include a quick germinating cover crop to prohibit weed infestations and a mix of native grasses and forbs that are generally slower to germinate but longer-lived.

Table 25 summarizes the revegetation criteria and techniques for the Colonizing Depositional cover type.

Table 25. Colonizing Depositional Cover Type Criteria and Revegetation Treatments.

Colonizing Depositional Cover Type	**Total Area = 15.3 acres** **Percent of Total Area = 12.2%**	
Treatments	**Criterion/Description**	**Treatment Area**
Grading	-1 to 0 feet relative to 2-year WSE	15.3 acres
Soil Texture	Sand, fine to coarse gravel or cobble (alluvium)	15.3 acres
Vegetative Backfill Depth	No vegetative backfill	N/A
Microtopography	Partially buried woody debris	15.3 acres
Containerized Planting: Shrubs and Trees	Shrubs and trees will be installed in approximately half of this cover type area	7.7 acres
Containerized Planting: Herbaceous Plugs	Herbaceous wetland plugs will be installed in approximately half of this cover type area to promote establishment of desired plant communities	7.7 acres
Seeding	Seed with two-stage seed mix for early germination cover crop and long-term diverse native mix of grasses and forbs	15.3 acres

3.10.2.3 Emergent Wetland

3.10.2.3.1 Description

The Emergent Wetland cover type will occur primarily within off-channel wetland features and connected wetland complexes throughout the floodplain. It will occupy a zone adjacent to the Riparian Wetland cover type (Section 3.10.2.4). This cover type will consist of herbaceous wetland plants such as sedges (*Carex* species), bulrushes (*Scirpus* species), cattails (*Typha* species), rushes (*Juncus* species), and some wetland grasses. These areas have deeper soils than adjacent cover types and more stable hydroperiods (less groundwater fluctuation within the rooting zone than would be present in the Riparian Wetland cover type), and they would likely be submerged during flows above the 2-year return flow. The Emergent Wetland cover type will support several floodplain functions including flood water retention and energy dissipation, sediment storage, primary production, aquatic and terrestrial habitat, aquifer recharge, and nutrient cycling.

3.10.2.3.2 Strategy

The revegetation strategy for Emergent Wetland cover type includes the following:

- Grading and substrate placement in association with floodplain shaping to create suitable growing conditions for native wetland vegetation.

- Placing large and coarse woody debris (microtopography) within connected wetland complexes to mimic floodplain and wetland features that are created and maintained by beaver.
- Planting herbaceous plugs within wetlands according to hydrologic zones preferred by various wetland species.
- Seeding with a two-stage seed mix to provide short- and long-term vegetative cover, and to promote a diverse native seed bank.

Table 26 summarizes revegetation criteria and treatments for the Emergent Wetland cover type.

Table 26. Emergent Wetland Cover Type Criteria and Revegetation Treatments.

Emergent Wetland Cover Type	**Total Area = 11.2 acres** **Percent of Total Area = 8.9%**	
Treatment	**Criterion/Description**	**Treatment Area**
Grading	-2.5 to -1.0 feet relative to 2-year WSE	11.2 acres
Soil Texture	Silt to sandy loam (vegetative backfill)	11.2 acres
Vegetative Backfill Depth	24 inches (over alluvium)	11.2 acres
Microtopography	Large and coarse woody debris complexes installed within linear swales that connect wetland features	11.2 acres
Containerized Planting: Herbaceous Plugs	Herbaceous plugs installed according to appropriate hydrologic zones	11.2 acres
Seeding	Seed with two-stage seed mix for early germination cover crop and long-term diverse native mix of grasses and forbs	11.2 acres

3.10.2.4 Riparian Wetland

3.10.2.4.1 Description

The Riparian Wetland cover type aims to mimic the floodplain landscape features that would have been created and maintained by beaver or natural abandoned channel meanders (oxbows) over time in this type of floodplain system. Plant communities in this cover type include a shrubby overstory of willows, birch (*Betula* species), and dogwood (*Cornus* species) with a diverse understory comprised of various bulrushes (*Scirpus* species), sedges (*Carex* species), rushes (*Juncus* species), wetland grasses, and forbs. Understory species composition will develop at a local-scale in response to elevation, depth to groundwater, and other hydrologic factors that influence vegetation development into distinct “zones”. The Riparian Wetland cover type will contribute to primary production, nutrient cycling, and aquatic and terrestrial habitat among other desired ecological functions. This cover type will occupy floodplain areas that are 0 to 1.0 feet below the 2-year WSE. Soils within this cover type are expected to remain saturated or inundated throughout much of the growing season, and therefore support various riparian and wetland plant communities. Over time, this community could shift to the Floodplain Riparian Shrub cover type depending on floodplain processes and plant community succession.

3.10.2.4.2 Strategy

The revegetation strategy for the Riparian Wetland cover type includes the following:

- Grading associated with floodplain construction to create connected off-channel wetland complexes, connected wetlands, and secondary channels where floodplain elevations and depth to groundwater will support a wide range of riparian and wetland plant species.
- Substrate variation and microtopographic enhancements to provide suitable growth media and microsites for better germination and plant survival.
- Installation of large and coarse woody debris (microtopography) to create niches and microsites for vegetation development and add organic matter to the soil.
- Installation of containerized plant material to promote establishment of the vegetation community and provide a long-term seed source.
- Installation of browse protection to protect containerized plants from ungulate and beaver browse.
- Seeding with a two-stage seed mix to provide immediate cover for erosion protection, establish perennial vegetation, and establish a native seed bank in the soil.

Table 27 summarizes the revegetation criteria and treatments for the Riparian Wetland cover type.

Table 27. Riparian Wetland Cover Type Criteria and Revegetation Treatments.

Riparian Wetland Cover Type	**Total Area = 7.4 acres** **Percent of Total Area = 5.9%**	
Treatment	**Criterion/Description**	**Treatment Area**
Grading	-1.0 to 0 feet relative to 2-year WSE	7.4 acres
Soil Texture	Silt to sandy loam (vegetative backfill) overlying gravel or cobble (alluvium)	7.4 acres
Vegetative Backfill Depth	12 inches	7.4 acres
Microtopography	Large and coarse woody debris will be partially buried and scattered throughout floodplain and within connected wetland complexes as grade control features	7.4 acres
Containerized Planting: Shrubs and Trees	Shrubs and trees will be installed in all areas of this cover type; features include swales, off-channel wetlands, and along secondary channels	7.4 acres
Browse Protection	Exclosures around planting floodplain swales; individual protectors along connected wetland complexes	TBD
Seeding	Seed with two-stage seed mix for early germination cover crop and long-term diverse native mix of grasses and forbs	7.4 acres

3.10.2.5 Floodplain Riparian Shrub

3.10.2.5.1 Description

The Floodplain Riparian Shrub cover type will occupy the largest percentage of floodplain area within the Phases 5 and 6 project areas. It will occur mostly at the 2-year WSE, but will include areas slightly below and slightly higher than this elevation. Soils are expected to be saturated for long enough during the growing season to support riparian plant communities with some wetland characteristics. Plant communities will consist of a variety of shrubs including those species that are components of the Riparian Wetland cover type described above. The Floodplain Riparian Shrub cover type will also have an overstory component consisting of patches of quaking aspen (*Populus tremuloides*) and black cottonwood (*Populus balsamifera ssp. trichocarpa*). Understory species will include some wetland graminoids, but drier species such as Rocky Mountain juniper (*Juniperus scopulorum*) will also be present, particularly where the design requires higher floodplain elevations to limit risk of a channel avulsion. This cover type will provide structural diversity in the floodplain, diverse terrestrial habitat, and long-term floodplain stability.

3.10.2.5.2 Strategy

The revegetation strategy for the Floodplain Riparian Shrub cover type includes the following:

- Grading and substrate placement associated with floodplain construction. This cover type will occupy the floodplain that is connected at the 2-year WSE with lower elevation swales incorporated into this surface.
- Substrate variation and microtopographic enhancements to provide suitable growth media and microsites for better germination and plant survival.
- Installation of large and coarse woody debris (microtopography) to create niches and microsites for vegetation development and add organic matter to the soil.
- Installation of containerized plant material within swale features and potential meander cut-offs to promote the establishment of the vegetation community and provide a long-term seed source.
- Installation of browse protection to protect containerized plants from ungulate and beaver browse.
- Seeding with a two-stage seed mix to provide immediate cover for erosion protection, establish perennial vegetation, and establish a native seed bank in the soil.

Table 28 summarizes revegetation criteria and treatments for the Floodplain Riparian Shrub cover type.

Table 28. Floodplain Riparian Shrub Cover Type Criteria and Revegetation Treatments.

Floodplain Riparian Shrub Cover Type	**Total Area = 76.5 acres** **Percent of Total Area = 61.1%**	
Treatment	**Criterion/Description**	**Treatment Area**
Grading	-0.5 to 2.5 feet relative to 2-year WSE	76.5 acres
Soil Texture	Silt loam to sandy loam	76.5 acres
Vegetative Backfill Depth	12 inches	76.5 acres
Microtopography	Partially buried large and coarse woody debris scattered throughout floodplain	76.5 acres
Containerized Planting	Shrubs and trees installed in swales and potential meander cut-offs	5.0 acres
Browse Protection	Exclosures around groups of planting swales and potential meander cut-offs; individual protectors in areas where exclosures are not feasible	TBD
Seeding	Seed with two-stage seed mix for early germination cover crop and long-term diverse native mix of grasses and forbs	76.5 acres

3.10.2.6 Outer Bank Riparian Shrub

3.10.2.6.1 Description

The Outer Bank Riparian Shrub cover type includes areas where the desired long-term vegetation community is dense, deeply rooted riparian trees and shrubs on outer meander bends where the objective is streambank stability. This cover type will be concentrated along outer meander bends to enhance streambank stability, provide overhanging bank vegetation, and create roughness along the channel margins. Native woody shrub and tree species will dominate the overstory and mid-canopy layers while a mix of native forbs and grasses will occupy the understory. Deep-rooted shrubs such as willow, birch, and dogwood provide streambank stability especially when they are incorporated into streambank bioengineered treatments. Plant communities developing in this cover type will contribute organic material to the stream through leaf litter and vegetation falling into the channel as banks erode over time; larger vegetation pieces will support aquatic habitat by creating roughness along the channel margins. This cover type differs from the Floodplain Riparian Shrub cover type because it has a denser distribution of native woody shrubs.

3.10.2.6.2 Strategy

The revegetation strategy for the Outer Bank Riparian Shrub cover type includes the following:

- Grading and substrate placement in association with streambank bioengineering and floodplain shaping to create suitable growing conditions for native vegetation.

- Installation of large and coarse woody debris (microtopography) to create niches and microsites for vegetation development and promote soil development.
- Installation of containerized plant material in conjunction with streambank treatments.
- Installation of individual browse protection or large browse exclosures around plantings to protect containerized plants from ungulate and beaver browse.
- Seeding with a two-stage seed mix to provide immediate cover for erosion protection, establish perennial vegetation, and establish a native seed bank in the soil.

Table 29 summarizes revegetation criteria and treatments for the Outer Bank Riparian Shrub cover type.

Table 29. Outer Bank Riparian Shrub Cover Type Criteria and Revegetation Treatments.

Outer Bank Riparian Shrub Cover Type	**Total Area = 3.6 acres** **Percent of Total Area = 2.9%**	
Treatment	**Criteria/Description**	**Treatment Area**
Grading	0 to 2.0 feet relative to 2-year WSE	3.6 acres
Soil Texture	Silt loam to sandy loam (vegetative backfill)	3.6 acres
Vegetative Backfill Depth	12 inches	3.6 acres
Microtopography	Partially buried large and coarse woody debris scattered throughout floodplain	3.6 acres
Containerized Planting: Trees and Shrubs	Planted in all areas throughout the cover type	3.6 acres
Browse Protection	Exclosures or individual protectors depending on proximity to channel and size of planting area	TBD
Mature Shrub Transplant	Behind streambank bioengineered treatments	TBD
Seeding	Seed with two-stage seed mix for early germination cover crop and long-term diverse native mix of grasses and forbs	3.6 acres

3.10.2.7 Upland Transition

3.10.2.7.1 Description

The Upland Transition cover type occurs at the outside edges of the newly constructed floodplain where the floodplain transitions to significantly higher ground. This cover type serves as a transition between the riparian and floodplain vegetation communities to surrounding drier, upland vegetation communities. This Upland Transition cover type will consist primarily of herbaceous grasses and forb species that are typically adapted for drier growing conditions. However, some species adapted to a wider range of hydrologic tolerance will be included to occupy slightly wetter microsites and prohibit weed invasion. The depth to groundwater is deeper than other cover types and soils will likely be relatively dry through most of the growing

season. The Upland Transition cover type will primarily serve as an intermediate zone between the floodplain and adjacent uplands, but also supports some floodplain functions such as providing terrestrial habitat, filtering sediment and nutrients associated with agricultural runoff, flood storage during large flood events, and food web support.

3.10.2.7.2 Strategy

The revegetation strategy for the Upland Transition cover type includes the following:

- Grading and substrate placement in association with floodplain shaping to create suitable growing conditions for native upland vegetation.
- Seeding with a two-stage seed mix to promote a diverse, native seed bank.

Table 30 summarizes revegetation criteria and treatments for the Upland Transition cover type.

Table 30. Upland Transition Cover Type Criteria and Revegetation Treatments.

Upland Transition Cover Type	**Total Area = 7.7 acres** **Percent of Total Area = 6.2%**	
Treatment	**Criterion/Description**	**Treatment**
Grading	2.0+ feet relative to 2-year WSE	7.7 acres
Soil Texture	Silt to sandy loam (vegetative backfill)	7.7 acres
Vegetative Backfill Depth	12+ inches	7.7 acres
Seeding	Drill seed with two-stage seed mix for early germination cover crop and long-term diverse native mix of grasses and forbs	7.7 acres

3.10.3 Revegetation Treatments

Table 31 summarizes revegetation treatments proposed for the Phases 5 and 6 project area and the general locations where each treatment is proposed for application. Each treatment is described in more detail in the following sections.

Table 31. Summary of Revegetation Treatments and General Locations for the Phases 5 and 6 Project Area.

Revegetation Treatment	Treatment Location
FLOODPLAIN GRADING	
Geomorphic Features	All areas within grading limits
Substrate	All areas within grading limits
Floodplain swales	Within the Floodplain Riparian Shrub cover type
Microtopography	All areas within grading limits except the Exposed Depositional and Upland Transition cover types
Bank Structure Revegetation	Dormant cuttings installed within bank treatments according to bank designs
PLANTING	
Containerized Trees and Shrubs	All vegetation cover types except Upland Transition and Exposed Depositional; only swales within the Floodplain Riparian Shrub cover type; and approximately half the area of Colonizing Depositional
Herbaceous Plugs	Approximately half the area within Colonizing Depositional and all areas of the Emergent Wetland cover type according to hydrologic zones
Browse Protection	All areas where containerized trees and shrubs are installed
SEEDING	
Two-Stage Seed Mix – Drill Seeding	All areas within grading limits where equipment access is feasible except the Exposed Depositional cover type
Two-Stage Seed Mix – Broadcast	All areas within grading limits where equipment access is not feasible except the Exposed Depositional cover type

3.10.3.1 Floodplain Grading

3.10.3.1.1 Geomorphic Features

The grading plan includes details for removing contaminated sediments from the floodplain and creating a new floodplain surface. Section 3.10.1 above describes the geomorphic features integrated into the grading plan and how floodplain cover types are tied to these geomorphic features. Floodplain cover types are the basis for applying revegetation treatments in the project area. Table 32 summarizes the grading criteria applied for each floodplain cover type and summarizes the total area of each floodplain cover type in the grading limits.

Table 32. Relationship of Floodplain Cover Type to Geomorphic Features, Elevation Relative to the 2-Year WSE, and Total Area Based on the Preliminary Design Grading Surface.

Floodplain Cover Type	Geomorphic Floodplain Feature	Elevation Relative to 2-Year WSE (feet)	Area (acres)
Exposed Depositional (Non-vegetated)	Non-vegetated portion of point bars	-2.5 to -1.0	3.5
Colonizing Depositional (Vegetated)	Vegetated portion of point bars	-1.0 to 0	15.3
Emergent Wetland	Passive margins along channel; wetlands, oxbows, and backwater areas	-2.5 to -1.0	11.2
Riparian Wetland	Bankfull floodplain in backwater areas; edge of emergent wetlands and oxbows	-1.0 to 0	7.4
Floodplain Riparian Shrub	Bankfull floodplain; low terrace	-0.5 to 2.5	76.5
Outer Bank Riparian Shrub	Streambanks along outer meanders	0 to 2.0	3.6
Upland Transition	Slope transitions to higher terraces; high inclusions within CMZ	2.0 +	7.7

3.10.3.1.2 Substrate Variation

Plant community development within vegetation cover types requires varied substrate and soil textures. Substrates range from bare alluvium in Exposed Depositional and Colonizing Depositional cover types to vegetative backfill (silt loam to sandy loam) in other cover types. Table 33 summarizes the desired substrate for each floodplain cover type; it also distinguishes among cover types where alluvium will underlie vegetative backfill and cover types where vegetative backfill can be placed on a wider range of material, depending on the available subgrade material.

Table 33. Substrate Criteria and Volumes for Floodplain Cover Types.

Floodplain Cover Type	Soil/Substrate Texture	Volume of Gravel Alluvium (cubic yards)	Vegetative Backfill Depth (inches)	Volume of Vegetative Backfill (cubic yards)
Exposed Depositional (Non-vegetated)	Sand, fine to coarse gravel or cobble (alluvium)	4,000	0	0
Colonizing Depositional (Vegetated)	Sand, fine to coarse gravel or cobble (alluvium)	21,000	0	0
Riparian Wetland	Silt to sandy loam (vegetative backfill) overlying gravel or cobble (alluvium)		12	6000
Floodplain Riparian Shrub	Silt loam to sandy loam (vegetative backfill) overlying alluvium		12	116,000
Outer Bank Riparian Shrub	Silt loam to sandy loam (vegetative backfill)		12	5,000
Emergent Wetland	Silt to sandy loam (vegetative backfill)		24	5,000
Upland Transition	Silt loam to sandy loam (vegetative backfill)		12	13,000

3.10.3.1.3 Floodplain Swales

Floodplain swales are small depression features incorporated into the Floodplain Riparian Shrub cover type that provide microsites where floodplain vegetation can establish at slightly lower elevations—closer to the water table—than adjacent floodplain surfaces. Floodplain swales also provide flood water and sediment storage at variable flows, in addition to broadening the range of ecological niches available on the floodplain surface to support different life stages (and behaviors) of plant, bird, amphibian, and terrestrial wildlife species.

To maximize diversity, floodplain swales should vary in size and depth. Dimensions will vary and range from 15 to 30 feet wide and 20 to 50 feet long. Swale depth will be at least 1 foot below the adjacent surface. For larger swales, depth can be up to 2.5 feet below the adjacent surface. The side slopes of swales will be no steeper than 3:1. Where avulsion risks are a concern, swales will be oriented perpendicular to the channel. Figure 35 shows examples of constructed floodplain swales.

Figure 35. Examples of Constructed Floodplain Swale Features.

3.10.3.1.4 Microtopography

This treatment creates complexity and microsites on newly constructed floodplain surfaces to trap and protect seed and other plant propagules, and to provide resistance to erosion by limiting rill formation. Microtopography is created using equipment to roughen the floodplain surface and partially bury woody debris in the soil (Figure 36). Roughness or microtopography creates variation in the constructed floodplain surface ranging from 0.5 feet above to 0.5 feet below the design floodplain surface. The woody debris increases soil moisture retention, creates protective microsites for establishing seed and plants, and promotes soil development by introducing organic material. Microtopography will be placed in all floodplain cover types except Exposed Depositional and Upland Transition.

Two types of woody debris, large and coarse, are included as part of the microtopography treatment. Large woody debris consists of 8-inch diameter pieces of wood that are at least 10 feet in length, and these pieces will be placed at a rate of approximately 50 pieces per acre. Large woody debris will be partially buried within the floodplain surface, leaving no more than half of the log exposed. Smaller, coarse woody debris can be highly variable in size (salvaged material from floodplain clearing within the removal boundary is suitable) and will be placed at a rate of approximately 100 to 150 pieces per acre. Coarse woody debris does not need to be buried but should be scattered within swales or piled around planted shrubs and trees.

Figure 36. Photograph Showing Microtopography Placed on a Constructed Floodplain Surface.

3.10.3.2 Bank Structure Revegetation

Dormant cuttings from native shrub and tree species are the primary plant material incorporated into streambank treatments. Cuttings are collected from plants that root easily, such as willows (*Salix* species) and cottonwoods (*Populus* species). The best species to use for willow cuttings for the Phases 5 and 6 project area, in order of preference, are as follows: sandbar willow (*Salix exigua*), Geyer willow (*Salix geyeriana*), Booth's willow (*Salix boothii*), Bebb willow (*Salix bebbiana*), yellow willow (*Salix lutea*), and Pacific willow (*Salix lasiandra*). All species should be used as part of a multi-species collection. In addition, black cottonwood (*Populus balsamifera ssp. trichocarpa*) cuttings can be used in some areas. Red-osier dogwood (*Cornus sericea*) and gray alder (*Alnus incana*) may also be used as cuttings, but should only be used as part of a mix consisting primarily of willow species. All streambank treatments require dormant cuttings incorporated into some portion of the reconstructed streambank; the quantities of cuttings needed for each treatment will be included in the final design.

3.10.3.3 Planting

Containerized plants will be installed within the following floodplain cover types: Colonizing Depositional, Emergent Wetland, Riparian Wetland, Outer Bank Riparian Shrub, and in swales within the Floodplain Riparian Shrub (Table 34). Containerized plant installation locations are shown in Figure 33 and Figure 34. In general, plant mixes include early-successional species such as cottonwoods, aspen, willows, currant (*Ribes* species), birch (*Betula* species), and alder (*Alnus* species) that may be better suited for the minimal shade conditions and lack of developed soils that will be present on the newly constructed floodplain surface.

In the Floodplain Riparian Shrub cover type, planting will be concentrated within excavated swale features. Shrubs will be installed throughout the Colonizing Depositional, Outer Bank Riparian Shrub, and Riparian Wetland cover types. Herbaceous plugs, consisting of sedges (*Carex* species) and rushes (*Juncus* species), will be installed within the Emergent Wetland and Colonizing Depositional cover types. Table 35 through Table 40 provide the species included in each plant mix.

Table 34. Floodplain Cover Type Planting Locations, Plant Mixes, and Number of Plants.

Floodplain Cover Type	Planting Locations	Area to be Planted (acres)	Type of Plant Material	Approx. Spacing (feet on center)	Total Number of Plants
Exposed Depositional	None	N/A	N/A	N/A	N/A
Colonizing Depositional	All Areas	7.7	10 in^3 herbaceous	6	9,257
		7.7	10 in^3 shrubs	6	9,257
Emergent Wetland	All Areas	11.2	10 in^3 herbaceous	3	54,208
Riparian Wetland	All Areas	7.4	1 gallon shrubs	8	5,037
Floodplain Riparian Shrub	Swales	5	1 gallon shrubs	8	3,403
			1 gallon trees	15	968
Outer Bank Riparian Shrub	All Areas	3.6	1 gallon shrubs	8	2,450
			1 gallon trees	15	697
Upland Transition	None	N/A	N/A	N/A	N/A
				Total	85,276

3.10.3.3.1 Plant Mixes

The following tables list the species for plant mixes to be used for the Phases 5 and 6 project area.

Table 35. Colonizing Depositional – Herbaceous Plant Mix.

Scientific Name	Common Name	Percent of Mix
Carex aquatilis	water sedge	20
Carex nebrascensis	Nebraska sedge	10
Carex pellita (syn. *C. lanuginosa*)	woolly sedge	10
Carex utriculata	Northwest Territory sedge	20
Eleocharis palustris	common spikerush	10
Juncus arcticus	arctic rush	10
Scirpus microcarpus	panicled bulrush	20
	Total	**100**

Table 36. Colonizing Depositional – Shrub Plant Mix.

Scientific Name	Common Name	Percent of Mix
Alnus incana	gray alder	5
Betula occidentalis	water birch	20
Salix bebbiana	Bebb willow	5
Salix boothii	Booth's willow	20
Salix exigua	sandbar willow	45
Salix geyeriana	Geyer willow	5
	Total	**100**

Table 37. Emergent Wetland – Herbaceous Plant Mix.

Scientific Name	Common Name	Percent of Mix
Carex aquatilis	water sedge	15
Carex microptera	small winged sedge	5
Carex nebrascensis	Nebraska sedge	5
Carex pellita (syn. C. lanuginosa)	woolly sedge	5
Carex utriculata	Northwest Territory sedge	10
Carex vesicaria	inflated sedge	20
Eleocharis palustris	common spikerush	10
Juncus arcticus	arctic rush	10
Schoenoplectus acutus	hardstem bulrush	10
Scirpus microcarpus	panicled bulrush	10
	Total	**100**

Table 38. Riparian Wetland – Shrub Plant Mix.

Scientific Name	Common Name	Percent of Mix
Alnus incana	gray alder	10
Betula occidentalis	water birch	15
Cornus sericea	red-osier dogwood	10
Ribes setosum	inland gooseberry	10
Salix bebbiana	Bebb willow	10
Salix boothii	Booth's willow	10
Salix exigua	sandbar willow	20
Salix geyeriana	Geyer willow	5
Salix lutea	yellow willow	5
Salix planifolia	plane-leaf willow	5
	Total	**100**

Table 39. Floodplain Riparian Shrub Swales – Tree and Shrub Plant Mix.

Scientific Name	Common Name	Percent of Mix
Trees		
Populus balsamifera ssp. trichocarpa	black cottonwood	85
Populus tremuloides	quaking aspen	15
	Total	**100**
Shrubs		
Alnus incana	gray alder	10
Betula occidentalis	water birch	10
Cornus sericea	red osier dogwood	10
Ribes setosum	inland gooseberry	10
Salix bebbiana	Bebb willow	10
Salix boothii	Booth's willow	5
Salix exigua	sandbar willow	10
Salix geyeriana	Geyer willow	5
Salix lutea	yellow willow	5
Salix planifolia	plane-leaf willow	5
Sheperdia argentea	silver buffaloberry	10
Symphoricarpos occidentalis	western snowberry	10
	Total	**100**

Table 40. Outer Bank Riparian Shrub – Tree and Shrub Plant Mix.

Scientific Name	Common Name	Percent of Mix
Trees		
Populus balsamifera ssp. trichocarpa	black cottonwood	85
Populus tremuloides	quaking aspen	15
	Total	**100**
Shrubs		
Alnus incana	gray alder	5
Betula occidentalis	water birch	15
Cornus sericea	red-osier dogwood	10
Dasiphora floribunda	shrubby cinquefoil	5
Ribes aureum	golden currant	5
Ribes setosum	inland gooseberry	5
Rosa woodsii	Woods' rose	5
Salix bebbiana	Bebb willow	10
Salix boothii	Booth's willow	10
Salix exigua	sandbar willow	5
Salix lutea	yellow willow	5
Sheperdia argentea	silver buffaloberry	15
Symphoricarpos occidentalis	western snowberry	5
	Total	**100**

3.10.3.4 Browse Protection

Browse protection measures are intended to protect planted shrubs and trees from browse and other damage caused by wildlife. Two types of browse protection may be used for the Phases 5 and 6 project area: fenced exclosures and individual plant protectors. Exclosures are the preferred method of protection because they require less maintenance than individual protectors and can protect plantings over a longer period of time. Exclosures will target groups of plants installed in constructed floodplain swale and wetland features. Individual protectors will be needed in areas where the feasibility of exclosure fencing installation is difficult, for example, planting units immediately adjacent to the channel.

A variety of fencing options are available to construct browse exclosures. The preferred fence option for floodplain swales includes 12-foot long, 4-inch diameter untreated wooden posts installed vertically at least 3 feet deep along the perimeter of a swale with a sturdy plastic mesh fencing material, such as Deer-D-Fence (Figure 37, left). The fencing material is secured to the posts with releasable cable ties or other fasteners that allow removal of fencing during high flows. Individual browse protectors consist of a 4-foot wide by 4-foot tall piece of black polyethylene (UV-stabilized) extruded mesh rounded into a 16-inch diameter cylinder (Figure 37, right). The individual browse protector encloses a plant and is secured to two 2-inch-square wooden stakes with releasable cable ties. The browse protector will be installed so its base is in contact with the ground surface to discourage rodents from girdling plants. Details for fencing browse protection will be included in the 90% Design drawing set.

Figure 37. Photographs Showing Examples of Browse Protection Measures: a Wildlife Exclosure Fence (left) and Individual Browse Protectors (right).

3.10.3.5 Seeding

Establishing native vegetative cover on the newly created floodplain is essential for maintaining soil stability and preventing weed infestations. Planting will establish native vegetation in portions of the floodplain, but seeding is the primary mechanism for stabilizing soil within the new floodplain. To ensure quick, long-lasting vegetation establishment a two-stage seed mix will be used. The two-stage seed mix includes two components: a mix of quick germinating species (nurse crop or cover crop) that will provide immediate cover to limit colonization by invasive species and a mix of long-term desired species that may not germinate immediately after construction because they may require a stratification period. Seed mixes consist of a range of herbaceous species including grasses, forbs, sedges, and/or rushes. Woody species may also be seeded in select areas of most of the floodplain cover types.

Several seed mixes will be used throughout the floodplain to support establishment of desired plant communities. Seed mixes are linked to specific floodplain cover types. Table 41 summarizes seed mixes by floodplain cover type. Table 42 through Table 45 provide the species for each seed mix. Seeding rates will be developed as part of the 90% Design plan set.

Various methods for seeding may be required due to ground conditions or because the variety of seeds within the seed mixes need to be planted at different depths and/or during different seasons. Hand broadcast seeding will be required in most areas where the microtopography treatment is installed. The roughness created by the microtopography treatment makes equipment access difficult or impossible. Broadcast seed should be either hand raked or harrowed into the soil after application, depending on the size and sensitivity of the seeded areas. Drill seeding should be possible in the Upland Transition cover type where the microtopography treatment will not be applied.

Table 41. Summary of Seed Mixes for Floodplain Cover Types.

Floodplain Cover Type	Seed Mix	Seeding Area (acres)
Colonizing Depositional (Vegetated)	Wet Floodplain	15.3
Emergent Wetland	Wetland	11.2
Riparian Wetland	Wet Floodplain	7.4
Floodplain Riparian Shrub	Floodplain	76.5
Outer Bank Riparian Shrub	Floodplain	3.6
Upland Transition	Upland	7.7

Table 42. Wet Floodplain Seed Mix.

Scientific Name	Common Name
Grasses	
Deschampsia caespitosa	tufted hairgrass
Elymus canadensis	Canada wildrye
Elymus trachycaulus	slender wheatgrass
Leymus (Elymus) cinereus	great basin wildrye
Pascopyrum smithii	western wheatgrass
Poa compressa	Canada bluegrass
Sporobolus airoides	alkali sacaton
Forbs	
Achillea millefolium	common yarrow
Argentina anserina	silverweed cinquefoil
Artemisia ludoviciana	white sage
Aster occidentalis	western aster
Astragalus canadensis	Canadian milkvetch
Cleome serrulata	Rocky Mountain bee plant
Linum lewisii	Lewis flax
Verbena hastata	swamp verbena

Table 43. Floodplain Seed Mix.

Scientific Name	Common Name
Grasses	
Sterile cover crop	TBD
Agropyron riparium	streambank wheatgrass
Elymus canadensis	Canada wildrye
Elymus lanceolatus	thickspike wheatgrass
Elymus trachycaulus	slender wheatgrass
Leymus (Elymus) cinereus	great basin wildrye
Forbs	
Achillea millefolium	common yarrow
Artemisia ludoviciana	white sage
Astragalus canadensis	Canadian milkvetch
Cleome serrulata	Rocky Mountain bee plant
Gaillardia spp.	blanketflower
Linum lewisii	Lewis flax
Verbena hastata	swamp verbena
Shrubs	
Cornus sericea	red-osier dogwood
Dasiphora floribunda	shrubby cinquefoil
Ribes setosum	inland gooseberry
Shepherdia argentea	silver buffaloberry

Table 44. Wetland Seed Mix.

Scientific Name	Common Name
Grasses, Sedges, and Rushes	
Beckmannia syzigachne	American sloughgrass
Carex aquatilis	water sedge
Carex pellita (syn. *C. lanuginosa*)	woolly sedge
Carex microptera	small winged sedge
Carex utriculata	Northwest Territory sedge
Deschampsia cespitosa	tufted hairgrass
Eleocharis palustris	common spikerush
Elymus trachycaulus	slender wheatgrass
Glyceria striata	fowl mannagrass
Juncus arcticus	arctic rush
Schoenoplectus acutus	hardstem bulrush
Scirpus microcarpus	panicled bulrush
Forbs	
Argentina anserina	silverweed cinquefoil
Iris missouriensis	Rocky Mountain Iris
Mimulus gutattus	seep monkey flower

Table 45. Upland Seed Mix.

Scientific Name	Common Name
Grasses	
Sterile cover crop	TBD
Bromus marginatus	mountain brome
Leymus (Elymus) cinereus	great basin wildrye
Elymus trachycaulus	slender wheatgrass
Elymus lanceolatus	thickspike wheatgrass
Festuca idahoensis	Idaho fescue
Pascopyrum smithii	western wheatgrass
Poa secunda	Sandberg bluegrass
Stipa viridula	green needlegrass
Forbs	
Achillea millefolium	common yarrow
Artemisia ludoviciana	white sage
Gaillardia spp.	blanketflower
Shrubs	
Artemisia cana	silver sagebrush
Artemisia frigida	prairie sagewort
Dasiphora floribunda	shrubby cinquefoil
Ericameria nauseosa	rubber rabbitbrush
Ribes setosum	inland gooseberry
Shepherdia argentea	silver buffaloberry

3.10.4 Preservation Areas within Removal Boundary

Four types of preservations areas occur in the Phases 5 and 6 project area:

- Distinct plant communities with no soil contamination,
- Hydrologically connected native wetland and riparian vegetation,
- Cottonwood stands, and
- Historical preservation of a cabin.

Figure 38 and Figure 39 show the locations of these types of preservation within Phases 5 and 6, respectively.

Some locations within the extents of soil sampling, described in Sections 2.5, were found to have clusters of soil pits with no contamination that closely corresponded to vegetation community boundaries. Two of these locations comprise approximately 2.2 acres. One location in Phase 5 is associated with an Upland Herbaceous vegetation community and another area in Phase 6 is associated with a Low Shrub-Upland Herbaceous vegetation community.

As described in Section 3.2, some hydrologically connected riparian and wetland vegetation communities will be preserved as long as they meet the following criteria:

- Located outside of the CMZ,
- Have less than 2 feet of contamination,
- Have arsenic levels not exceeding cleanup levels, and
- Have elevations 0.5 feet above the 2-year WSE or lower.

These communities are currently providing important ecological functions in the floodplain including primary production, aquatic and terrestrial habitat, aquifer recharge, and nutrient cycling. Reestablishing similar vegetation and ecological functions after remediation can take many years. Preserving these communities where feasible leaves some areas of the floodplain with highly functioning wetland and riparian communities that can also serve as seed sources for other portions of the floodplain. Hydrologically connected areas that meet the criteria for preservation comprise approximately 2.7 acres, consisting of former oxbow features on the east side of the river.

Mature cottonwoods are rare within Phases 5 and 6 of the CFROU and include the Cottonwood Stand and Willow/Birch – Cottonwood Overstory existing vegetation communities. These communities comprise approximately 0.4 acres. Because cottonwood stands are uncommon and provide important habitat and seed source with the CFROU, they will be preserved regardless of their location and depth of contaminated soil.

A cabin within the project area will be preserved for its historical significance. The area to be preserved associated with the cabin is approximately 0.2 acres on the east side of the river near the middle of Phase 5.

All preservation areas will be clearly marked in the field prior to the start of construction. Floodplain grading will occur up to the edges of the preservation area, grading to the necessary depth to remove contaminants from the surrounding area. Alluvium and vegetative backfill will be placed to the necessary depths as specified for the assigned floodplain cover types. Final grading will create gentle slopes of no greater than 3:1 between the vegetation preservation areas and the constructed floodplain.

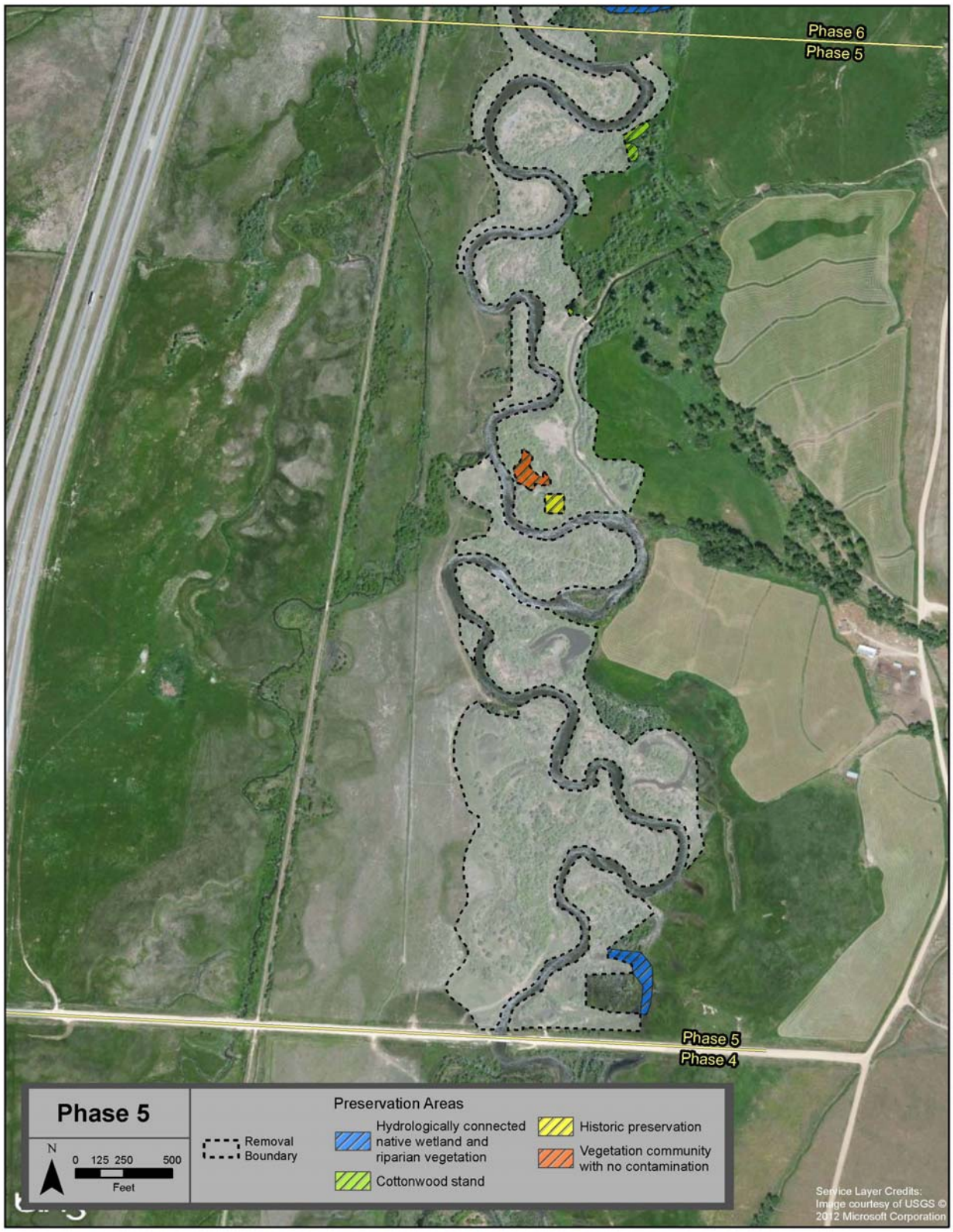

Figure 38. Preservation Areas within Phase 5

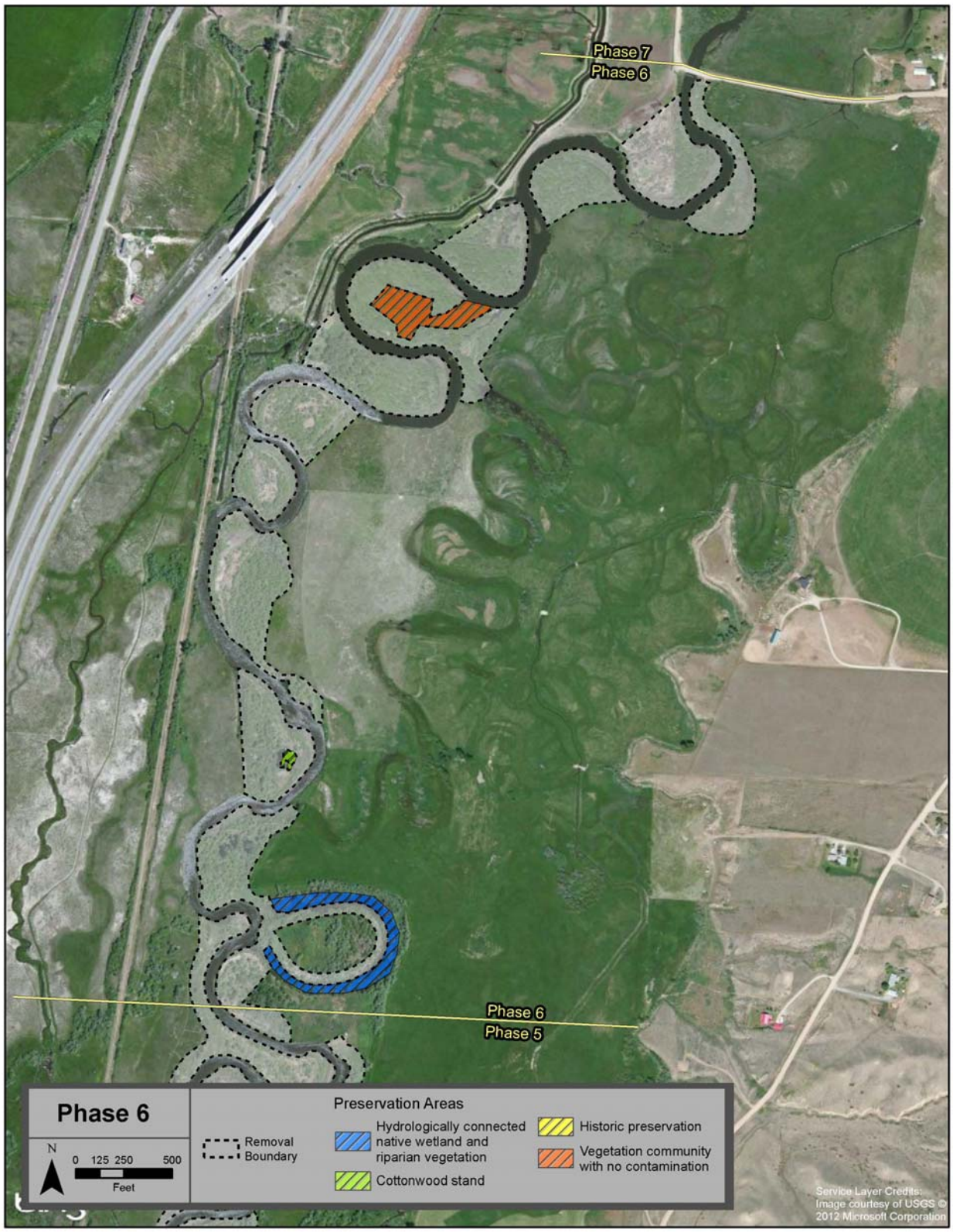

Figure 39. Preservation Areas within Phase 6.

3.10.5 Weed Management and Long-Term Maintenance

Weed management will occur prior to, in conjunction with, and after the revegetation activities described above. During construction the following practices should be followed to avoid the introduction and spread of noxious weeds:

- All vehicles and equipment should arrive free of weeds and weed seeds.
- Vehicle and equipment traffic should remain within designated construction limits and on designated access routes.
- Vehicles should avoid driving through existing weed infestations to the greatest extent possible.
- Noxious weed infestations adjacent to construction limits should be treated according to the weed management plan in order to prohibit the spread of infestations within construction limits.
- All vegetative backfill used during revegetation should be weed and weed seed free.

Vegetation mapping conducted between 2010 and 2012 identified the state-listed noxious weed species within the project area, as shown in Table 46. Other noxious weeds may be present in Phases 5 and 6 that were not recorded within the vegetation sampling plots. All the noxious weeds identified at the site are listed as Priority 2b by the State of Montana (2010). Priority 2b weeds are abundant in Montana and widespread in many counties. Management criteria require eradication or containment where less abundant (State of Montana, 2010).

A long-term weed management plan will be necessary to control weed infestations at the site post-construction and to ensure project goals and objectives are met. Weed management will be most successful if it is coordinated with local weed management experts and authorities. Development of a long-term vegetation management plan for the site and post-construction weed mapping should be coordinated with the Anaconda/Deer Lodge Weed Coordinator and Powell County Weed Coordinator, adjacent private landowners, and watershed groups.

Table 46. Noxious Weed Species Found in Phases 5 and 6 and Their Listing Priority.

Scientific Name	Common Name	Priority
Cardaria draba	whitetop	2b
Centaurea maculosa	spotted knapweed	2b
Cirsium arvense	Canada thistle	2b
Euphorbia esula	leafy spurge	2b
Linaria vulgaris	yellow toadflax	2b

3.11 Supporting Design Elements

Supporting design elements are those components of the project that enable construction of the project and implementation of the primary goals for tailings removal, floodplain and streambank reconstruction, and revegetation. Activities identified as “contractor’s responsibilities” are generally subject to approval by DEQ under the construction contract.

3.11.1 Groundwater Dewatering

Groundwater on the site fluctuates from a high during spring runoff to a low during the irrigation season. Depending on the time of year, a portion of contaminated soil may be saturated and below groundwater. Excavated wastes must be fully drained prior to being hauled to the disposal site. Groundwater dewatering is expected to lower groundwater elevations prior to and during excavation of contaminated soil to permit handling of relatively dry soil. Additionally, it is difficult to keep contaminated and uncontaminated soils from mixing during construction activities when saturated materials are present close to the surface. Although groundwater dewatering is expected to be the primary means of dewatering, saturated material may be stockpiled and allowed to drain prior to hauling; however, this second method requires double handling by the contractor. Dewatered wastes will be more easily handled and will be lower in moisture content for direct placement in the Opportunity Ponds Waste Management Area.

The groundwater dewatering system consists of three design components: (1) dewatering trenches designed to lower the groundwater in the floodplain, (2) collection sumps and pumps and piping to transmit the water to and from the sediment detention/infiltration basins, and (3) sedimentation/infiltration basins designed to detain water pumped from the dewatering trenches prior to discharge to the CFR.

Dewatering collector trenches will consist of primary and secondary trenches. Primary trenches will be located along the center of each meander tab or removal area. The excavated surface will generally slope from the most landward side of the removal boundary toward the river, with low points generally toward the river near the point bar. Secondary trenches may be located within the removal boundary at the contractor's discretion to control surface runoff, in areas that are affected by groundwater or irrigation seepage, and to address the variability of groundwater elevations within the removal boundary. The contaminated soil excavated from the trenches will be disposed in the Opportunity Ponds Waste Management Area. Saturated wastes excavated from the dewatering trenches must be stockpiled to drain water prior to hauling. A typical cross-section of a sump is shown in Appendix E, Preliminary Design Plans on Sheet D1, Dewatering Details.

Collection sumps will be located at the low points of the dewatering trenches. Low points of the primary trenches are located near the river. The contractor shall utilize a pump of sufficient capacity to effectively dewater the site at a rate that equals or exceeds the incoming flow. Pumps will be connected to a piping system that will route flows to the nearest sedimentation/infiltration basin.

Groundwater collected in dewatering trenches must be routed through a sedimentation/ infiltration basin prior to discharge to the CFR. Groundwater must be detained for a sufficient amount of time to reduce turbidity to acceptable levels prior to discharge. Sedimentation/ infiltration basins are sized based on the estimated conditions at the site and in conjunction with the guidelines outlined in the *Montana Sediment and Erosion Control Manual* (DEQ, 1996). Actual pond sizes will be adjusted during construction based on the seasonal groundwater

conditions and actual conditions encountered in the field. Ponds will be removed after they are no longer needed. Approximate pond locations are shown in Appendix E, Preliminary Design Plans on Sheets C5 and C8, Dewatering Plans. Sheet D1, Dewatering Details, shows a cross-section and plan of a typical sedimentation/infiltration basin.

3.11.2 Haul Routes

Haul routes on public roads will be necessary to transport waste and borrow materials to and from the project area. Use of off-site borrow sources such as the Beck Borrow Area requires substantial travel along the existing local road infrastructure. The Beck Borrow Area is located about 11 miles from the site, a half-mile west of the Greenhouse Road and Lake Hill Road intersection. Other off-site borrow areas may be used for coarse backfill but those sources will be selected by the contractor. Waste materials will be transported to the Waste Management Area at Opportunity Ponds, which is located near Highway 48 between Interstate 90 and Highway 1. Highway haul trucks will be utilized to transfer materials from the borrow source area. The planned haul routes will require crossing the Burlington Northern Santa Fe (BNSF) Railway, public road intersections, and utilities while transporting both waste and borrow source materials.

Haul roads located within the project area consist of primary and secondary haul roads. The approximate locations of the primary haul roads are shown in Appendix E, Preliminary Design Plans on the Sheet C9-C12, Excavation Plans. Primary haul roads will run the length of the site along both sides of the river and tie into public roads at Galen Road and Gemback Road. The secondary haul roads, used to access the individual removal areas, will be located by the contractor. The contractor will be responsible for design and construction of the haul roads, approaches and crossings for the anticipated loads, and sizes of the trucks utilized for hauling waste and borrow materials. Adequate drainage measures will be required, including culverts at drainage crossings and road ditches.

Haul Road Design Requirements

Haul routes will be established for safe and efficient materials handling from the Beck Borrow Area and to the Waste Management Area. Development of haul routes will allow haul vehicles to directly deliver materials to and remove materials from the construction areas. During construction activities, haul routes and crossings (public roads, railways, and utilities) will be maintained and appropriate traffic control will be instituted to sustain safe traffic flows.

The following design criteria were developed for the design of construction haul routes/roads:

- Minimize haul lengths.
- Minimize the disturbance of contaminated areas.
- Minimize the effects on the public.
- Maximize safety.
- Utilize a cost-effective design.

Haul routes have been selected for transport of materials based on the design criteria. Specific road routes have been determined for both the Beck Borrow Area source and the Opportunity Ponds Waste Management Area. Only general design parameters have been developed because design and construction of both primary and secondary haul roads will be the responsibility of the contractor.

3.11.3 Traffic Control

A Traffic Control Plan outlining controls, signing, barricades, and access control stations in accordance with the Manual on Uniform Traffic Control Devices (MUTCD) (DOT FHWA, 2012), will be prepared and included in the Bid Package.

Traffic control will also include control of the two crossings of the BNSF Railway. The contractor shall coordinate the required crossing system with BNSF personnel. It is anticipated that both the Sager Lane and the Cross Road 2 crossings of the BNSF Railway will require flaggers during operational hours of the railway.

3.11.4 Mine Waste Repository

The Opportunity Ponds Waste Management Area will be used for relocation of all mine wastes (tailings) excavated from the site. The exact location of the repository for this specific project is unknown at this time; however, it will be within Cell B2-12 of the Waste Management Area. Cell B2-12 is situated in the northwest portion of the Opportunity Ponds Waste Management Area. The cell is approximately 200 acres in area and is surrounded by earthen berms. A railroad spur and load out structure are located near the cell's southwest corner and are currently used for delivery of mine waste materials from the Streamside Tailings Operable Unit projects.

The repository site is located in a semiarid region and average annual precipitation is expected to be within the range of 10 to 14 inches per year, based on rainfall data for Butte, Montana. Tailings waste material was placed in the cell during past operation of the nearby Anaconda Company Smelter. Initial depth of tailings material was estimated at 10 to 20 feet, based on comparison of elevation contours for the cell to adjacent areas that were undisturbed. Characteristics of the smelter tailings were not determined but are expected to consist of mostly silt and sand size material. The cell's foundation material likely consists of sand and gravel similar to that exposed along the margins of the Waste Management Area. Depth to groundwater is estimated at 10 to 20 feet below the contact between smelter tailings and foundation soil. Upon completion of waste disposal from the site, BP will be responsible for placing cover fill on the waste, revegetating the site, and conducting long-term management.

3.11.5 Landowner

The Phases 5 and 6 project is located within the Dry Cottonwood Creek Ranch, which is a 2,300-acre working cattle ranch managed by the Clark Fork Coalition, and on part of the Two Bar Ranch. The project is being coordinated with owners through the Clark Fork Coalition ranch

managers and directly with the owner of the Two Bar Ranch. Impacts to the ranch may include loss of use, access control, irrigation use, borrow sources, noise, dust, and fencing modifications. Loss of use will generally occur between the two primary haul roads on the east and west sides of the river as shown in Appendix E, Preliminary Design Plans on Sheets C9 to C12, Excavation Plans. Portions of the impacted area may be available for grazing and haying as the project begins and prior to removals. Access control to the site will be limited to two locations at Gemback Road and two locations at Galen Road. Access control within the site will be maintained between the primary haul roads and at certain locations where ranching operations need access to irrigation facilities or water for cattle. The project is generally located off irrigated fields and avoids the majority of the irrigation ditches associated with irrigated fields. Some impacts to irrigated fields or irrigation ditches may occur along the western edge of the fields on the east side of the river in the vicinity of the Dry Cottonwood Creek alluvial fan and the Alvi Beck Ditch as shown in Appendix E, Preliminary Design Plans on Sheets C1 and C2, Existing Conditions. The project does impact Alvi Beck Ditch and Whalen Ditch as discussed in Section 3.11.6.

Two potential borrow sources have been identified for the project in coordination with the Dry Cottonwood Creek Ranch managers as shown on Figure 31. Noise and dust will be managed through supporting plans and limitations on work hours to be imposed in the construction contract. Fencing will be removed as needed to accommodate the remedial action. Temporary fencing will be installed along portions of the site that are being actively remediated and will remain in place until vegetation is reestablished and vegetation goals are met. Once vegetation goals are met, permanent fencing will be installed and the temporary fencing will be removed wherever it is no longer needed.

3.11.6 Irrigation Ditches

Both Alvi Beck Ditch and Whalen Ditch will be impacted by the project. Alvi Beck Ditch is contaminated from the headgate at the CFR for approximately 1,200 feet down-gradient. To access and remove the contamination, Alvi Beck Ditch will be removed and reconstructed including replacement of the headgate. The portion of Alvi Beck Ditch impacted by the project is shown in Appendix E, Preliminary Design Plans on Sheet C6, Dewatering Plan. Due to migration of the river into the Whalen Ditch embankment, a portion of the ditch requires realignment to stabilize the streambank. The eroding bank is shown in Figure 8 and is located between Stations 178+00 and 180+00 on Sheet C11, Excavation Plan. The existing bank will likely be abandoned to maintain the swallow habitat and the ditch will be realigned west toward the abandoned railroad embankment. Streambank stabilization may be installed behind the existing embankment in the approximate location of the Whalen Ditch bottom. The activities associated with both of these ditches will occur after the irrigation season so they are completed prior to the following irrigation season.

3.11.7 Construction Sequencing

Construction can be completed in two construction seasons. Certain activities should be performed at designated times of year due to seasonal high water, weather conditions, ranching operations, and vegetation requirements. The timing and extent of spring high water is variable but generally begins around mid-May through late June and tapers off in July. Winter weather

conditions are also variable and long periods of cold temperatures and snow are possible from mid-November until March. Dormant plant cuttings should be harvested during the fall, or between late winter and early spring. Cuttings harvested in the spring may be stored in a cooler, but if they are stored this way they must be installed before July 15. Wetland herbaceous plugs (graminoids) should be planted between May 15 and July 15. Trees and shrubs must be planted while dormant, either during spring after the soil thaws and before leaf-out; or in the fall after October 15. Because willow cuttings are incorporated into some streambank reconstruction treatments, those treatments should be implemented either after willows become dormant in the fall (approximately mid-October) or between late winter and July 15 using dormant cuttings either collected at the time of installation or stored in a cooler. Other than contractual requirements to accommodate landowner operations or plant availability and timing, construction sequencing will be determined by the contractor. Given the constraints discussed above, construction activity may be conducted throughout the year.

3.12 Supporting Plans

Supporting plans are prepared by DEQ or the construction contractor to guide aspects of construction such as quality assurance (QA) and environmental protection that are outside the primary design objectives. At a minimum, six plans will be required, additional plans may be required to meet project specific objectives. The six required plans are:

1. Construction Quality Assurance Plan,
2. Contractor Quality Control Plan
3. Contractor Health and Safety Plan
4. Erosion Control Plan
5. Dust Control Plan, and
6. Weed Control Plan.

In some cases DEQ has prepared a generic plan to address an activity for the entire CFROU; in other cases, a specific plan needs to be prepared by the construction contractor to address the activity. This section provides a summary of what is required by each plan and how responsibilities for items in the plan are apportioned.

3.12.1 Construction Quality Assurance and Quality Control Plan

Construction quality control (QC) will be the responsibility of the Remedial Action construction contractor. QC responsibilities are identified in the Special Provisions and Technical Specifications of the Remedial Action construction documents. DEQ, in consultation, has the responsibility to implement and maintain a QA program that ensures the overall quality of the project. DEQ has prepared a draft Construction Quality Assurance Plan (CQAP) for the CFROU for this purpose (DEQ, 2008a). This plan will be revised to be specific to CFR Reach A Phases 5 and 6. The main purpose of the CQAP is to outline the Agencies' QA procedures for confirming that the Remedial Action for the CFROU meets all performance standards presented in the Property-Specific Remedial Action Work Plans/Bid Packages, plans, specifications, and other Remedial Design/Remedial Action documents. The specific objectives of the CQAP are as follows:

- Define the QA team organization and responsibilities;
- Define the interaction between the QA program and the contractor's QC plan;
- Describe project communication, documentation, and record-keeping protocols, on-site communications, progress meetings, and preparation of progress reports and construction files; and
- Detail the role of the QA team in reviewing and approving certification and calibration submittals; surveying and verifying construction grade and alignment; conducting verification testing, sampling, and analysis; and monitoring during Remedial Action construction activities.

These QA efforts are in addition to the contractor QC program testing and analysis. The draft CQAP will be updated during final design to account for activities to be implemented during construction.

3.12.2 Erosion Control Plan

The construction Erosion Control Plan provides the information necessary to ensure that the substantive requirements of the *Montana General Permit for Storm Water Discharges Associated with Construction Activity* (DEQ, 2013) are met. This plan will identify types of actions where construction activities will require the use of erosion control BMPs and the best type of BMP suitable for each location. Erosion control BMPs are expected to be implemented and maintained at locations of mine wastes and contaminated soils removal; construction roads; and borrow areas, construction staging areas, streambanks, and areas where soils will be lime amended, if any. In addition, the plan will outline the necessary requirements for monitoring and documenting erosion control activities. This plan will be updated during final design to address all stormwater BMPs expected to be used during construction.

The specifications require that the construction contractor prepare an Erosion Control Plan that reflects implementation of the BMPs on the site. The Erosion Control Plan will detail the locations and types of BMPs to be used during construction activities, and is subject to approval by DEQ.

3.12.3 Dust Control Plan

The Dust Control Plan will be the responsibility of the Remedial Action construction contractor. The plan will include a description of the processes that will be implemented to address fugitive dust during construction activities. The plan will identify potential fugitive dust sources and activities at the construction site along with applicable procedures to monitor and minimize dust generation and is subject to approval by DEQ.

3.12.4 Weed Control Plan

Design specifications will require the construction contractor to prepare a weed control plan specific to the project. This plan will describe specific methods and procedures to be used by the

contractor to prevent and/or minimize spread of noxious weeds. It will include designation of washing and decontamination areas and is subject to approval by DEQ.

Section 4.0 References

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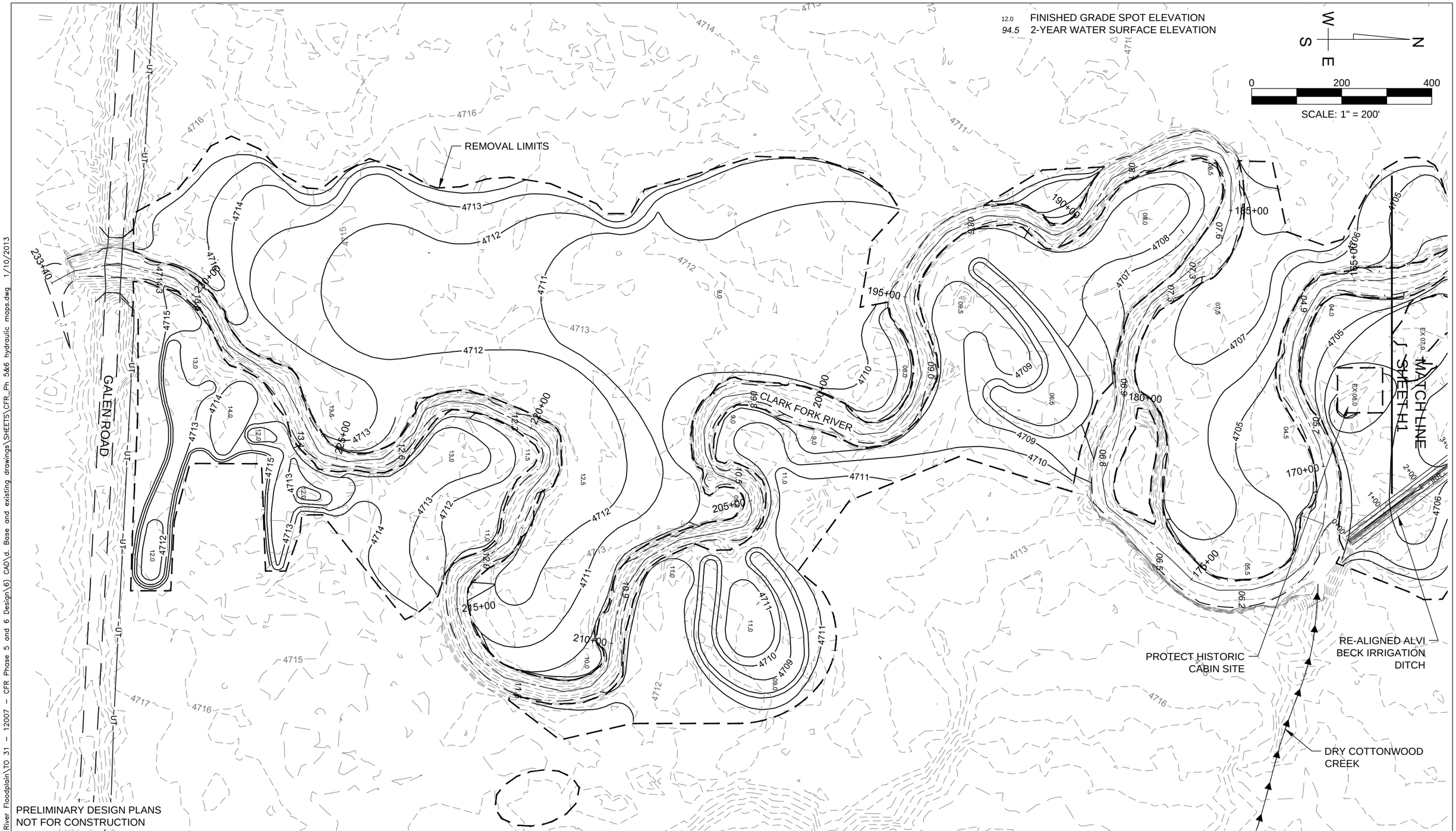
Appendix A

Hydraulic Analysis



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TerraGraphics
Environmental Engineering, Inc.

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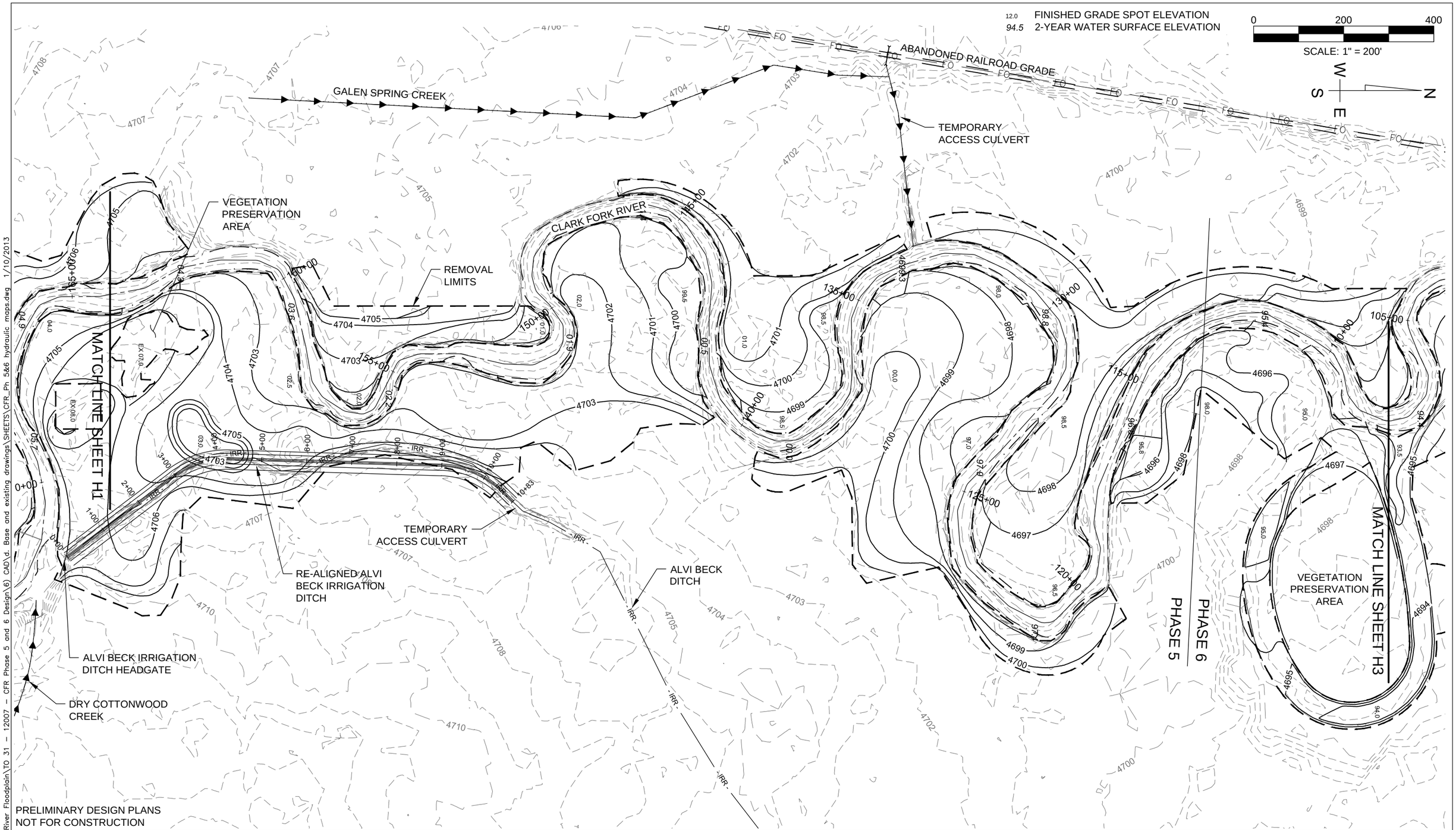
ENGINEER: M. CULPO	SCALE: AS SHOWN		
CHECKED: S. FIROR	APPROVED:	DEER LODGE, MONTANA	
DATE:	DATE:		

SHEET INDEX:	H1
PROJECT NO.:	12007
DATE:	1/10/2013
SHEET:	15 OF 26



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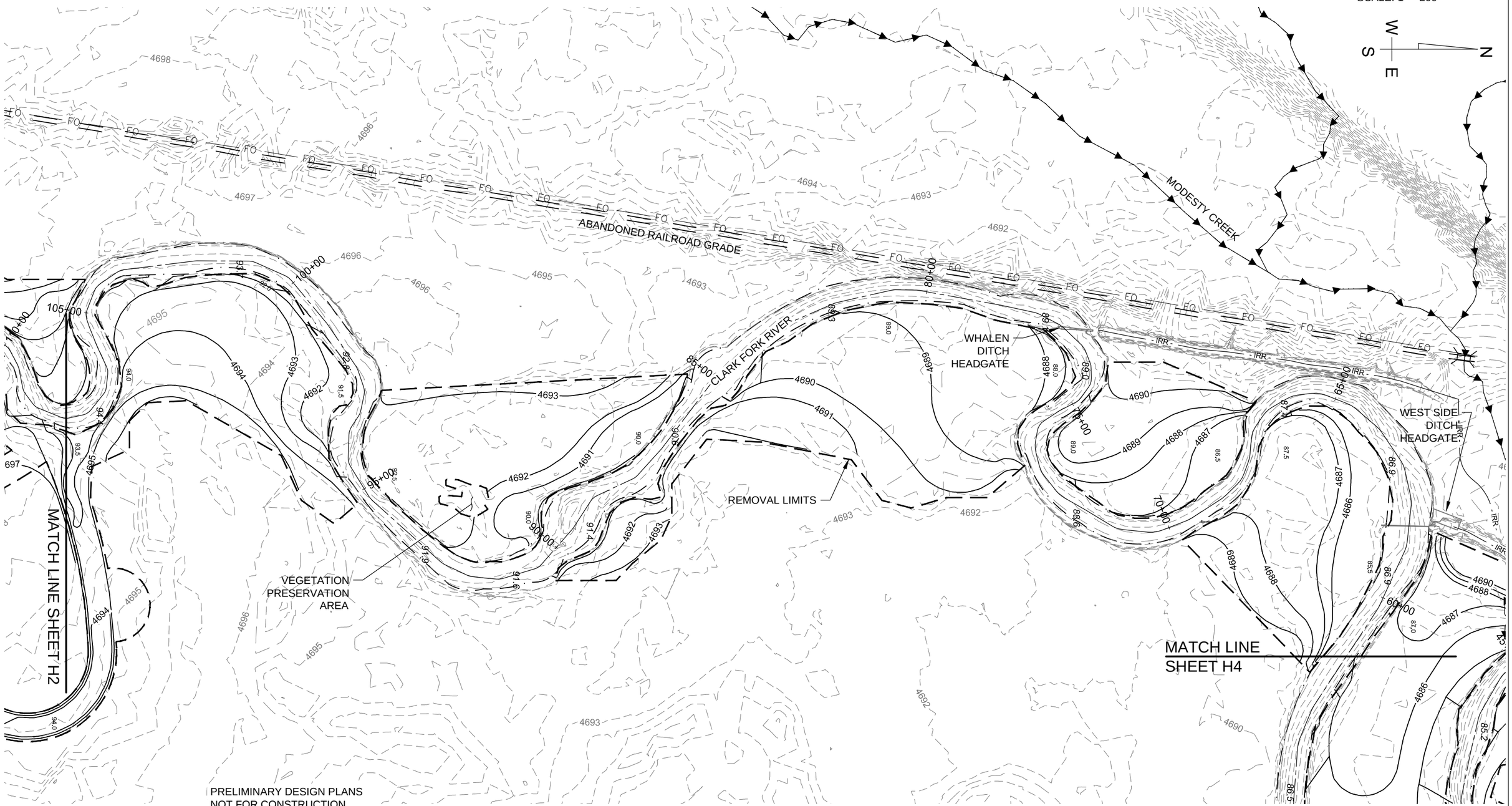
TerraGraphics Environmental Engineering, Inc.

DRAWN: G. HOGGATT	COORDINATE SYSTEM: MSP, NAD 83, INT FT	CLARK FORK RIVER OPERABLE UNIT REACH A, PHASES 5 & 6 REMEDIAL ACTION	HYDRAULIC MAPS
ENGINEER: M. CULPO	SCALE: AS SHOWN		
CHECKED: S. FIROR	APPROVED:	DEER LODGE, MONTANA	
DATE:	DATE:		

SHEET INDEX:	H2
PROJECT NO.:	12007
DATE:	1/10/2013
SHEET:	16 OF 26

12.0 FINISHED GRADE SPOT ELEVATION
94.5 2-YEAR WATER SURFACE ELEVATION

0 200 400
SCALE: 1" = 200'



PRELIMINARY DESIGN PLANS
NOT FOR CONSTRUCTION

C:\Clark Fork River Floodplain\TO 31 – 12007 – CFR Phase 5 and 6 Design\6) CAD\d. Base and existing drawings\SHEETS\CFR_Ph 5&6 hydraulic maps.dwg 1/10/2013

TerraGraphics
Environmental Engineering, Inc.

DRAWN: G. HOGGATT	COORDINATE SYSTEM: MSP, NAD 83, INT FT	CLARK FORK RIVER OPERABLE UNIT REACH A, PHASES 5 & 6 REMEDIAL ACTION	HYDRAULIC MAPS
ENGINEER: M. CULPO	SCALE: AS SHOWN		
CHECKED: S. FIROR	APPROVED:	DEER LODGE, MONTANA	
DATE:	DATE:		

SHEET INDEX:	H3
PROJECT NO.:	12007
DATE:	1/10/2013
SHEET:	17 OF 26

12.0 FINISHED GRADE SPOT ELEVATION
94.5 2-YEAR WATER SURFACE ELEVATION

N
W E
S

0 200 400
SCALE: 1" = 200'

WEST SIDE IRR. DITCH HEADGATE

WHALEN IRRIGATION DITCH

WEST SIDE IRRIGATION DITCH

MATCH LINE SHEET H3

REMOVAL LIMITS

VEGETATION PRESERVATION AREA

CLARK FORK RIVER

GEMBACK ROAD

PRELIMINARY DESIGN PLANS
NOT FOR CONSTRUCTION

C:\Clark Fork River Floodplain\TO 31 – 12007 – CFR Phase 5 and 6 Design\6) CAD\d. Base and existing drawings\SHEETS\CFR_Ph 5&6 hydraulic maps.dwg 1/10/2013

TerraGraphics Environmental Engineering, Inc.

DRAWN: G. HOGGATT	COORDINATE SYSTEM: MSP, NAD 83, INT FT	CLARK FORK RIVER OPERABLE UNIT REACH A, PHASES 5 & 6 REMEDIAL ACTION	HYDRAULIC MAPS
ENGINEER: M. CULPO	SCALE: AS SHOWN		
CHECKED: S. FIROR	APPROVED:	DEER LODGE, MONTANA	
DATE:	DATE:		

SHEET INDEX:	H4
PROJECT NO.:	12007
DATE:	1/10/2013
SHEET:	18 OF 26

Existing Conditions

2 year Event

HEC-RAS Plan: ex River: CFR_CL Reach: CFR Profile: 2yr

Reach	River Sta	Profile	Q Total	Min Ch El Sta	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Top Width	Vel Chnl	Q Channel	Froude # Chl	Hydr Depth C	Hydr Radius C	Top W Act Chan	Shear Chan
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft)	(ft/s)	(cfs)		(ft)	(ft)	(ft)	(lb/sq ft)
CFR	23282.1	2yr	584.00	1218.78	4709.25	4714.79		4714.91	0.000955	61.39	2.79	584.00	0.27	3.41	3.23	61.39	0.19
CFR	23228	2yr	584.00	48.44	4709.77	4714.78	4712.22	4714.86	0.000585	73.78	2.25	584.00	0.21	3.52	3.39	73.78	0.12
CFR	23192		Bridge														
CFR	23156	2yr	584.00	66.62	4709.20	4714.74		4714.81	0.000406	72.97	2.03	584.00	0.18	3.94	3.82	72.97	0.10
CFR	23100.0	2yr	584.00	1762.76	4710.58	4714.55		4714.75	0.001984	55.73	3.61	584.00	0.37	2.90	2.76	55.73	0.34
CFR	22956.3	2yr	584.00	1995.88	4709.50	4714.33		4714.51	0.001385	50.64	3.41	584.00	0.32	3.44	3.31	49.70	0.29
CFR	22606.0	2yr	584.00	2266.54	4710.59	4713.78		4713.96	0.001778	62.09	3.36	584.00	0.35	2.80	2.68	62.09	0.30
CFR	22349.9	2yr	584.00	2334.50	4708.62	4713.38		4713.56	0.001390	55.95	3.36	583.98	0.32	3.43	3.23	50.61	0.28
CFR	22047.4	2yr	584.00	2111.87	4707.88	4713.01		4713.17	0.001148	116.50	3.25	579.12	0.29	3.90	3.54	45.63	0.25
CFR	21661.8	2yr	584.00	2612.14	4707.98	4712.56		4712.73	0.001159	194.40	3.29	578.88	0.29	3.91	3.58	44.96	0.26
CFR	21288.1	2yr	584.00	2686.46	4709.10	4711.69		4711.99	0.003913	58.74	4.35	584.00	0.51	2.28	2.19	58.74	0.54
CFR	20885.9	2yr	584.00	2523.84	4706.91	4710.95		4711.10	0.001308	58.32	3.13	584.00	0.31	3.20	3.03	58.32	0.25
CFR	20452.2	2yr	584.00	2497.18	4704.59	4710.50		4710.63	0.000903	59.32	2.90	583.66	0.26	3.87	3.58	51.93	0.20
CFR	20152.9	2yr	584.00	1944.66	4706.09	4709.95		4710.20	0.002469	72.16	3.98	582.65	0.42	2.82	2.70	51.90	0.42
CFR	19673.0	2yr	584.00	1999.41	4704.02	4709.37		4709.47	0.000925	112.17	2.59	581.48	0.26	3.13	2.97	71.70	0.17
CFR	19289.8	2yr	584.00	1501.03	4704.64	4708.69		4708.94	0.002197	52.90	3.94	583.99	0.40	3.08	2.91	48.15	0.40
CFR	18852.7	2yr	584.00	1448.54	4702.78	4708.27		4708.39	0.000723	50.47	2.75	584.00	0.24	4.21	3.90	50.47	0.18
CFR	18469.6	2yr	584.00	1430.10	4705.00	4707.80		4707.96	0.001873	80.10	3.20	582.60	0.36	2.47	2.40	73.54	0.28
CFR	18351.3	2yr	584.00	1611.47	4703.40	4707.60		4707.74	0.001758	80.73	2.98	584.00	0.34	2.43	2.26	80.73	0.25
CFR	18290.2	2yr	584.00	1712.05	4702.42	4707.53		4707.66	0.000968	90.44	2.92	583.79	0.26	3.77	3.43	53.02	0.21
CFR	18044.8	2yr	584.00	1955.43	4702.07	4707.30		4707.44	0.000877	73.30	2.93	583.93	0.26	3.96	3.71	50.35	0.20
CFR	17872.7	2yr	584.00	2131.20	4703.15	4707.22		4707.29	0.000642	175.83	2.01	580.43	0.21	2.85	2.66	101.61	0.11
CFR	17595.7	2yr	584.00	2265.13	4703.15	4706.98		4707.08	0.000883	116.79	2.44	583.66	0.25	2.93	2.81	81.50	0.15
CFR	17396.7	2yr	584.00	2319.37	4702.89	4706.76		4706.88	0.001134	91.21	2.71	583.70	0.28	2.83	2.72	76.22	0.19
CFR	16918.1	2yr	700.00	2185.89	4701.82	4705.89		4706.13	0.002034	73.02	3.94	698.10	0.39	3.12	3.07	56.82	0.39
CFR	16612.2	2yr	700.00	1592.47	4701.15	4705.16		4705.44	0.002534	55.18	4.20	700.00	0.43	3.02	2.87	55.18	0.45
CFR	16264.4	2yr	700.00	1409.21	4700.10	4704.59		4704.76	0.001428	165.69	3.44	644.26	0.32	3.53	3.28	53.01	0.29
CFR	15947.2	2yr	700.00	1275.10	4700.27	4703.67		4704.04	0.003828	50.34	4.88	700.00	0.51	2.85	2.64	50.34	0.63
CFR	15586.1	2yr	700.00	1394.03	4698.28	4702.55		4702.86	0.002492	44.79	4.46	700.00	0.42	3.50	3.18	44.79	0.50
CFR	15091.5	2yr	700.00	1249.55	4695.42	4702.31		4702.39	0.000413	60.39	2.33	700.00	0.18	4.98	4.62	60.39	0.12
CFR	14604.7	2yr	700.00	1046.67	4697.51	4701.66		4701.95	0.002842	70.48	4.30	699.95	0.45	2.83	2.73	57.52	0.48
CFR	14218.6	2yr	700.00	1201.02	4695.79	4700.73		4701.01	0.002107	46.92	4.20	700.00	0.39	3.55	3.30	46.92	0.43
CFR	13905.5	2yr	700.00	1325.86	4694.55	4700.24		4700.45	0.001414	82.27	3.72	685.46	0.33	3.95	3.70	46.75	0.33
CFR	13422.4	2yr	700.00	803.40	4694.12	4699.61		4699.79	0.001295	53.75	3.46	700.00	0.31	3.76	3.55	53.75	0.29
CFR	13012.6	2yr	700.00	936.60	4695.50	4699.01		4699.17	0.001737	78.49	3.29	699.99	0.35	2.78	2.64	76.46	0.29
CFR	12583.6	2yr	700.00	1497.41	4694.36	4697.93		4698.19	0.003046	69.70	4.16	699.78	0.46	2.52	2.47	66.63	0.47
CFR	12145.0	2yr	700.00	1709.00	4690.77	4697.50		4697.61	0.000658	90.06	2.57	696.58	0.23	3.93	3.78	69.06	0.16
CFR	11609.7	2yr	700.00	1268.31	4692.95	4696.79		4697.02	0.002040	56.33	3.90	700.00	0.38	3.19	3.02	56.33	0.38
CFR	11181.9	2yr	700.00	1011.45	4691.31	4695.64		4695.92	0.003313	69.13	4.21	700.00	0.48	2.41	2.36	69.13	0.49
CFR	10736.1	2yr	700.00	969.42	4690.24	4694.99		4695.10	0.001056	294.96	2.75	677.79	0.28	3.05	2.94	80.73	0.19
CFR	10137.7	2yr	700.00	576.61	4690.47	4694.06		4694.25	0.001997	87.04	3.55	699.71	0.38	2.75	2.67	71.67	0.33
CFR	9823.3	2yr	700.00	367.58	4689.60	4693.16		4693.45	0.003290	107.16	4.34	697.99	0.48	2.55	2.48	63.07	0.51
CFR	9326.1	2yr	700.00	1083.94	4687.73	4692.16		4692.36	0.001495	66.44	3.53	698.56	0.33	3.50	3.29	56.64	0.31
CFR	9106.3	2yr	700.00	1055.26	4689.06	4691.66		4691.90	0.003123	382.44	3.90	687.14	0.46	2.26	2.20	77.81	0.43
CFR	8951.0	2yr	700.00	937.37	4688.01	4691.46		4691.54	0.001417	654.50	2.27	700.00	0.30	1.81	1.76	170.30	0.16
CFR	8861.2	2yr	700.00	738.60	4686.90	4690.80		4691.02	0.002113	586.14	3.82	699.29	0.38	3.08	2.86	59.42	0.38
CFR	8221.4	2yr	700.00	345.72	4685.71	4689.99		4690.20	0.001659	199.77	3.64	700.00	0.35	3.42	3.19	56.24	0.33
CFR	7755.8	2yr	700.00	420.10	4685.03	4689.37	4687.31	4689.53	0.001200	152.48	3.19	699.96	0.30	3.53	3.33	62.20	0.25
CFR	7700		Inl Struct														
CFR	7614.0	2yr	700.00	398.08	4685.44	4689.31		4689.47	0.001398	379.41	3.21	694.58	0.32	3.11	3.00	69.45	0.26
CFR	7214.1	2yr	700.00	704.44	4685.33	4688.74		4688.90	0.001488	819.61	3.21	690.16	0.33	2.93	2.87	73.18	0.27
CFR	6630.6	2yr	700.00	389.47	4683.67	4687.72		4687.92	0.001884	503.74	3.60	699.81	0.37	2.91	2.85	66.86	0.33
CFR	6329.6	2yr	700.00	251.60	4683.98	4687.15	4685.83	4687.33	0.001966	353.45	3.39	700.00	0.37	2.60	2.52	79.51	0.31
CFR	6165		Inl Struct														
CFR	6070.3	2yr	700.00	545.45	4682.94	4687.14		4687.23	0.000713	347.36	2.33	700.00	0.23	3.21	3.07	93.72	0.14
CFR	5559.7	2yr	700.00	1069.26	4681.52	4686.68		4686.81	0.000903	155.06	2.89	699.97	0.26	3.76	3.56	64.46	0.20
CFR	5088.6	2yr	700.00	1226.65	4681.41	4686.01		4686.22	0.001828	182.88	3.75	682.07	0.36	3.30	3.10	55.11	0.35
CFR	4683.6	2yr	700.00	875.36	4682.02	4685.51		4685.63	0.001109	779.40	2.78	699.94	0.28	3.01	2.88	83.44	0.20
CFR	4235.7	2yr	700.00	265.33	4680.81	4684.74		4684.95	0.002131	239.21	3.63	700.00	0.39	2.75	2.63	70.09	0.35

HEC-RAS Plan: ex River: CFR_CL Reach: CFR Profile: 2yr (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El Sta	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Top Width	Vel Chnl	Q Channel	Froude # Chl	Hydr Depth C	Hydr Radius C	Top W Act Chan	Shear Chan
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft)	(ft/s)	(cfs)		(ft)	(ft)	(ft)	(lb/sq ft)
CFR	3783.9	2yr	700.00	239.20	4680.74	4683.93		4684.07	0.001713	130.72	3.07	685.51	0.35	2.45	2.41	91.13	0.26
CFR	3487.5	2yr	700.00	427.08	4679.19	4683.42		4683.59	0.001494	89.71	3.41	684.33	0.33	3.32	3.12	60.44	0.29
CFR	3028.0	2yr	700.00	507.11	4679.26	4682.51		4682.72	0.002480	133.56	3.65	699.21	0.41	2.45	2.37	78.31	0.37
CFR	2786.0	2yr	700.00	396.69	4678.24	4682.15		4682.27	0.001291	89.70	2.81	700.00	0.30	2.78	2.61	89.70	0.21
CFR	2645.3	2yr	700.00	196.42	4678.17	4682.00		4682.10	0.001056	164.79	2.74	629.01	0.28	3.07	2.93	74.56	0.19
CFR	2244.1	2yr	700.00	86.79	4677.95	4681.13		4681.41	0.003160	81.23	4.26	699.76	0.47	2.60	2.49	63.34	0.49
CFR	1921.5	2yr	700.00	531.55	4676.06	4680.50		4680.69	0.001552	60.20	3.50	700.00	0.34	3.32	3.16	60.20	0.31
CFR	1558.4	2yr	700.00	759.92	4675.85	4680.06		4680.20	0.001101	67.89	3.02	699.99	0.29	3.44	3.27	67.35	0.22
CFR	1224.6	2yr	700.00	786.25	4675.55	4679.54		4679.73	0.001780	64.83	3.55	700.00	0.36	3.04	2.92	64.83	0.32
CFR	835.5	2yr	700.00	448.01	4675.27	4678.82		4679.00	0.001993	80.39	3.41	700.00	0.37	2.61	2.52	78.69	0.31
CFR	682.5	2yr	700.00	281.66	4673.19	4678.57		4678.75	0.001326	62.25	3.46	699.70	0.32	3.62	3.50	55.80	0.29
CFR	529	2yr	700.00	40.62	4673.72	4678.33	4676.29	4678.53	0.001550	55.31	3.63	700.00	0.34	3.48	3.34	55.31	0.32
CFR	496		Bridge														
CFR	463	2yr	700.00	31.70	4673.23	4678.25		4678.42	0.001312	61.19	3.32	700.00	0.32	3.45	3.31	61.19	0.27
CFR	368.0	2yr	700.00	202.50	4674.07	4678.08		4678.27	0.001940	198.23	3.58	671.46	0.37	2.87	2.76	65.44	0.33
CFR	139.6	2yr	700.00	382.40	4672.96	4677.67	4675.73	4677.87	0.001600	205.78	3.61	700.00	0.34	3.47	3.24	55.89	0.32

HEC-RAS Plan: ex River: CFR_CL Reach: CFR Profile: 2yr

Reach	River Sta	Profile	Q Total	Q Left	Q Right	Hydr Depth L	Hydr Depth R	Shear LOB	Shear ROB	Shear Total	Shear Chan	Vel Left	Vel Right
			(cfs)	(cfs)	(cfs)	(ft)	(ft)	(lb/sq ft)	(lb/sq ft)	(lb/sq ft)	(lb/sq ft)	(ft/s)	(ft/s)
CFR	23282.1	2yr	584.00							0.19	0.19		
CFR	23228	2yr	584.00							0.12	0.12		
CFR	23192		Bridge										
CFR	23156	2yr	584.00							0.10	0.10		
CFR	23100.0	2yr	584.00							0.34	0.34		
CFR	22956.3	2yr	584.00		0.00		0.01		0.00	0.28	0.29		0.05
CFR	22606.0	2yr	584.00							0.30	0.30		
CFR	22349.9	2yr	584.00	0.02		0.06		0.00		0.26	0.28	0.08	
CFR	22047.4	2yr	584.00	4.88		0.29		0.02		0.12	0.25	0.24	
CFR	21661.8	2yr	584.00	5.12		0.20		0.01		0.07	0.26	0.17	
CFR	21288.1	2yr	584.00							0.54	0.54		
CFR	20885.9	2yr	584.00							0.25	0.25		
CFR	20452.2	2yr	584.00	0.34		0.19		0.01		0.18	0.20	0.25	
CFR	20152.9	2yr	584.00		1.35		0.17		0.03	0.31	0.42		0.38
CFR	19673.0	2yr	584.00		2.52		0.30		0.02	0.12	0.17		0.20
CFR	19289.8	2yr	584.00		0.01		0.03		0.00	0.36	0.40		0.06
CFR	18852.7	2yr	584.00							0.18	0.18		
CFR	18469.6	2yr	584.00		1.40		0.39		0.04	0.26	0.28		0.55
CFR	18351.3	2yr	584.00							0.25	0.25		
CFR	18290.2	2yr	584.00	0.22		0.05		0.00		0.13	0.21	0.11	
CFR	18044.8	2yr	584.00	0.07		0.05		0.00		0.14	0.20	0.06	
CFR	17872.7	2yr	584.00	3.45	0.12	0.29	0.11	0.01	0.00	0.07	0.11	0.18	0.14
CFR	17595.7	2yr	584.00	0.34		0.10		0.01		0.11	0.15	0.10	
CFR	17396.7	2yr	584.00	0.30		0.15		0.01		0.16	0.19	0.14	
CFR	16918.1	2yr	700.00	0.43	1.47	0.16	1.81	0.02	0.11	0.31	0.39	0.19	0.41
CFR	16612.2	2yr	700.00							0.45	0.45		
CFR	16264.4	2yr	700.00	55.63	0.11	0.71	0.10	0.06	0.01	0.14	0.29	0.79	0.08
CFR	15947.2	2yr	700.00							0.63	0.63		
CFR	15566.1	2yr	700.00							0.50	0.50		
CFR	15091.5	2yr	700.00							0.12	0.12		
CFR	14604.7	2yr	700.00		0.05		0.05		0.01	0.40	0.48		0.07
CFR	14218.6	2yr	700.00							0.43	0.43		
CFR	13905.5	2yr	700.00	14.54		0.61		0.05		0.21	0.33	0.67	
CFR	13422.4	2yr	700.00							0.29	0.29		
CFR	13012.6	2yr	700.00		0.01		0.04		0.00	0.28	0.29		0.13
CFR	12583.6	2yr	700.00		0.22		0.24		0.04	0.45	0.47		0.31
CFR	12145.0	2yr	700.00	3.40	0.02	0.41	0.31	0.02	0.01	0.12	0.16	0.41	0.18
CFR	11609.7	2yr	700.00							0.38	0.38		
CFR	11181.9	2yr	700.00							0.49	0.49		
CFR	10736.1	2yr	700.00	0.02	22.19	0.06	0.40	0.00	0.03	0.07	0.19	0.12	0.26
CFR	10137.7	2yr	700.00		0.29		0.12		0.01	0.28	0.33		0.16
CFR	9823.3	2yr	700.00		2.01		0.17		0.04	0.32	0.51		0.26

HEC-RAS Plan: ex River: CFR_CL Reach: CFR Profile: 2yr (Continued)

Reach	River Sta	Profile	Q Total	Q Left	Q Right	Hydr Depth L	Hydr Depth R	Shear LOB	Shear ROB	Shear Total	Shear Chan	Vel Left	Vel Right
			(cfs)	(cfs)	(cfs)	(ft)	(ft)	(lb/sq ft)	(lb/sq ft)	(lb/sq ft)	(lb/sq ft)	(ft/s)	(ft/s)
CFR	9326.1	2yr	700.00	1.44		0.38		0.03		0.28	0.31	0.50	
CFR	9106.3	2yr	700.00	12.86		0.39		0.08		0.31	0.43	0.81	
CFR	8951.0	2yr	700.00							0.16	0.16		
CFR	8661.2	2yr	700.00	0.71		0.17		0.02		0.32	0.38	0.35	
CFR	8221.4	2yr	700.00							0.33	0.33		
CFR	7755.8	2yr	700.00		0.04		0.05		0.00	0.21	0.25		0.07
CFR	7700		Inl Struct										
CFR	7614.0	2yr	700.00		5.42		0.21		0.02	0.14	0.26		0.36
CFR	7214.1	2yr	700.00	9.84		0.61		0.06		0.21	0.27	0.55	
CFR	6630.6	2yr	700.00		0.19		0.07		0.01	0.30	0.33		0.31
CFR	6329.6	2yr	700.00							0.31	0.31		
CFR	6165		Inl Struct										
CFR	6070.3	2yr	700.00							0.14	0.14		
CFR	5559.7	2yr	700.00	0.03		0.04		0.00		0.17	0.20	0.05	
CFR	5088.6	2yr	700.00	17.93		0.38		0.04		0.16	0.35	0.46	
CFR	4683.6	2yr	700.00	0.05	0.01	0.07	0.03	0.00	0.00	0.18	0.20	0.08	0.14
CFR	4235.7	2yr	700.00							0.35	0.35		
CFR	3783.9	2yr	700.00		14.49		0.39		0.04	0.19	0.26		0.94
CFR	3487.5	2yr	700.00		15.67		0.49		0.04	0.21	0.29		1.09
CFR	3028.0	2yr	700.00	0.79		0.09		0.01		0.26	0.37	0.26	
CFR	2786.0	2yr	700.00							0.21	0.21		
CFR	2645.3	2yr	700.00	70.99		1.20		0.08		0.14	0.19	0.97	
CFR	2244.1	2yr	700.00		0.24		0.06		0.01	0.39	0.49		0.22
CFR	1921.5	2yr	700.00							0.31	0.31		
CFR	1558.4	2yr	700.00		0.01		0.08		0.00	0.22	0.22		0.24
CFR	1224.6	2yr	700.00							0.32	0.32		
CFR	835.5	2yr	700.00							0.31	0.31		
CFR	682.5	2yr	700.00	0.03	0.26	0.07	0.13	0.01	0.01	0.26	0.29	0.27	0.41
CFR	529	2yr	700.00							0.32	0.32		
CFR	496		Bridge										
CFR	463	2yr	700.00							0.27	0.27		
CFR	368.0	2yr	700.00		28.54		1.38		0.15	0.31	0.33		2.13
CFR	139.6	2yr	700.00							0.32	0.32		

Existing Conditions

10 year Event

HEC-RAS Plan: ex River: CFR_CL Reach: CFR Profile: 10yr

Reach	River Sta	Profile	Q Total	Min Ch El Sta	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Top Width	Vel Chnl	Q Channel	Froude # Chl	Hydr Depth C	Hydr Radius C	Top W Act Chan	Shear Chan
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft)	(ft/s)	(cfs)		(ft)	(ft)	(ft)	(lb/sq ft)
CFR	23282.1	10yr	1216.00	1218.78	4709.25	4716.27		4716.51	0.001382	84.35	3.96	1216.00	0.33	4.41	4.14	69.69	0.36
CFR	23228	10yr	1216.00	48.44	4709.77	4716.26	4713.11	4716.42	0.000932	91.28	3.19	1216.00	0.28	4.17	4.03	91.28	0.23
CFR	23192		Bridge														
CFR	23156	10yr	1216.00	66.62	4709.20	4716.20		4716.34	0.000711	85.75	3.02	1216.00	0.25	4.69	4.55	85.75	0.20
CFR	23100.0	10yr	1216.00	1762.76	4710.58	4715.84		4716.25	0.002673	90.03	5.13	1212.76	0.45	3.95	3.73	59.82	0.62
CFR	22956.3	10yr	1216.00	1995.88	4709.50	4715.65	4713.46	4715.92	0.001573	705.38	4.42	1051.79	0.36	4.67	4.43	50.99	0.44
CFR	22606.0	10yr	1216.00	2266.54	4710.59	4715.10		4715.34	0.001675	798.57	4.16	1070.08	0.36	4.04	3.86	63.64	0.40
CFR	22349.9	10yr	1216.00	2334.50	4708.62	4714.64	4712.35	4714.91	0.001703	862.17	4.46	1066.76	0.37	4.57	4.24	52.32	0.45
CFR	22047.4	10yr	1216.00	2111.87	4707.88	4714.33		4714.48	0.001109	1311.24	3.64	882.48	0.29	4.76	4.32	50.82	0.30
CFR	21661.8	10yr	1216.00	2612.14	4707.98	4713.96		4714.09	0.000946	1319.36	3.51	846.31	0.28	5.06	4.60	47.62	0.27
CFR	21288.1	10yr	1216.00	2686.46	4709.10	4713.21	4711.77	4713.55	0.002689	723.68	4.91	1103.28	0.45	3.68	3.47	61.01	0.58
CFR	20885.9	10yr	1216.00	2523.84	4706.91	4712.54		4712.77	0.001412	492.49	4.03	1139.93	0.34	4.47	4.19	63.22	0.37
CFR	20452.2	10yr	1216.00	2497.18	4704.59	4711.94		4712.19	0.001315	460.90	4.14	1152.78	0.33	4.96	4.59	56.15	0.38
CFR	20152.9	10yr	1216.00	1944.66	4706.09	4711.39	4709.68	4711.70	0.002105	443.36	4.76	1053.22	0.41	4.24	3.98	52.19	0.52
CFR	19673.0	10yr	1216.00	1999.41	4704.02	4710.89		4711.04	0.000886	541.29	3.22	1089.35	0.27	4.51	4.25	74.96	0.24
CFR	19289.8	10yr	1216.00	1501.03	4704.64	4710.25		4710.53	0.002161	490.83	4.51	1064.52	0.41	3.80	3.61	62.14	0.49
CFR	18852.7	10yr	1216.00	1448.54	4702.78	4709.48		4709.77	0.001454	328.71	4.33	1196.53	0.34	4.93	4.56	56.07	0.41
CFR	18469.6	10yr	1216.00	1430.10	4705.00	4709.08		4709.22	0.001251	983.34	3.42	947.53	0.31	3.72	3.59	74.49	0.28
CFR	18351.3	10yr	1216.00	1611.47	4703.40	4708.98		4709.07	0.000973	1170.87	2.84	887.32	0.27	3.54	3.28	88.35	0.20
CFR	18290.2	10yr	1216.00	1712.05	4702.42	4708.93		4709.02	0.000786	1203.12	2.85	815.05	0.25	4.18	3.86	68.53	0.19
CFR	18044.8	10yr	1216.00	1955.43	4702.07	4708.59		4708.79	0.001162	1020.17	3.83	1034.79	0.31	4.79	4.49	56.42	0.33
CFR	17872.7	10yr	1216.00	2131.20	4703.15	4708.53		4708.58	0.000674	1410.68	2.02	949.53	0.22	2.69	2.58	175.01	0.11
CFR	17595.7	10yr	1216.00	2265.13	4703.15	4708.31		4708.41	0.000711	1203.10	2.78	969.71	0.24	4.20	4.02	82.93	0.18
CFR	17396.7	10yr	1216.00	2319.37	4702.89	4708.14		4708.25	0.000877	1204.67	3.04	982.01	0.26	4.10	3.93	78.63	0.22
CFR	16918.1	10yr	1337.00	2185.89	4701.82	4707.32	4705.23	4707.65	0.001891	560.17	4.79	1243.33	0.40	4.44	4.35	58.56	0.51
CFR	16612.2	10yr	1337.00	1592.47	4701.15	4706.46	4704.70	4706.92	0.002934	278.70	5.51	1325.46	0.48	4.09	3.87	58.89	0.71
CFR	16264.4	10yr	1337.00	1409.21	4700.10	4706.08		4706.24	0.001101	514.41	3.60	988.05	0.30	4.58	4.27	59.89	0.29
CFR	15947.2	10yr	1337.00	1275.10	4700.27	4705.22	4703.60	4705.67	0.003025	369.80	5.57	1254.46	0.48	4.14	3.84	54.35	0.73
CFR	15566.1	10yr	1337.00	1394.03	4698.28	4704.15		4704.62	0.002613	83.82	5.57	1301.82	0.45	4.76	4.28	49.11	0.70
CFR	15091.5	10yr	1337.00	1249.55	4695.42	4703.84		4703.99	0.000627	378.80	3.21	1282.08	0.23	5.90	5.47	67.83	0.21
CFR	14604.7	10yr	1337.00	1046.67	4697.51	4703.18		4703.48	0.002111	490.23	4.64	1189.46	0.41	4.02	3.83	63.73	0.50
CFR	14218.6	10yr	1337.00	1201.02	4695.79	4702.26	4700.08	4702.65	0.002237	411.58	5.17	1255.82	0.42	4.65	4.31	52.21	0.60
CFR	13905.5	10yr	1337.00	1325.86	4694.55	4701.85		4702.09	0.001267	423.41	4.33	1124.52	0.32	5.51	5.05	47.20	0.40
CFR	13422.4	10yr	1337.00	803.40	4694.12	4701.01	4698.44	4701.33	0.002006	292.50	4.61	1316.50	0.40	4.14	3.94	68.89	0.49
CFR	13012.6	10yr	1337.00	936.60	4695.50	4700.40		4700.61	0.001430	521.72	3.81	1225.65	0.33	4.08	3.81	78.88	0.34
CFR	12583.6	10yr	1337.00	1497.41	4694.36	4699.46		4699.82	0.002441	140.81	4.80	1327.19	0.44	3.70	3.62	74.64	0.55
CFR	12145.0	10yr	1337.00	1709.00	4690.77	4699.05		4699.21	0.000762	148.01	3.30	1280.34	0.26	5.12	4.93	75.78	0.23
CFR	11609.7	10yr	1337.00	1268.31	4692.95	4698.14		4698.51	0.002625	104.79	4.90	1318.76	0.45	3.69	3.53	72.88	0.58
CFR	11181.9	10yr	1337.00	1011.45	4691.31	4696.67		4697.13	0.004029	80.21	5.42	1337.00	0.55	3.07	2.98	80.21	0.75
CFR	10736.1	10yr	1337.00	969.42	4690.24	4696.13		4696.26	0.000960	519.82	3.18	1087.08	0.28	4.06	3.92	84.18	0.23
CFR	10137.7	10yr	1337.00	576.61	4690.47	4695.19		4695.47	0.002023	344.96	4.38	1233.96	0.40	3.76	3.62	75.01	0.46
CFR	9823.3	10yr	1337.00	367.58	4689.60	4694.39		4694.74	0.002683	275.48	5.01	1202.25	0.46	3.75	3.59	64.05	0.60
CFR	9326.1	10yr	1337.00	1083.94	4687.73	4693.24		4693.58	0.002068	916.15	4.84	1259.00	0.41	4.43	4.14	58.71	0.53
CFR	9106.3	10yr	1337.00	1055.26	4689.06	4692.84		4693.09	0.002228	1193.80	4.26	1150.40	0.41	3.34	3.24	80.86	0.45
CFR	8951.0	10yr	1337.00	937.37	4688.01	4692.77		4692.85	0.000793	1701.25	2.29	1271.93	0.24	2.85	2.77	194.32	0.14
CFR	8861.2	10yr	1337.00	738.60	4686.90	4692.17		4692.48	0.001973	1821.13	4.66	1240.81	0.39	4.36	4.06	60.98	0.50
CFR	8221.4	10yr	1337.00	345.72	4685.71	4691.29		4691.59	0.002061	1748.89	4.56	1235.89	0.40	4.05	3.80	66.87	0.49
CFR	7755.8	10yr	1337.00	420.10	4685.03	4690.53	4688.21	4690.74	0.001551	1169.26	3.95	1173.03	0.35	4.00	3.79	74.14	0.37
CFR	7700		Inl Struct														
CFR	7614.0	10yr	1337.00	398.08	4685.44	4690.52		4690.71	0.001265	1153.99	3.76	1127.94	0.32	4.31	4.10	69.60	0.32
CFR	7214.1	10yr	1337.00	704.44	4685.33	4689.84		4690.12	0.001772	1489.50	4.29	1270.60	0.38	4.01	3.88	73.78	0.43
CFR	6630.6	10yr	1337.00	389.47	4683.67	4688.84		4689.09	0.001764	1280.58	4.25	1152.36	0.38	3.97	3.84	68.30	0.42
CFR	6329.6	10yr	1337.00	251.60	4683.98	4688.41	4686.59	4688.61	0.001471	1093.05	3.73	1154.57	0.34	3.78	3.62	81.76	0.33
CFR	6165		Inl Struct														
CFR	6070.3	10yr	1337.00	545.45	4682.94	4688.41		4688.52	0.000766	1189.12	2.87	1213.82	0.25	4.16	3.99	101.65	0.19
CFR	5559.7	10yr	1337.00	1069.26	4681.52	4687.78		4688.01	0.001300	1041.90	3.98	1253.30	0.33	4.62	4.37	68.18	0.35
CFR	5088.6	10yr	1337.00	1226.65	4681.41	4687.15		4687.36	0.001566	1345.62	4.22	1032.83	0.35	4.42	4.14	55.46	0.41
CFR	4683.6	10yr	1337.00	875.36	4682.02	4686.70		4686.85	0.000991	2468.09	3.27	1151.61	0.28	4.17	3.99	84.58	0.25
CFR	4235.7	10yr	1337.00	265.33	4680.81	4685.78		4686.15	0.002719	1113.54	4.88	1309.97	0.45	3.57	3.41	75.27	0.58

HEC-RAS Plan: ex River: CFR_CL Reach: CFR Profile: 10yr (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El Sta	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Top Width	Vel Chnl	Q Channel	Froude # Chl	Hydr Depth C	Hydr Radius C	Top W Act Chan	Shear Chan
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft)	(ft/s)	(cfs)		(ft)	(ft)	(ft)	(lb/sq ft)
CFR	3783.9	10yr	1337.00	239.20	4680.74	4685.01		4685.19	0.001565	1004.07	3.61	1176.14	0.35	3.34	3.29	97.53	0.32
CFR	3487.5	10yr	1337.00	427.08	4679.19	4684.46		4684.71	0.001673	939.20	4.29	1135.40	0.36	4.33	4.05	61.15	0.42
CFR	3028.0	10yr	1337.00	507.11	4679.26	4683.72		4683.94	0.001772	1169.84	4.01	1153.90	0.37	3.62	3.51	79.43	0.39
CFR	2786.0	10yr	1337.00	396.69	4678.24	4683.34		4683.52	0.001611	979.52	3.48	1297.69	0.34	3.22	3.05	115.58	0.31
CFR	2645.3	10yr	1337.00	196.42	4678.17	4683.18		4683.33	0.001121	838.84	3.41	1089.27	0.30	4.07	3.88	78.55	0.27
CFR	2244.1	10yr	1337.00	86.79	4677.95	4682.41	4680.92	4682.69	0.002461	732.39	4.54	1145.28	0.43	3.45	3.31	73.05	0.51
CFR	1921.5	10yr	1337.00	531.55	4676.06	4681.91		4682.10	0.001362	633.63	3.79	1109.94	0.33	4.12	3.92	71.15	0.33
CFR	1558.4	10yr	1337.00	759.92	4675.85	4681.41		4681.63	0.001210	501.21	3.90	1265.92	0.32	4.71	4.48	68.85	0.34
CFR	1224.6	10yr	1337.00	786.25	4675.55	4681.04		4681.22	0.001229	605.72	3.68	1107.63	0.31	4.26	4.05	70.73	0.31
CFR	835.5	10yr	1337.00	448.01	4675.27	4680.53		4680.73	0.001302	1080.40	3.70	1296.08	0.32	4.04	3.92	86.68	0.32
CFR	682.5	10yr	1337.00	281.66	4673.19	4680.30		4680.55	0.001117	858.30	4.13	1233.01	0.31	5.36	5.17	55.80	0.36
CFR	529	10yr	1337.00	40.62	4673.72	4680.00	4677.40	4680.33	0.001713	63.17	4.59	1337.00	0.38	4.61	4.40	63.17	0.47
CFR	496		Bridge														
CFR	463	10yr	1337.00	31.70	4673.23	4679.94		4680.21	0.001410	69.38	4.17	1337.00	0.34	4.62	4.42	69.38	0.39
CFR	368.0	10yr	1337.00	202.50	4674.07	4679.86		4680.06	0.001316	842.30	3.79	1192.59	0.33	4.21	4.02	74.70	0.33
CFR	139.6	10yr	1337.00	382.40	4672.96	4679.43	4676.74	4679.72	0.001601	947.10	4.36	1317.62	0.36	4.58	4.29	65.96	0.43

HEC-RAS Plan: ex River: CFR_CL Reach: CFR Profile: 10yr

Reach	River Sta	Profile	Q Total	Q Left	Q Right	Hydr Depth L	Hydr Depth R	Shear LOB	Shear ROB	Shear Total	Shear Chan	Vel Left	Vel Right
			(cfs)	(cfs)	(cfs)	(ft)	(ft)	(lb/sq ft)	(lb/sq ft)	(lb/sq ft)	(lb/sq ft)	(ft/s)	(ft/s)
CFR	23282.1	10yr	1216.00							0.36	0.36		
CFR	23228	10yr	1216.00							0.23	0.23		
CFR	23192		Bridge										
CFR	23156	10yr	1216.00							0.20	0.20		
CFR	23100.0	10yr	1216.00		3.24		0.17		0.03	0.43	0.62		0.63
CFR	22956.3	10yr	1216.00	116.30	47.91	0.44	0.25	0.04	0.02	0.06	0.44	0.97	0.51
CFR	22606.0	10yr	1216.00	131.67	14.25	0.41	0.21	0.04	0.02	0.07	0.40	0.58	0.36
CFR	22349.9	10yr	1216.00	28.58	120.66	0.24	0.43	0.03	0.05	0.06	0.45	0.32	0.64
CFR	22047.4	10yr	1216.00	249.96	83.56	0.88	0.33	0.06	0.02	0.05	0.30	0.46	0.40
CFR	21661.8	10yr	1216.00	296.08	73.61	0.78	0.38	0.05	0.02	0.05	0.27	0.42	0.74
CFR	21288.1	10yr	1216.00	112.72		0.39		0.07		0.11	0.58	0.44	
CFR	20885.9	10yr	1216.00	23.53	52.54	0.25	0.38	0.02	0.03	0.07	0.37	0.45	0.62
CFR	20452.2	10yr	1216.00	26.98	36.23	0.46	0.28	0.04	0.02	0.07	0.38	0.72	0.40
CFR	20152.9	10yr	1216.00	74.56	88.22	0.49	0.40	0.06	0.05	0.12	0.52	0.85	1.04
CFR	19673.0	10yr	1216.00	37.54	89.11	0.37	0.86	0.02	0.05	0.06	0.24	0.50	0.40
CFR	19289.8	10yr	1216.00	1.81	149.67	0.38	0.65	0.05	0.09	0.14	0.49	1.04	0.54
CFR	18852.7	10yr	1216.00		19.47		0.28		0.03	0.10	0.41		0.27
CFR	18469.6	10yr	1216.00	230.78	37.69	0.68	0.27	0.05	0.02	0.06	0.28	0.71	0.44
CFR	18351.3	10yr	1216.00	300.82	27.86	0.70	0.25	0.04	0.01	0.05	0.20	0.63	0.35
CFR	18290.2	10yr	1216.00	356.56	44.39	0.75	0.45	0.04	0.02	0.04	0.19	0.58	0.43
CFR	18044.8	10yr	1216.00	179.61	1.60	0.59	0.38	0.04	0.03	0.06	0.33	0.37	0.04
CFR	17872.7	10yr	1216.00	237.44	29.03	0.69	0.64	0.03	0.03	0.04	0.11	0.32	0.53
CFR	17595.7	10yr	1216.00	228.39	17.90	0.69	0.90	0.03	0.04	0.04	0.18	0.31	1.05
CFR	17396.7	10yr	1216.00	233.93	0.06	0.63	0.21	0.03	0.01	0.05	0.22	0.33	0.40
CFR	16918.1	10yr	1337.00	60.84	32.82	0.42	0.67	0.05	0.08	0.11	0.51	0.41	0.33
CFR	16612.2	10yr	1337.00		11.54		0.23		0.04	0.19	0.71		0.22
CFR	16264.4	10yr	1337.00	307.92	41.04	1.35	0.65	0.09	0.04	0.10	0.29	1.08	0.26
CFR	15947.2	10yr	1337.00	7.22	75.33	0.21	0.68	0.04	0.13	0.21	0.73	0.70	0.42
CFR	15566.1	10yr	1337.00	35.18		0.76		0.12		0.47	0.70	1.33	
CFR	15091.5	10yr	1337.00	49.65	5.27	0.83	0.25	0.03	0.01	0.06	0.21	0.55	0.10
CFR	14604.7	10yr	1337.00	0.63	146.91	0.32	0.87	0.04	0.11	0.16	0.50	0.05	0.43
CFR	14218.6	10yr	1337.00	39.76	41.42	0.29	0.59	0.04	0.08	0.13	0.60	0.61	0.53
CFR	13905.5	10yr	1337.00	212.48		0.71		0.06		0.10	0.40	0.80	
CFR	13422.4	10yr	1337.00	15.64	4.86	0.30	0.13	0.04	0.02	0.14	0.49	1.01	0.21
CFR	13012.6	10yr	1337.00	16.52	94.83	0.20	0.48	0.02	0.04	0.08	0.34	0.56	0.67
CFR	12583.6	10yr	1337.00	0.26	9.55	0.06	0.40	0.01	0.06	0.31	0.55	0.22	0.53
CFR	12145.0	10yr	1337.00	56.44	0.22	1.09	1.36	0.05	0.02	0.15	0.23	0.72	0.32
CFR	11609.7	10yr	1337.00		18.24		0.84		0.14	0.45	0.58		0.68
CFR	11181.9	10yr	1337.00							0.75	0.75		
CFR	10736.1	10yr	1337.00	45.35	204.57	0.69	1.14	0.04	0.07	0.09	0.23	0.64	0.54
CFR	10137.7	10yr	1337.00		103.04		0.71		0.09	0.17	0.46		0.53
CFR	9823.3	10yr	1337.00		134.75		0.89		0.15	0.26	0.60		0.72

HEC-RAS Plan: ex River: CFR_CL Reach: CFR Profile: 10yr (Continued)

Reach	River Sta	Profile	Q Total	Q Left	Q Right	Hydr Depth L	Hydr Depth R	Shear LOB	Shear ROB	Shear Total	Shear Chan	Vel Left	Vel Right
			(cfs)	(cfs)	(cfs)	(ft)	(ft)	(lb/sq ft)	(lb/sq ft)	(lb/sq ft)	(lb/sq ft)	(ft/s)	(ft/s)
CFR	9326.1	10yr	1337.00	78.00		0.42		0.05		0.15	0.53	0.69	
CFR	9106.3	10yr	1337.00	186.60		0.59		0.08		0.15	0.45	0.95	
CFR	8951.0	10yr	1337.00	51.85	13.22	0.47	0.48	0.02	0.02	0.07	0.14	0.42	0.73
CFR	8661.2	10yr	1337.00	72.23	23.96	0.71	0.64	0.09	0.08	0.22	0.50	0.88	1.41
CFR	8221.4	10yr	1337.00	5.76	95.34	0.30	0.47	0.04	0.06	0.13	0.49	0.51	0.68
CFR	7755.8	10yr	1337.00		163.97		0.75		0.07	0.12	0.37		0.48
CFR	7700		Inl Struct										
CFR	7614.0	10yr	1337.00		209.06		0.81		0.06	0.11	0.32		0.76
CFR	7214.1	10yr	1337.00	66.40		0.66		0.07		0.18	0.43	0.53	
CFR	6630.6	10yr	1337.00	0.02	184.63	0.07	0.56	0.01	0.06	0.14	0.42	0.18	1.27
CFR	6329.6	10yr	1337.00		182.43		0.68		0.06	0.14	0.33		1.37
CFR	6165		Inl Struct										
CFR	6070.3	10yr	1337.00		123.18		0.59		0.03	0.08	0.19		0.95
CFR	5559.7	10yr	1337.00	83.58	0.12	0.51	0.16	0.04	0.01	0.08	0.35	0.34	0.45
CFR	5088.6	10yr	1337.00	235.72	68.45	0.79	0.32	0.08	0.03	0.08	0.41	0.50	0.78
CFR	4683.6	10yr	1337.00	25.13	160.26	0.39	0.43	0.02	0.03	0.05	0.25	0.28	0.79
CFR	4235.7	10yr	1337.00		27.03		0.18		0.03	0.19	0.58		0.76
CFR	3783.9	10yr	1337.00		160.86		0.54		0.05	0.14	0.32		1.39
CFR	3487.5	10yr	1337.00	99.71	101.89	0.52	0.57	0.05	0.06	0.11	0.42	0.68	1.34
CFR	3028.0	10yr	1337.00	157.30	25.80	0.59	0.86	0.06	0.09	0.12	0.39	0.73	1.61
CFR	2786.0	10yr	1337.00	35.69	3.62	0.40	0.28	0.04	0.03	0.15	0.31	0.56	0.73
CFR	2645.3	10yr	1337.00	210.61	37.12	1.99	0.26	0.14	0.02	0.09	0.27	1.30	0.58
CFR	2244.1	10yr	1337.00		191.72		0.41		0.06	0.11	0.51		0.71
CFR	1921.5	10yr	1337.00	39.16	187.90	0.50	0.48	0.04	0.04	0.08	0.33	0.59	1.02
CFR	1558.4	10yr	1337.00	69.72	1.36	0.39	0.17	0.03	0.01	0.07	0.34	0.46	0.43
CFR	1224.6	10yr	1337.00	163.53	65.85	0.61	0.59	0.05	0.04	0.08	0.31	0.63	1.04
CFR	835.5	10yr	1337.00	27.60	13.32	0.35	0.79	0.03	0.06	0.12	0.32	0.46	1.29
CFR	682.5	10yr	1337.00	43.24	60.75	0.94	0.53	0.07	0.04	0.14	0.36	1.36	1.12
CFR	529	10yr	1337.00							0.47	0.47		
CFR	496		Bridge										
CFR	463	10yr	1337.00							0.39	0.39		
CFR	368.0	10yr	1337.00	0.06	144.34	0.09	0.73	0.01	0.06	0.14	0.33	0.07	1.24
CFR	139.6	10yr	1337.00	2.16	17.23	0.48	0.42	0.05	0.04	0.25	0.43	0.24	0.95

Existing Conditions

100 year Event

HEC-RAS Plan: ex River: CFR_CL Reach: CFR Profile: 100yr

Reach	River Sta	Profile	Q Total	Min Ch El Sta	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Top Width	Vel Chnl	Q Channel	Froude # Chl	Hydr Depth C	Hydr Radius C	Top W Act Chan	Shear Chan
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft)	(ft/s)	(cfs)		(ft)	(ft)	(ft)	(lb/sq ft)
CFR	23282.1	100yr	1893.00	1218.78	4709.25	4716.97		4717.38	0.002016	476.08	5.22	1862.02	0.41	5.03	4.72	70.98	0.59
CFR	23228	100yr	1893.00	48.44	4709.77	4716.97	4713.89	4717.25	0.001411	95.87	4.23	1893.00	0.35	4.67	4.51	95.87	0.40
CFR	23192		Bridge														
CFR	23156	100yr	1893.00	66.62	4709.20	4716.87		4717.13	0.001186	91.17	4.10	1893.00	0.32	5.06	4.91	91.17	0.36
CFR	23100.0	100yr	1893.00	1762.76	4710.58	4716.10	4714.97	4716.95	0.005212	247.46	7.44	1873.01	0.64	4.18	3.94	60.27	1.28
CFR	22956.3	100yr	1893.00	1995.88	4709.50	4716.15		4716.39	0.001589	991.93	4.72	1244.79	0.37	5.15	4.86	51.21	0.48
CFR	22606.0	100yr	1893.00	2266.54	4710.59	4715.64		4715.84	0.001539	1321.43	4.33	1260.87	0.36	4.58	4.37	63.64	0.42
CFR	22349.9	100yr	1893.00	2334.50	4708.62	4715.11	4713.47	4715.40	0.001982	1700.96	5.11	1346.87	0.40	5.03	4.63	52.45	0.57
CFR	22047.4	100yr	1893.00	2111.87	4707.88	4714.84		4714.96	0.001023	1887.86	3.75	1004.54	0.29	5.28	4.78	50.82	0.31
CFR	21661.8	100yr	1893.00	2612.14	4707.98	4714.53		4714.63	0.000829	1996.21	3.53	945.45	0.26	5.63	5.12	47.62	0.26
CFR	21288.1	100yr	1893.00	2686.46	4709.10	4713.83		4714.15	0.002651	1174.28	5.33	1398.32	0.46	4.21	3.97	62.29	0.66
CFR	20885.9	100yr	1893.00	2523.84	4706.91	4713.17		4713.40	0.001460	1280.42	4.48	1443.91	0.35	5.10	4.78	63.22	0.44
CFR	20452.2	100yr	1893.00	2497.18	4704.59	4712.55	4710.01	4712.82	0.001465	1225.60	4.72	1475.98	0.35	5.57	5.16	56.15	0.47
CFR	20152.9	100yr	1893.00	1944.66	4706.09	4712.13		4712.35	0.001669	1323.89	4.67	1214.67	0.37	4.92	4.61	52.90	0.48
CFR	19673.0	100yr	1893.00	1999.41	4704.02	4711.60		4711.77	0.000959	829.50	3.70	1446.33	0.29	5.22	4.92	74.96	0.29
CFR	19289.8	100yr	1893.00	1501.03	4704.64	4711.09		4711.31	0.001659	815.89	4.51	1298.46	0.37	4.63	4.40	62.14	0.46
CFR	18852.7	100yr	1893.00	1448.54	4702.78	4709.96	4707.55	4710.44	0.002375	679.48	5.78	1754.80	0.44	5.26	4.87	57.76	0.72
CFR	18469.8	100yr	1893.00	1430.10	4705.00	4709.69		4709.80	0.001019	1930.29	3.42	1102.47	0.29	4.33	4.18	74.49	0.27
CFR	18351.3	100yr	1893.00	1611.47	4703.40	4709.62		4709.69	0.000717	2018.76	2.72	1005.01	0.24	4.17	3.87	88.35	0.17
CFR	18290.2	100yr	1893.00	1712.05	4702.42	4709.59		4709.64	0.000577	2013.80	2.63	872.70	0.21	4.66	4.31	71.37	0.16
CFR	18044.8	100yr	1893.00	1955.43	4702.07	4709.27		4709.45	0.001150	1658.92	4.16	1282.34	0.31	5.46	5.13	56.42	0.37
CFR	17872.7	100yr	1893.00	2131.20	4703.15	4709.22		4709.26	0.000512	1993.48	2.05	1209.67	0.20	3.38	3.24	175.01	0.10
CFR	17595.7	100yr	1893.00	2265.13	4703.15	4709.06		4709.14	0.000592	1896.53	2.83	1162.49	0.22	4.95	4.73	82.93	0.17
CFR	17396.7	100yr	1893.00	2319.37	4702.89	4708.94		4709.02	0.000632	1973.66	2.91	1124.71	0.23	4.91	4.71	78.63	0.19
CFR	16918.1	100yr	2171.00	2185.89	4701.82	4708.32	4706.46	4708.59	0.001509	1714.92	4.90	1559.10	0.37	5.44	5.34	58.56	0.50
CFR	16612.2	100yr	2171.00	1592.47	4701.15	4707.34	4705.82	4707.90	0.003300	868.28	6.42	1892.33	0.52	4.70	4.46	62.68	0.92
CFR	16264.4	100yr	2171.00	1409.21	4700.10	4706.97		4707.15	0.001180	950.06	4.20	1372.91	0.32	5.46	5.09	59.89	0.38
CFR	15947.2	100yr	2171.00	1275.10	4700.27	4706.39		4706.68	0.001900	1112.60	5.21	1503.83	0.40	5.31	4.93	54.35	0.58
CFR	15566.1	100yr	2171.00	1394.03	4698.28	4705.15	4703.44	4705.81	0.003158	619.18	6.90	1951.78	0.51	5.72	5.13	49.50	1.01
CFR	15091.5	100yr	2171.00	1249.55	4695.42	4704.76		4704.99	0.000837	1005.54	4.08	1888.43	0.28	6.82	6.32	67.83	0.33
CFR	14804.7	100yr	2171.00	1046.67	4697.51	4703.93		4704.34	0.002563	693.27	5.73	1743.18	0.46	4.77	4.54	63.73	0.73
CFR	14218.6	100yr	2171.00	1201.02	4695.79	4703.06	4701.36	4703.45	0.002227	923.26	5.74	1634.97	0.43	5.46	5.05	52.21	0.70
CFR	13905.5	100yr	2171.00	1325.86	4694.55	4702.69		4702.91	0.001231	1137.77	4.64	1394.21	0.33	6.26	5.74	48.03	0.44
CFR	13422.4	100yr	2171.00	803.40	4694.12	4701.69	4699.54	4702.09	0.002514	963.80	5.49	1839.47	0.45	4.53	4.32	73.97	0.68
CFR	13012.6	100yr	2171.00	936.60	4695.50	4701.28		4701.42	0.000993	1258.93	3.59	1402.99	0.28	4.95	4.58	78.95	0.28
CFR	12583.6	100yr	2171.00	1497.41	4694.36	4700.65		4700.89	0.001589	1480.33	4.48	1650.39	0.37	4.59	4.49	80.29	0.45
CFR	12145.0	100yr	2171.00	1709.00	4690.77	4700.26		4700.44	0.000748	1032.72	3.77	1804.71	0.26	6.32	6.10	75.78	0.28
CFR	11609.7	100yr	2171.00	1268.31	4692.95	4699.28	4697.40	4699.75	0.002579	464.61	5.70	2023.09	0.46	4.68	4.48	75.94	0.72
CFR	11181.9	100yr	2171.00	1011.45	4691.31	4697.43		4698.20	0.005253	92.62	7.04	2170.65	0.64	3.75	3.61	82.20	1.18
CFR	10736.1	100yr	2171.00	969.42	4690.24	4697.07		4697.21	0.000921	858.02	3.57	1504.50	0.28	5.00	4.82	84.18	0.28
CFR	10137.7	100yr	2171.00	576.61	4690.47	4696.12		4696.45	0.002063	471.49	5.08	1783.72	0.41	4.66	4.46	75.32	0.57
CFR	9823.3	100yr	2171.00	367.58	4689.60	4695.26		4695.70	0.002858	327.32	5.89	1744.14	0.48	4.59	4.36	64.48	0.78
CFR	9326.1	100yr	2171.00	1083.94	4687.73	4694.01		4694.42	0.002387	1822.06	5.65	1732.59	0.44	5.01	4.69	61.17	0.70
CFR	9106.3	100yr	2171.00	1055.26	4689.06	4693.74		4693.94	0.001679	1600.85	4.24	1458.91	0.37	4.10	3.97	83.87	0.42
CFR	8951.0	100yr	2171.00	937.37	4688.01	4693.67		4693.76	0.000665	1868.23	2.49	1821.74	0.23	3.69	3.58	198.50	0.15
CFR	8661.2	100yr	2171.00	738.60	4686.90	4692.95		4693.39	0.002390	1967.43	5.73	1801.55	0.45	5.15	4.79	60.98	0.71
CFR	8221.4	100yr	2171.00	345.72	4685.71	4692.14		4692.42	0.001870	1991.12	4.93	1614.64	0.39	4.90	4.59	66.87	0.54
CFR	7755.8	100yr	2171.00	420.10	4685.03	4691.44	4689.19	4691.65	0.001433	1556.81	4.30	1571.72	0.34	4.83	4.57	75.70	0.41
CFR	7700		Inl Struct														
CFR	7614.0	100yr	2171.00	398.08	4685.44	4691.44		4691.62	0.001153	1646.25	4.06	1479.28	0.31	5.23	4.94	69.66	0.36
CFR	7214.1	100yr	2171.00	704.44	4685.33	4690.57		4690.98	0.002349	2127.87	5.49	1919.09	0.44	4.74	4.54	73.87	0.67
CFR	6630.6	100yr	2171.00	389.47	4683.67	4689.62		4689.85	0.001592	1756.85	4.51	1462.10	0.37	4.72	4.53	68.78	0.45
CFR	6329.6	100yr	2171.00	251.60	4683.98	4689.22	4687.84	4689.42	0.001413	1890.65	4.14	1553.47	0.34	4.58	4.35	81.95	0.38
CFR	6165		Inl Struct														
CFR	6070.3	100yr	2171.00	545.45	4682.94	4689.22		4689.36	0.000922	1916.80	3.38	1720.43	0.28	4.61	4.43	110.25	0.26
CFR	5559.7	100yr	2171.00	1069.26	4681.52	4688.34		4688.69	0.001898	1351.87	5.19	1829.25	0.40	5.17	4.90	68.18	0.58
CFR	5088.6	100yr	2171.00	1226.65	4681.41	4687.73		4687.91	0.001473	1895.06	4.44	1231.06	0.35	5.00	4.69	55.46	0.43
CFR	4683.6	100yr	2171.00	875.36	4682.02	4687.30		4687.43	0.000936	2791.03	3.47	1401.08	0.28	4.77	4.56	84.58	0.27
CFR	4235.7	100yr	2171.00	265.33	4680.81	4686.45		4686.79	0.002620	2064.53	5.32	1694.40	0.46	4.19	3.99	76.07	0.65

HEC-RAS Plan: ex River: CFR_CL Reach: CFR Profile: 100yr (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El Sta	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Top Width	Vel Chnl	Q Channel	Froude # Chl	Hydr Depth C	Hydr Radius C	Top W Act Chan	Shear Chan
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft)	(ft/s)	(cfs)		(ft)	(ft)	(ft)	(lb/sq ft)
CFR	3783.9	100yr	2171.00	239.20	4680.74	4685.67		4685.87	0.001659	1758.95	4.15	1620.44	0.37	3.95	3.88	98.84	0.40
CFR	3487.5	100yr	2171.00	427.08	4679.19	4685.13		4685.38	0.001700	1597.25	4.76	1454.92	0.38	5.00	4.68	61.15	0.50
CFR	3028.0	100yr	2171.00	507.11	4679.26	4684.43		4684.66	0.001719	1660.07	4.45	1529.61	0.38	4.33	4.19	79.43	0.45
CFR	2786.0	100yr	2171.00	396.69	4678.24	4683.90		4684.19	0.002174	1476.88	4.50	1969.30	0.41	3.78	3.58	115.58	0.49
CFR	2645.3	100yr	2171.00	196.42	4678.17	4683.71		4683.91	0.001492	1648.36	4.27	1540.68	0.35	4.60	4.38	78.55	0.41
CFR	2244.1	100yr	2171.00	86.79	4677.95	4683.11		4683.29	0.001816	1478.02	4.34	1318.41	0.38	4.04	3.87	75.21	0.44
CFR	1921.5	100yr	2171.00	531.55	4676.06	4682.81		4682.92	0.000829	1500.61	3.37	1204.26	0.27	5.02	4.78	71.15	0.25
CFR	1558.4	100yr	2171.00	759.92	4675.85	4682.40		4682.59	0.001007	1036.09	4.04	1586.69	0.30	5.70	5.42	68.85	0.34
CFR	1224.6	100yr	2171.00	786.25	4675.55	4682.24		4682.32	0.000567	1478.55	2.94	1135.57	0.22	5.43	5.17	71.12	0.18
CFR	835.5	100yr	2171.00	448.01	4675.27	4681.86		4682.05	0.000937	1570.97	3.80	1771.65	0.29	5.38	5.22	86.68	0.31
CFR	682.5	100yr	2171.00	281.66	4673.19	4681.75		4681.92	0.000733	1212.30	3.92	1488.31	0.26	6.80	6.57	55.80	0.30
CFR	529	100yr	2171.00	40.62	4673.72	4681.16	4678.46	4681.70	0.002380	70.36	5.89	2171.00	0.45	5.24	5.00	70.36	0.74
CFR	496		Bridge														
CFR	463	100yr	2171.00	31.70	4673.23	4681.07		4681.53	0.001966	75.20	5.39	2171.00	0.41	5.36	5.06	75.20	0.62
CFR	368.0	100yr	2171.00	202.50	4674.07	4681.16		4681.32	0.000858	947.15	3.65	1506.42	0.27	5.48	5.24	75.31	0.28
CFR	139.6	100yr	2171.00	382.40	4672.96	4680.67	4677.82	4681.04	0.001602	1095.92	5.12	1964.91	0.37	5.82	5.45	65.96	0.54

HEC-RAS Plan: ex River: CFR_CL Reach: CFR Profile: 100yr

Reach	River Sta	Profile	Q Total	Q Left	Q Right	Hydr Depth L	Hydr Depth R	Shear LOB	Shear ROB	Shear Total	Shear Chan	Vel Left	Vel Right
			(cfs)	(cfs)	(cfs)	(ft)	(ft)	(lb/sq ft)	(lb/sq ft)	(lb/sq ft)	(lb/sq ft)	(ft/s)	(ft/s)
CFR	23282.1	100yr	1893.00	6.45	24.53	0.40	0.30	0.05	0.04	0.36	0.59	0.60	2.98
CFR	23228	100yr	1893.00							0.40	0.40		
CFR	23192		Bridge										
CFR	23156	100yr	1893.00							0.36	0.36		
CFR	23100.0	100yr	1893.00	2.62	17.37	0.06	0.21	0.02	0.07	0.36	1.28	0.53	0.78
CFR	22956.3	100yr	1893.00	405.54	242.67	0.81	0.55	0.08	0.06	0.09	0.48	1.48	0.73
CFR	22606.0	100yr	1893.00	485.86	146.28	0.89	0.41	0.09	0.04	0.08	0.42	0.90	0.57
CFR	22349.9	100yr	1893.00	159.60	386.53	0.52	0.54	0.06	0.07	0.08	0.57	0.45	0.74
CFR	22047.4	100yr	1893.00	505.37	383.09	1.35	0.63	0.09	0.04	0.07	0.31	0.58	0.60
CFR	21661.8	100yr	1893.00	617.30	330.24	1.15	0.57	0.06	0.03	0.05	0.26	0.47	0.89
CFR	21288.1	100yr	1893.00	494.68		0.73		0.12		0.15	0.66	0.64	
CFR	20885.9	100yr	1893.00	209.89	239.20	0.47	0.68	0.04	0.06	0.07	0.44	0.61	0.74
CFR	20452.2	100yr	1893.00	131.75	285.27	0.36	0.66	0.03	0.06	0.07	0.47	0.62	0.75
CFR	20152.9	100yr	1893.00	255.60	422.73	0.66	0.66	0.07	0.07	0.09	0.48	0.79	0.82
CFR	19673.0	100yr	1893.00	205.74	240.92	0.70	1.37	0.04	0.08	0.08	0.29	0.66	0.57
CFR	19289.8	100yr	1893.00	86.67	507.87	0.44	1.27	0.05	0.13	0.14	0.46	1.05	0.71
CFR	18852.7	100yr	1893.00		138.20		0.49		0.07	0.13	0.72		0.47
CFR	18469.6	100yr	1893.00	547.00	243.53	0.95	0.64	0.06	0.04	0.06	0.27	0.76	0.60
CFR	18351.3	100yr	1893.00	695.65	192.34	1.10	0.67	0.05	0.03	0.05	0.17	0.70	0.51
CFR	18290.2	100yr	1893.00	845.85	174.45	1.26	0.73	0.05	0.03	0.04	0.16	0.69	0.49
CFR	18044.8	100yr	1893.00	601.90	8.76	1.04	0.74	0.07	0.05	0.09	0.37	0.52	0.07
CFR	17872.7	100yr	1893.00	607.83	75.50	1.21	1.13	0.04	0.04	0.05	0.10	0.38	0.62
CFR	17595.7	100yr	1893.00	687.31	43.20	1.19	1.51	0.04	0.06	0.05	0.17	0.41	1.35
CFR	17396.7	100yr	1893.00	767.77	0.52	1.19	0.96	0.05	0.02	0.05	0.19	0.43	0.65
CFR	16918.1	100yr	2171.00	487.99	123.91	0.78	0.85	0.07	0.08	0.09	0.50	0.51	0.38
CFR	16612.2	100yr	2171.00	65.35	213.32	0.33	0.81	0.07	0.17	0.19	0.92	0.69	0.51
CFR	16264.4	100yr	2171.00	629.37	168.72	1.35	1.13	0.10	0.08	0.11	0.38	1.11	0.37
CFR	15947.2	100yr	2171.00	345.74	321.42	0.68	1.64	0.08	0.19	0.15	0.58	0.84	0.60
CFR	15566.1	100yr	2171.00	216.64	2.58	0.47	0.18	0.09	0.04	0.17	1.01	0.94	0.18
CFR	15091.5	100yr	2171.00	196.09	86.48	0.64	0.90	0.03	0.05	0.06	0.33	0.53	0.27
CFR	14604.7	100yr	2171.00	5.43	422.39	0.59	1.29	0.10	0.21	0.24	0.73	0.09	0.62
CFR	14218.6	100yr	2171.00	381.70	154.33	0.67	0.98	0.09	0.14	0.14	0.70	0.89	0.69
CFR	13905.5	100yr	2171.00	754.77	22.03	1.03	0.24	0.08	0.02	0.08	0.44	0.89	0.34
CFR	13422.4	100yr	2171.00	157.38	174.15	0.37	0.59	0.06	0.09	0.13	0.68	1.32	0.52
CFR	13012.6	100yr	2171.00	330.34	437.66	0.72	0.92	0.04	0.06	0.07	0.28	1.08	0.78
CFR	12583.6	100yr	2171.00	423.62	96.99	0.62	0.60	0.06	0.06	0.08	0.45	0.72	0.53
CFR	12145.0	100yr	2171.00	364.22	2.07	0.71	0.19	0.03	0.01	0.05	0.28	0.58	0.31
CFR	11609.7	100yr	2171.00	48.35	99.56	0.44	0.54	0.07	0.09	0.19	0.72	0.74	0.78
CFR	11181.9	100yr	2171.00		0.35		0.09		0.03	1.06	1.18		0.36
CFR	10736.1	100yr	2171.00	167.71	498.79	1.00	1.45	0.06	0.08	0.10	0.28	0.78	0.61
CFR	10137.7	100yr	2171.00	0.56	386.72	0.10	1.28	0.01	0.16	0.23	0.57	0.41	0.80
CFR	9823.3	100yr	2171.00		426.86		1.65		0.29	0.40	0.78		1.11

HEC-RAS Plan: ex River: CFR_CL Reach: CFR Profile: 100yr (Continued)

Reach	River Sta	Profile	Q Total	Q Left	Q Right	Hydr Depth L	Hydr Depth R	Shear LOB	Shear ROB	Shear Total	Shear Chan	Vel Left	Vel Right
			(cfs)	(cfs)	(cfs)	(ft)	(ft)	(lb/sq ft)	(lb/sq ft)	(lb/sq ft)	(lb/sq ft)	(ft/s)	(ft/s)
CFR	9326.1	100yr	2171.00	438.41		1.10		0.16		0.26	0.70	1.29	
CFR	9106.3	100yr	2171.00	665.11	46.98	1.40	0.40	0.15	0.04	0.16	0.42	1.27	0.95
CFR	8951.0	100yr	2171.00	284.25	65.01	1.33	0.99	0.06	0.04	0.09	0.15	0.77	1.09
CFR	8661.2	100yr	2171.00	271.98	97.46	1.00	1.32	0.15	0.20	0.28	0.71	1.44	2.49
CFR	8221.4	100yr	2171.00	59.86	496.50	0.66	1.26	0.08	0.15	0.19	0.54	0.92	1.25
CFR	7755.8	100yr	2171.00	2.70	596.58	0.23	1.64	0.02	0.15	0.18	0.41	0.35	0.78
CFR	7700		Inl Struct										
CFR	7614.0	100yr	2171.00	5.69	686.03	0.24	1.57	0.02	0.11	0.13	0.36	0.35	1.14
CFR	7214.1	100yr	2171.00	251.91		1.05		0.15		0.25	0.67	0.76	
CFR	6630.6	100yr	2171.00	2.79	706.12	0.46	0.89	0.04	0.09	0.14	0.45	0.58	1.69
CFR	6329.6	100yr	2171.00		617.53		0.75		0.07	0.11	0.38		1.51
CFR	6165		Inl Struct										
CFR	6070.3	100yr	2171.00		450.57		0.87		0.05	0.09	0.26		1.17
CFR	5559.7	100yr	2171.00	339.73	2.02	1.05	0.47	0.12	0.05	0.18	0.58	0.67	1.10
CFR	5088.6	100yr	2171.00	565.82	374.12	1.32	0.87	0.12	0.08	0.13	0.43	0.69	1.48
CFR	4683.6	100yr	2171.00	104.96	664.96	0.83	0.89	0.05	0.05	0.07	0.27	0.40	1.21
CFR	4235.7	100yr	2171.00		476.60		0.51		0.08	0.15	0.65		1.45
CFR	3783.9	100yr	2171.00		550.56		0.73		0.08	0.13	0.40		1.54
CFR	3487.5	100yr	2171.00	373.14	342.94	1.02	0.99	0.11	0.10	0.15	0.50	1.03	1.84
CFR	3028.0	100yr	2171.00	574.55	66.85	1.22	1.45	0.13	0.15	0.18	0.45	1.17	2.24
CFR	2786.0	100yr	2171.00	177.01	24.69	0.80	0.61	0.11	0.08	0.23	0.49	0.99	1.42
CFR	2645.3	100yr	2171.00	329.66	300.66	2.14	0.55	0.20	0.05	0.12	0.41	1.58	1.11
CFR	2244.1	100yr	2171.00		852.59		0.85		0.10	0.12	0.44		0.95
CFR	1921.5	100yr	2171.00	168.07	798.67	1.31	0.90	0.07	0.05	0.06	0.25	0.85	1.14
CFR	1558.4	100yr	2171.00	528.43	55.88	1.35	0.50	0.08	0.03	0.10	0.34	0.96	0.85
CFR	1224.6	100yr	2171.00	677.75	357.68	1.61	1.14	0.06	0.04	0.06	0.18	0.86	1.10
CFR	835.5	100yr	2171.00	345.25	54.10	1.57	1.45	0.09	0.08	0.15	0.31	1.02	1.65
CFR	682.5	100yr	2171.00	184.37	498.33	0.97	1.45	0.04	0.07	0.09	0.30	1.37	1.47
CFR	529	100yr	2171.00							0.74	0.74		
CFR	496		Bridge										
CFR	463	100yr	2171.00							0.62	0.62		
CFR	368.0	100yr	2171.00	19.20	645.38	0.82	2.03	0.04	0.11	0.13	0.28	0.25	1.98
CFR	139.6	100yr	2171.00	34.67	171.42	1.25	1.66	0.12	0.17	0.30	0.54	0.46	2.38

Proposed Conditions

2 year Event

HEC-RAS Plan: pr River: CFR_CL Reach: CFR_Design Profile: 2yr

Reach	River Sta	Profile	Q Total	Min Ch El Sta	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Top Width	Vel Chnl	Q Channel	Froude # Chl	Hydr Depth C	Hydr Radius C	Top W Act Chan	Shear Chan
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft)	(ft/s)	(cfs)		(ft)	(ft)	(ft)	(lb/sq ft)
CFR_Design	23282.1	2yr	584.00	1218.78	4709.25	4714.21		4714.38	0.001398	53.74	3.30	584.00	0.32	3.29	3.13	53.74	0.27
CFR_Design	23228	2yr	584.00	48.44	4709.77	4714.19	4712.22	4714.30	0.000996	70.44	2.70	584.00	0.27	3.08	2.98	70.44	0.19
CFR_Design	23192		Bridge														
CFR_Design	23156	2yr	584.00	66.62	4709.20	4714.13		4714.22	0.000652	69.32	2.39	584.00	0.22	3.52	3.42	69.32	0.14
CFR_Design	23100.0	2yr	584.00	1762.76	4710.58	4713.73		4714.11	0.005548	55.27	4.98	584.00	0.60	2.12	2.06	55.27	0.71
CFR_Design	22956.3	2yr	584.00	1995.88	4709.50	4713.76		4713.81	0.000703	358.58	2.16	313.30	0.23	2.82	2.77	51.46	0.12
CFR_Design	22606.0	2yr	584.00	2266.54	4710.59	4713.29		4713.42	0.002042	247.76	3.21	471.33	0.37	2.31	2.26	63.64	0.29
CFR_Design	22349.9	2yr	584.00	2334.50	4708.62	4712.56		4712.82	0.002781	174.42	4.14	564.88	0.44	2.73	2.62	49.97	0.45
CFR_Design	22047.4	2yr	584.00	2111.87	4707.88	4712.24		4712.31	0.000950	243.14	2.53	366.98	0.26	2.94	2.80	49.35	0.17
CFR_Design	21661.8	2yr	584.00	2612.14	4707.98	4711.89		4711.96	0.000901	617.20	2.56	380.76	0.26	3.12	2.97	47.62	0.17
CFR_Design	21288.1	2yr	584.00	2686.46	4709.10	4711.45		4711.54	0.002057	468.44	2.88	356.06	0.37	1.92	1.91	64.33	0.24
CFR_Design	20885.9	2yr	584.00	2523.84	4706.91	4710.76		4710.90	0.001406	177.75	3.05	552.83	0.32	2.86	2.77	63.22	0.24
CFR_Design	20452.2	2yr	584.00	2497.18	4704.59	4710.32		4710.43	0.000869	282.58	2.72	539.06	0.25	3.53	3.34	56.15	0.18
CFR_Design	20152.9	2yr	584.00	1944.66	4706.09	4709.69		4709.96	0.003133	91.52	4.23	569.92	0.47	2.55	2.48	52.89	0.48
CFR_Design	19673.0	2yr	584.00	1999.41	4704.02	4708.87		4709.00	0.001303	161.59	2.83	578.86	0.30	2.73	2.62	74.95	0.21
CFR_Design	19289.8	2yr	584.00	1501.03	4704.64	4708.45		4708.51	0.001234	341.17	2.50	353.57	0.29	2.36	2.26	59.96	0.17
CFR_Design	18852.7	2yr	584.00	1448.54	4702.78	4708.02		4708.12	0.000706	190.97	2.62	529.61	0.23	3.91	3.70	51.70	0.16
CFR_Design	18469.6	2yr	584.00	1430.10	4705.00	4707.52		4707.68	0.002355	196.01	3.33	540.30	0.40	2.20	2.15	73.84	0.32
CFR_Design	18351.3	2yr	584.00	1611.47	4703.40	4707.23		4707.39	0.002614	213.54	3.27	572.00	0.41	1.99	1.93	87.88	0.32
CFR_Design	18290.2	2yr	584.00	1712.05	4702.42	4707.16		4707.27	0.001134	439.59	2.75	564.45	0.29	2.88	2.78	71.37	0.20
CFR_Design	18044.8	2yr	584.00	1955.43	4702.07	4706.80		4706.97	0.001286	143.46	3.34	582.67	0.31	3.60	3.39	48.45	0.27
CFR_Design	17872.7	2yr	584.00	2131.20	4703.15	4706.71		4706.76	0.000756	560.27	2.02	490.35	0.22	2.52	2.37	96.48	0.11
CFR_Design	17595.7	2yr	584.00	2265.13	4703.15	4706.45		4706.53	0.001095	550.50	2.47	487.08	0.28	2.50	2.43	78.78	0.17
CFR_Design	17396.7	2yr	584.00	2319.37	4702.89	4706.21		4706.30	0.001319	571.46	2.63	475.66	0.30	2.39	2.33	75.64	0.19
CFR_Design	16918.1	2yr	700.00	2185.89	4701.82	4705.65		4705.74	0.001183	400.85	2.92	506.72	0.30	2.96	2.95	58.56	0.22
CFR_Design	16612.2	2yr	700.00	1592.47	4701.15	4704.94		4705.19	0.002827	230.61	4.20	648.74	0.44	2.77	2.64	55.76	0.47
CFR_Design	16264.4	2yr	700.00	1409.21	4700.10	4704.31		4704.46	0.001540	323.32	3.30	603.28	0.34	3.02	2.91	60.57	0.28
CFR_Design	15947.2	2yr	700.00	1275.10	4700.27	4703.55		4703.79	0.003092	331.42	4.29	590.03	0.46	2.75	2.56	49.98	0.49
CFR_Design	15586.1	2yr	700.00	1394.03	4698.28	4702.18		4702.54	0.003627	74.10	4.86	698.90	0.50	2.91	2.73	49.50	0.62
CFR_Design	15091.5	2yr	700.00	1249.55	4695.42	4701.85		4701.94	0.000523	152.70	2.40	685.90	0.21	4.21	4.06	67.83	0.13
CFR_Design	14604.7	2yr	700.00	1046.67	4697.51	4701.36		4701.50	0.001994	370.27	3.40	550.26	0.38	2.54	2.50	63.73	0.31
CFR_Design	14218.6	2yr	700.00	1201.02	4695.79	4700.54		4700.76	0.001982	129.34	3.89	645.28	0.38	3.18	3.08	52.17	0.38
CFR_Design	13905.5	2yr	700.00	1325.86	4694.55	4700.02		4700.22	0.001476	167.71	3.69	652.77	0.34	3.68	3.55	48.03	0.33
CFR_Design	13422.4	2yr	700.00	803.40	4694.12	4699.32		4699.50	0.001507	157.22	3.40	687.71	0.33	3.21	3.09	62.93	0.29
CFR_Design	13012.6	2yr	700.00	936.60	4695.50	4698.77		4698.88	0.001469	515.63	2.86	564.78	0.32	2.51	2.43	78.89	0.22
CFR_Design	12583.6	2yr	700.00	1497.41	4694.36	4697.85		4698.03	0.003018	304.55	3.63	619.35	0.45	2.06	2.03	82.97	0.38
CFR_Design	12145.0	2yr	700.00	1709.00	4690.77	4697.43		4697.51	0.000596	278.02	2.34	648.33	0.21	3.67	3.53	75.72	0.13
CFR_Design	11609.7	2yr	700.00	1268.31	4692.95	4696.76		4696.94	0.002275	158.61	3.54	667.21	0.39	2.50	2.41	75.33	0.34
CFR_Design	11181.9	2yr	700.00	1011.45	4691.31	4695.39		4695.73	0.003570	56.11	4.68	700.00	0.50	2.67	2.61	56.11	0.58
CFR_Design	10736.1	2yr	700.00	969.42	4690.24	4694.37		4694.54	0.001932	195.44	3.29	684.84	0.37	2.48	2.44	84.18	0.29
CFR_Design	10137.7	2yr	700.00	576.61	4690.47	4693.65		4693.72	0.001061	242.56	2.44	442.64	0.27	2.48	2.44	73.17	0.16
CFR_Design	9823.3	2yr	700.00	367.58	4689.60	4692.77		4693.10	0.004617	195.40	4.73	671.93	0.56	2.24	2.19	63.37	0.63
CFR_Design	9326.1	2yr	700.00	1083.94	4687.73	4691.87		4691.99	0.001222	292.70	3.05	558.61	0.30	3.21	3.08	56.97	0.23
CFR_Design	9106.3	2yr	700.00	1055.26	4689.06	4691.61		4691.69	0.001523	501.65	2.74	479.56	0.32	2.25	2.22	77.68	0.21
CFR_Design	8951.0	2yr	700.00	937.37	4688.01	4691.38		4691.46	0.001643	752.98	2.20	673.37	0.31	1.54	1.51	198.50	0.15
CFR_Design	8661.2	2yr	700.00	738.60	4686.90	4690.64		4690.87	0.002406	416.09	3.90	680.84	0.41	2.86	2.68	60.98	0.40
CFR_Design	8221.4	2yr	700.00	345.72	4685.71	4689.29		4689.61	0.003374	103.22	4.55	697.61	0.48	2.77	2.62	55.32	0.55
CFR_Design	7755.8	2yr	700.00	420.10	4685.03	4689.07	4687.46	4689.10	0.000427	417.85	1.76	380.55	0.18	3.02	2.97	71.64	0.08
CFR_Design	7700		Inl Struct														
CFR_Design	7614.0	2yr	700.00	398.08	4685.44	4689.03		4689.09	0.000889	451.07	2.41	473.58	0.25	2.83	2.74	69.41	0.15
CFR_Design	7214.1	2yr	700.00	704.44	4685.33	4688.55		4688.67	0.001384	945.98	2.99	603.46	0.32	2.77	2.72	72.81	0.23
CFR_Design	6630.6	2yr	700.00	389.47	4683.67	4687.40		4687.62	0.002441	476.88	3.85	686.15	0.42	2.63	2.59	67.81	0.40
CFR_Design	6329.6	2yr	700.00	251.60	4683.98	4686.93	4685.83	4687.03	0.001540	568.52	2.82	537.52	0.32	2.36	2.29	81.04	0.22
CFR_Design	6165		Inl Struct														
CFR_Design	6070.3	2yr	700.00	545.45	4682.94	4686.93		4686.98	0.000745	507.95	2.07	593.62	0.23	2.57	2.50	111.13	0.12
CFR_Design	5559.7	2yr	700.00	1069.26	4681.52	4686.46		4686.52	0.001139	393.33	1.95	630.22	0.27	1.69	1.66	191.15	0.12
CFR_Design	5088.6	2yr	700.00	1226.65	4681.41	4685.78		4685.92	0.001531	458.90	3.32	563.09	0.33	3.15	2.95	53.81	0.28
CFR_Design	4683.6	2yr	700.00	875.36	4682.02	4685.21		4685.33	0.001384	486.39	2.91	665.63	0.31	2.71	2.60	84.58	0.22
CFR_Design	4235.7	2yr	700.00	265.33	4680.81	4684.62		4684.70	0.001373	302.30	2.21	700.00	0.29	1.76	1.74	179.50	0.15
CFR_Design	3783.9	2yr	700.00	239.20	4680.74	4683.91		4684.03	0.001586	162.20	2.92	653.68	0.33	2.40	2.37	93.23	0.23
CFR_Design	3487.5	2yr	700.00	427.08	4679.19	4683.37		4683.56	0.001590	232.27	3.49	690.98	0.34	3.28	3.08	60.41	0.31
CFR_Design	3028.0	2yr	700.00	507.11	4679.26	4682.51		4682.69	0.002305	313.49	3.52	672.42	0.40	2.44	2.36	78.30	0.34

HEC-RAS Plan: pr River: CFR_CL Reach: CFR_Design Profile: 2yr (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El Sta	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Top Width	Vel Chnl	Q Channel	Froude # Chl	Hydr Depth C	Hydr Radius C	Top W Act Chan	Shear Chan
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft)	(ft/s)	(cfs)		(ft)	(ft)	(ft)	(lb/sq ft)
CFR_Design	2786.0	2yr	700.00	396.69	4678.24	4682.14		4682.26	0.001338	181.71	2.80	697.68	0.30	2.69	2.53	92.68	0.21
CFR_Design	2645.3	2yr	700.00	196.42	4678.17	4681.96		4682.08	0.001199	328.55	2.84	651.84	0.29	2.92	2.80	78.55	0.21
CFR_Design	2244.1	2yr	700.00	86.79	4677.95	4681.06	4680.07	4681.33	0.003254	326.45	4.21	681.79	0.47	2.46	2.39	65.84	0.49
CFR_Design	1921.5	2yr	700.00	531.55	4676.06	4680.44		4680.62	0.001499	189.21	3.40	671.95	0.33	3.25	3.11	60.83	0.29
CFR_Design	1558.4	2yr	700.00	759.92	4675.85	4679.98		4680.13	0.001187	122.39	3.09	699.85	0.30	3.37	3.20	67.20	0.24
CFR_Design	1224.6	2yr	700.00	786.25	4675.55	4679.52		4679.68	0.001563	326.08	3.23	656.17	0.34	2.85	2.79	71.12	0.27
CFR_Design	835.5	2yr	700.00	448.01	4675.27	4678.85		4679.01	0.001904	110.76	3.25	697.39	0.36	2.49	2.42	86.25	0.29
CFR_Design	682.5	2yr	700.00	281.66	4673.19	4678.59		4678.77	0.001267	78.90	3.41	696.89	0.31	3.66	3.54	55.80	0.28
CFR_Design	529	2yr	700.00	40.62	4673.72	4678.36	4676.29	4678.56	0.001505	55.41	3.60	700.00	0.34	3.51	3.37	55.41	0.32
CFR_Design	496		Bridge														
CFR_Design	463	2yr	700.00	31.70	4673.23	4678.29		4678.46	0.001269	61.31	3.28	700.00	0.31	3.48	3.34	61.31	0.26
CFR_Design	368.0	2yr	700.00	202.50	4674.07	4678.09		4678.30	0.002094	174.71	3.72	700.00	0.39	2.87	2.76	65.51	0.36
CFR_Design	139.6	2yr	700.00	382.40	4672.96	4677.68	4675.75	4677.88	0.001600	170.82	3.60	700.00	0.34	3.45	3.22	56.40	0.32

HEC-RAS Plan: pr River: CFR_CL Reach: CFR_Design Profile: 2yr

Reach	River Sta	Profile	Q Total	Q Left	Q Right	Hydr Depth L	Hydr Depth R	Shear LOB	Shear ROB	Shear Total	Shear Chan	Vel Left	Vel Right
			(cfs)	(cfs)	(cfs)	(ft)	(ft)	(lb/sq ft)	(lb/sq ft)	(lb/sq ft)	(lb/sq ft)	(ft/s)	(ft/s)
CFR_Design	23282.1	2yr	584.00							0.27	0.27		
CFR_Design	23228	2yr	584.00							0.19	0.19		
CFR_Design	23192		Bridge										
CFR_Design	23156	2yr	584.00							0.14	0.14		
CFR_Design	23100.0	2yr	584.00							0.71	0.71		
CFR_Design	22956.3	2yr	584.00		270.70		1.15		0.05	0.06	0.12		0.77
CFR_Design	22606.0	2yr	584.00	61.37	51.30	0.57	0.75	0.07	0.10	0.14	0.29	0.98	0.93
CFR_Design	22349.9	2yr	584.00	16.00	3.12	0.47	0.09	0.08	0.02	0.16	0.45	0.79	0.43
CFR_Design	22047.4	2yr	584.00	216.16	0.86	1.53	0.08	0.09	0.00	0.09	0.17	1.02	0.20
CFR_Design	21661.8	2yr	584.00	175.19	28.06	0.56	0.49	0.03	0.03	0.04	0.17	0.70	0.46
CFR_Design	21288.1	2yr	584.00	227.94		0.61		0.08		0.10	0.24	0.93	
CFR_Design	20885.9	2yr	584.00	30.14	1.04	0.56	0.13	0.05	0.01	0.11	0.24	0.65	0.24
CFR_Design	20452.2	2yr	584.00	42.48	2.46	0.41	0.31	0.02	0.02	0.05	0.18	0.51	0.34
CFR_Design	20152.9	2yr	584.00		14.08		0.45		0.09	0.32	0.48		0.81
CFR_Design	19673.0	2yr	584.00	2.04	3.11	0.28	0.17	0.02	0.01	0.11	0.21	0.38	0.27
CFR_Design	19289.8	2yr	584.00		230.43		0.96		0.07	0.09	0.17		0.85
CFR_Design	18852.7	2yr	584.00		54.39		0.72		0.03	0.07	0.16		0.54
CFR_Design	18469.6	2yr	584.00		43.70		0.48		0.07	0.16	0.32		0.74
CFR_Design	18351.3	2yr	584.00	0.10	11.90	0.03	0.23	0.01	0.04	0.15	0.32	0.13	0.49
CFR_Design	18290.2	2yr	584.00	11.18	8.37	0.24	0.15	0.02	0.01	0.04	0.20	0.33	0.24
CFR_Design	18044.8	2yr	584.00	1.33		0.08		0.01		0.10	0.27	0.17	
CFR_Design	17872.7	2yr	584.00	93.65		0.44		0.02		0.04	0.11	0.46	
CFR_Design	17595.7	2yr	584.00	96.92		0.42		0.03		0.05	0.17	0.49	
CFR_Design	17396.7	2yr	584.00	108.34		0.41		0.03		0.06	0.19	0.53	
CFR_Design	16918.1	2yr	700.00	164.53	28.74	0.84	0.57	0.06	0.04	0.08	0.22	0.76	0.60
CFR_Design	16612.2	2yr	700.00		51.26		0.37		0.07	0.17	0.47		0.79
CFR_Design	16264.4	2yr	700.00	50.13	46.59	0.66	0.47	0.06	0.04	0.10	0.28	0.79	0.60
CFR_Design	15947.2	2yr	700.00		109.97		0.47		0.09	0.16	0.49		0.83
CFR_Design	15566.1	2yr	700.00	0.48	0.62	0.10	0.16	0.02	0.04	0.43	0.62	0.32	0.43
CFR_Design	15091.5	2yr	700.00	14.09	0.01	0.50	0.02	0.02	0.00	0.07	0.13	0.36	0.05
CFR_Design	14604.7	2yr	700.00	0.22	149.51	0.46	0.57	0.04	0.07	0.11	0.31	0.52	0.85
CFR_Design	14218.6	2yr	700.00		54.72		0.77		0.09	0.21	0.38		0.92
CFR_Design	13905.5	2yr	700.00	40.18	7.06	0.56	1.02	0.05	0.09	0.13	0.33	0.64	0.92
CFR_Design	13422.4	2yr	700.00		12.29		0.25		0.02	0.13	0.29		0.52
CFR_Design	13012.6	2yr	700.00		135.22		0.51		0.05	0.07	0.22		0.61
CFR_Design	12583.6	2yr	700.00	0.73	79.92	0.05	0.56	0.01	0.11	0.16	0.38	0.23	0.92
CFR_Design	12145.0	2yr	700.00	51.67		0.60		0.02		0.05	0.13	0.43	
CFR_Design	11609.7	2yr	700.00		32.79		0.52		0.07	0.20	0.34		0.76
CFR_Design	11181.9	2yr	700.00							0.58	0.58		
CFR_Design	10736.1	2yr	700.00	1.69	13.48	0.19	0.31	0.02	0.04	0.15	0.29	0.36	0.51
CFR_Design	10137.7	2yr	700.00		257.36		1.46		0.10	0.12	0.16		1.04
CFR_Design	9823.3	2yr	700.00		28.07		0.29		0.08	0.26	0.63		0.74
CFR_Design	9326.1	2yr	700.00	141.39		0.80		0.06		0.10	0.23	0.75	
CFR_Design	9106.3	2yr	700.00	220.44		0.99		0.09		0.12	0.21	0.96	
CFR_Design	8951.0	2yr	700.00	25.66	0.97	0.44	0.20	0.04	0.02	0.11	0.15	0.58	0.34

HEC-RAS Plan: pr River: CFR_CL Reach: CFR_Design Profile: 2yr (Continued)

Reach	River Sta	Profile	Q Total	Q Left	Q Right	Hydr Depth L	Hydr Depth R	Shear LOB	Shear ROB	Shear Total	Shear Chan	Vel Left	Vel Right
			(cfs)	(cfs)	(cfs)	(ft)	(ft)	(lb/sq ft)	(lb/sq ft)	(lb/sq ft)	(lb/sq ft)	(ft/s)	(ft/s)
CFR_Design	8661.2	2yr	700.00	19.16	0.00	0.39	0.02	0.06	0.00	0.22	0.40	0.65	0.08
CFR_Design	8221.4	2yr	700.00		2.39		0.13		0.03	0.32	0.55		0.37
CFR_Design	7755.8	2yr	700.00		319.46		1.45		0.04	0.05	0.08		0.66
CFR_Design	7700		Inl Struct										
CFR_Design	7614.0	2yr	700.00		226.42		1.00		0.06	0.07	0.15		0.74
CFR_Design	7214.1	2yr	700.00	96.54		0.70		0.06		0.11	0.23	0.73	
CFR_Design	6630.6	2yr	700.00		13.85		0.24		0.04	0.17	0.40		0.48
CFR_Design	6329.6	2yr	700.00		162.48		0.64		0.06	0.09	0.22		0.72
CFR_Design	6165		Inl Struct										
CFR_Design	6070.3	2yr	700.00	0.19	106.19	0.06	0.85	0.00	0.04	0.06	0.12	0.11	0.61
CFR_Design	5559.7	2yr	700.00	69.78		0.61		0.04		0.08	0.12	0.60	
CFR_Design	5088.6	2yr	700.00	136.91		0.53		0.05		0.08	0.28	0.64	
CFR_Design	4683.6	2yr	700.00	33.92	0.45	0.33	0.13	0.03	0.01	0.08	0.22	0.44	0.24
CFR_Design	4235.7	2yr	700.00							0.15	0.15		
CFR_Design	3783.9	2yr	700.00		46.32		0.79		0.08	0.17	0.23		0.85
CFR_Design	3487.5	2yr	700.00	4.27	4.75	0.14	0.23	0.01	0.02	0.10	0.31	0.27	0.37
CFR_Design	3028.0	2yr	700.00	27.58		0.26		0.04		0.12	0.34	0.49	
CFR_Design	2786.0	2yr	700.00	2.32		0.12		0.01		0.12	0.21	0.22	
CFR_Design	2645.3	2yr	700.00	31.62	16.54	0.67	0.30	0.05	0.02	0.08	0.21	0.65	0.39
CFR_Design	2244.1	2yr	700.00		18.21		0.16		0.03	0.13	0.49		0.43
CFR_Design	1921.5	2yr	700.00		28.05		0.41		0.04	0.12	0.29		0.53
CFR_Design	1558.4	2yr	700.00	0.15	0.00	0.03	0.01	0.00		0.13	0.24	0.09	0.04
CFR_Design	1224.6	2yr	700.00	32.87	10.97	0.33	0.43	0.03	0.04	0.09	0.27	0.47	0.56
CFR_Design	835.5	2yr	700.00		2.61		0.27		0.03	0.24	0.29		0.45
CFR_Design	682.5	2yr	700.00	0.09	3.02	0.15	0.34	0.01	0.03	0.21	0.28	0.24	0.43
CFR_Design	529	2yr	700.00							0.32	0.32		
CFR_Design	496		Bridge										
CFR_Design	463	2yr	700.00							0.26	0.26		
CFR_Design	368.0	2yr	700.00							0.36	0.36		
CFR_Design	139.6	2yr	700.00							0.32	0.32		

Proposed Conditions

10 year Event

HEC-RAS Plan: pr River: CFR_CL Reach: CFR_Design Profile: 100yr

Reach	River Sta	Profile	Q Total	Min Ch El Sta	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Top Width	Vel Chnl	Q Channel	Froude # Chl	Hydr Depth C	Hydr Radius C	Top W Act Chan	Shear Chan
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft)	(ft/s)	(cfs)		(ft)	(ft)	(ft)	(lb/sq ft)
CFR_Design	23282.1	100yr	1893.00	1218.78	4709.25	4716.65		4717.13	0.002455	241.79	5.56	1881.97	0.45	4.77	4.48	70.98	0.69
CFR_Design	23228	100yr	1893.00	48.44	4709.77	4716.65	4713.90	4716.97	0.001737	93.93	4.54	1893.00	0.38	4.44	4.29	93.93	0.47
CFR_Design	23192		Bridge														
CFR_Design	23156	100yr	1893.00	66.62	4709.20	4716.52		4716.82	0.001444	88.84	4.40	1893.00	0.35	4.84	4.70	88.84	0.42
CFR_Design	23100.0	100yr	1893.00	1762.76	4710.58	4714.97	4714.97	4716.52	0.013146	67.75	9.98	1890.97	0.99	3.17	3.06	59.75	2.51
CFR_Design	22956.3	100yr	1893.00	1995.88	4709.50	4715.28		4715.36	0.000934	669.35	3.26	734.65	0.28	4.25	4.16	52.93	0.24
CFR_Design	22606.0	100yr	1893.00	2266.54	4710.59	4714.77		4714.93	0.001806	668.57	4.20	1013.20	0.38	3.79	3.71	63.64	0.42
CFR_Design	22349.9	100yr	1893.00	2334.50	4708.62	4714.03		4714.36	0.003033	814.35	5.64	1206.42	0.49	4.07	3.91	52.52	0.74
CFR_Design	22047.4	100yr	1893.00	2111.87	4707.88	4713.55		4713.68	0.001641	960.03	4.19	885.11	0.36	4.16	3.96	50.82	0.41
CFR_Design	21661.8	100yr	1893.00	2612.14	4707.98	4713.13		4713.21	0.001071	1285.20	3.49	722.81	0.29	4.35	4.15	47.62	0.28
CFR_Design	21288.1	100yr	1893.00	2686.46	4709.10	4712.79		4712.86	0.001307	963.16	3.26	683.72	0.32	3.25	3.22	64.60	0.26
CFR_Design	20885.9	100yr	1893.00	2523.84	4706.91	4712.41		4712.50	0.000872	1247.66	3.26	929.52	0.27	4.51	4.37	63.22	0.24
CFR_Design	20452.2	100yr	1893.00	2497.18	4704.59	4712.19		4712.25	0.000560	1299.79	2.89	876.85	0.22	5.40	5.10	56.15	0.18
CFR_Design	20152.9	100yr	1893.00	1944.66	4706.09	4711.32	4710.76	4711.85	0.003967	498.89	6.62	1462.02	0.57	4.18	4.06	52.90	1.01
CFR_Design	19673.0	100yr	1893.00	1999.41	4704.02	4710.44		4710.65	0.001617	463.95	4.27	1373.98	0.36	4.29	4.13	74.96	0.42
CFR_Design	19289.8	100yr	1893.00	1501.03	4704.64	4710.09		4710.16	0.000996	560.48	3.12	754.06	0.28	3.89	3.71	62.14	0.23
CFR_Design	18852.7	100yr	1893.00	1448.54	4702.78	4709.45		4709.66	0.001472	785.76	4.45	1237.28	0.35	4.97	4.71	55.94	0.43
CFR_Design	18469.6	100yr	1893.00	1430.10	4705.00	4708.83		4709.05	0.002479	1055.02	4.65	1206.64	0.44	3.48	3.40	74.49	0.53
CFR_Design	18351.3	100yr	1893.00	1611.47	4703.40	4708.60		4708.77	0.002035	1221.40	4.09	1211.88	0.39	3.35	3.26	88.35	0.41
CFR_Design	18290.2	100yr	1893.00	1712.05	4702.42	4708.57		4708.67	0.001018	1287.38	3.40	1037.68	0.29	4.28	4.14	71.37	0.26
CFR_Design	18044.8	100yr	1893.00	1955.43	4702.07	4708.06		4708.31	0.002235	954.32	4.95	1198.96	0.42	4.30	4.04	56.38	0.56
CFR_Design	17872.7	100yr	1893.00	2131.20	4703.15	4707.93		4707.98	0.000934	1092.17	2.38	896.63	0.25	2.72	2.59	138.26	0.15
CFR_Design	17595.7	100yr	1893.00	2265.13	4703.15	4707.74		4707.80	0.000851	1066.40	2.80	846.43	0.26	3.65	3.55	82.93	0.19
CFR_Design	17396.7	100yr	1893.00	2319.37	4702.89	4707.60		4707.65	0.000803	1071.88	2.72	782.01	0.25	3.67	3.56	78.26	0.18
CFR_Design	16918.1	100yr	2171.00	2185.89	4701.82	4707.15		4707.25	0.001136	946.03	3.76	982.51	0.31	4.46	4.44	58.56	0.31
CFR_Design	16612.2	100yr	2171.00	1592.47	4701.15	4706.44		4706.72	0.002914	506.49	5.27	1313.50	0.48	3.80	3.64	65.60	0.66
CFR_Design	16264.4	100yr	2171.00	1409.21	4700.10	4705.85		4706.01	0.001445	693.17	4.21	1163.04	0.35	4.56	4.40	60.57	0.40
CFR_Design	15947.2	100yr	2171.00	1275.10	4700.27	4705.46		4705.59	0.001469	584.82	4.03	958.92	0.34	4.38	4.06	54.35	0.37
CFR_Design	15566.1	100yr	2171.00	1394.03	4698.28	4704.11	4703.57	4704.79	0.004195	277.77	7.34	1755.85	0.59	4.83	4.55	49.50	1.19
CFR_Design	15091.5	100yr	2171.00	1249.55	4695.42	4703.43		4703.69	0.001207	325.66	4.51	1770.10	0.33	5.79	5.58	67.83	0.42
CFR_Design	14604.7	100yr	2171.00	1046.67	4697.51	4702.97		4703.10	0.001354	505.72	3.88	1026.79	0.34	4.15	4.09	63.73	0.35
CFR_Design	14218.6	100yr	2171.00	1201.02	4695.79	4702.40		4702.60	0.001525	573.54	4.63	1216.45	0.36	5.04	4.87	52.21	0.46
CFR_Design	13905.5	100yr	2171.00	1325.86	4694.55	4701.81		4702.10	0.001751	465.14	5.23	1376.77	0.39	5.48	5.28	48.03	0.58
CFR_Design	13422.4	100yr	2171.00	803.40	4694.12	4700.64		4701.00	0.003206	618.58	5.55	1601.31	0.50	3.79	3.66	76.04	0.73
CFR_Design	13012.6	100yr	2171.00	936.60	4695.50	4700.01		4700.14	0.001469	669.51	3.73	1101.91	0.34	3.74	3.62	78.96	0.33
CFR_Design	12583.6	100yr	2171.00	1497.41	4694.36	4699.59		4699.66	0.000955	814.49	3.07	967.10	0.28	3.79	3.74	82.97	0.22
CFR_Design	12145.0	100yr	2171.00	1709.00	4690.77	4699.31		4699.39	0.000564	776.46	2.97	1248.71	0.22	5.54	5.29	75.78	0.19
CFR_Design	11609.7	100yr	2171.00	1268.31	4692.95	4698.75		4698.94	0.001491	505.32	4.23	1435.12	0.35	4.47	4.32	75.94	0.40
CFR_Design	11181.9	100yr	2171.00	1011.45	4691.31	4696.97	4696.68	4697.73	0.007079	205.25	7.25	2002.25	0.73	3.08	3.02	89.78	1.33
CFR_Design	10736.1	100yr	2171.00	969.42	4690.24	4696.09		4696.28	0.001563	714.95	4.20	1483.10	0.36	4.20	4.13	84.18	0.40
CFR_Design	10137.7	100yr	2171.00	576.61	4690.47	4695.34		4695.48	0.001400	342.90	3.88	1191.22	0.34	4.09	3.98	75.11	0.35
CFR_Design	9823.3	100yr	2171.00	367.58	4689.60	4694.41		4694.82	0.003748	279.94	6.04	1490.83	0.54	3.85	3.69	64.06	0.86
CFR_Design	9326.1	100yr	2171.00	1083.94	4687.73	4693.62		4693.76	0.001284	1493.86	3.94	1123.25	0.32	4.57	4.35	62.42	0.35
CFR_Design	9106.3	100yr	2171.00	1055.26	4689.06	4693.41		4693.51	0.001147	1366.49	3.25	1041.27	0.30	3.60	3.54	89.03	0.25
CFR_Design	8951.0	100yr	2171.00	937.37	4688.01	4693.30		4693.37	0.000709	1845.98	2.47	1695.36	0.23	3.46	3.37	198.50	0.15
CFR_Design	8661.2	100yr	2171.00	738.60	4686.90	4692.50		4692.96	0.002901	1860.88	5.99	1728.03	0.49	4.73	4.43	60.98	0.80
CFR_Design	8221.4	100yr	2171.00	345.72	4685.71	4691.04		4691.48	0.003941	1574.13	6.14	1587.57	0.55	3.87	3.65	66.87	0.90
CFR_Design	7755.8	100yr	2171.00	420.10	4685.03	4690.79	4688.54	4690.84	0.000549	1286.82	2.63	897.67	0.22	4.58	4.48	74.58	0.15
CFR_Design	7700		Inl Struct														
CFR_Design	7614.0	100yr	2171.00	398.08	4685.44	4690.74		4690.82	0.000850	1352.59	3.18	1002.73	0.26	4.53	4.29	69.63	0.23
CFR_Design	7214.1	100yr	2171.00	704.44	4685.33	4690.21		4690.40	0.001559	1977.95	4.27	1385.77	0.36	4.39	4.25	73.83	0.41
CFR_Design	6630.6	100yr	2171.00	389.47	4683.67	4688.70		4689.13	0.003608	1307.97	6.04	1612.69	0.54	3.91	3.80	68.28	0.86
CFR_Design	6329.6	100yr	2171.00	251.60	4683.98	4688.35	4687.18	4688.47	0.001377	1279.27	3.60	1103.90	0.33	3.75	3.61	81.75	0.31
CFR_Design	6165		Inl Struct														
CFR_Design	6070.3	100yr	2171.00	545.45	4682.94	4688.32		4688.44	0.001092	1190.28	3.35	1476.58	0.30	3.97	3.85	111.13	0.26
CFR_Design	5559.7	100yr	2171.00	1069.26	4681.52	4687.77		4687.87	0.001138	1070.44	2.74	1624.13	0.29	2.80	2.76	211.38	0.20
CFR_Design	5088.6	100yr	2171.00	1226.65	4681.41	4687.32		4687.42	0.001041	1674.91	3.53	899.86	0.29	4.60	4.31	55.46	0.28
CFR_Design	4683.6	100yr	2171.00	875.36	4682.02	4686.86		4686.99	0.001119	2716.05	3.59	1326.12	0.30	4.37	4.20	84.58	0.29
CFR_Design	4235.7	100yr	2171.00	265.33	4680.81	4686.36		4686.50	0.001124	2032.30	3.12	1982.21	0.30	3.44	3.38	184.65	0.24
CFR_Design	3783.9	100yr	2171.00	239.20	4680.74	4685.48		4685.79	0.002398	1595.13	4.87	1822.89	0.44	3.79	3.73	98.93	0.56
CFR_Design	3487.5	100yr	2171.00	427.08	4679.19	4684.84		4685.11	0.002108	1300.10	5.09	1462.61	0.41	4.70	4.40	61.15	0.58
CFR_Design	3028.0	100yr	2171.00	507.11	4679.26	4684.19		4684.35	0.001537	1557.39	4.05	1314.42	0.35	4.09	3.96	79.43	0.38

HEC-RAS Plan: pr River: CFR_CL Reach: CFR_Design Profile: 100yr (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El Sta	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Top Width	Vel Chnl	Q Channel	Froude # Chl	Hydr Depth C	Hydr Radius C	Top W Act Chan	Shear Chan
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft)	(ft/s)	(cfs)		(ft)	(ft)	(ft)	(lb/sq ft)
CFR_Design	2786.0	100yr	2171.00	396.69	4678.24	4683.67		4683.92	0.002179	1283.45	4.35	1798.96	0.41	3.57	3.40	115.58	0.46
CFR_Design	2645.3	100yr	2171.00	196.42	4678.17	4683.39		4683.63	0.001855	1225.43	4.61	1573.22	0.39	4.35	4.17	78.55	0.48
CFR_Design	2244.1	100yr	2171.00	86.79	4677.95	4682.91		4683.02	0.001336	1262.85	3.61	1058.04	0.33	3.81	3.70	76.98	0.31
CFR_Design	1921.5	100yr	2171.00	531.55	4676.06	4682.55		4682.68	0.001006	1152.47	3.64	1246.82	0.29	4.82	4.63	71.15	0.29
CFR_Design	1558.4	100yr	2171.00	759.92	4675.85	4682.27		4682.38	0.000705	976.39	3.33	1279.44	0.25	5.58	5.30	68.85	0.23
CFR_Design	1224.6	100yr	2171.00	786.25	4675.55	4682.17		4682.21	0.000334	1142.08	2.32	906.49	0.17	5.50	5.38	71.12	0.11
CFR_Design	835.5	100yr	2171.00	448.01	4675.27	4681.94		4682.06	0.000617	1076.01	3.16	1527.07	0.24	5.57	5.41	86.68	0.21
CFR_Design	682.5	100yr	2171.00	281.66	4673.19	4681.72		4681.93	0.000879	961.60	4.29	1622.39	0.29	6.78	6.55	55.80	0.36
CFR_Design	529	100yr	2171.00	40.62	4673.72	4681.15	4678.46	4681.69	0.002390	70.30	5.90	2171.00	0.45	5.24	4.99	70.30	0.75
CFR_Design	496		Bridge														
CFR_Design	463	100yr	2171.00	31.70	4673.23	4681.07		4681.52	0.001977	75.19	5.40	2171.00	0.41	5.35	5.05	75.19	0.62
CFR_Design	368.0	100yr	2171.00	202.50	4674.07	4681.05		4681.31	0.001324	775.08	4.47	1814.04	0.34	5.39	5.14	75.31	0.42
CFR_Design	139.6	100yr	2171.00	382.40	4672.96	4680.60	4677.84	4680.97	0.001602	904.06	5.12	1963.35	0.37	5.81	5.46	65.96	0.55

HEC-RAS Plan: pr River: CFR_CL Reach: CFR_Design Profile: 100yr

Reach	River Sta	Profile	Q Total	Q Left	Q Right	Hydr Depth L	Hydr Depth R	Shear LOB	Shear ROB	Shear Total	Shear Chan	Vel Left	Vel Right
			(cfs)	(cfs)	(cfs)	(ft)	(ft)	(lb/sq ft)	(lb/sq ft)	(lb/sq ft)	(lb/sq ft)	(ft/s)	(ft/s)
CFR_Design	23282.1	100yr	1893.00	0.19	10.84	0.14	0.73	0.02	0.11	0.57	0.69	0.33	0.99
CFR_Design	23228	100yr	1893.00							0.47	0.47		
CFR_Design	23192		Bridge										
CFR_Design	23156	100yr	1893.00							0.42	0.42		
CFR_Design	23100.0	100yr	1893.00		2.03		0.24		0.19	2.25	2.51		1.08
CFR_Design	22956.3	100yr	1893.00	30.35	1128.00	0.30	2.28	0.02	0.13	0.10	0.24	0.42	1.32
CFR_Design	22606.0	100yr	1893.00	576.26	303.53	1.00	1.69	0.11	0.19	0.16	0.42	1.16	1.62
CFR_Design	22349.9	100yr	1893.00	232.50	454.08	0.62	0.90	0.12	0.17	0.18	0.74	1.02	1.28
CFR_Design	22047.4	100yr	1893.00	685.70	322.19	1.14	0.83	0.12	0.09	0.12	0.41	1.27	0.89
CFR_Design	21661.8	100yr	1893.00	905.83	264.36	1.08	1.18	0.07	0.08	0.08	0.28	0.85	0.90
CFR_Design	21288.1	100yr	1893.00	1206.43	2.85	1.25	0.68	0.10	0.05	0.11	0.26	1.08	0.68
CFR_Design	20885.9	100yr	1893.00	556.64	406.84	0.97	1.17	0.05	0.06	0.07	0.24	0.72	0.89
CFR_Design	20452.2	100yr	1893.00	735.47	280.68	1.33	0.93	0.05	0.03	0.05	0.18	0.73	0.62
CFR_Design	20152.9	100yr	1893.00	91.41	339.57	0.50	0.76	0.12	0.19	0.26	1.01	1.46	1.40
CFR_Design	19673.0	100yr	1893.00	221.56	297.46	1.18	1.20	0.12	0.12	0.17	0.42	1.11	1.13
CFR_Design	19289.8	100yr	1893.00	0.43	1138.51	0.27	1.92	0.02	0.12	0.13	0.23	0.32	1.21
CFR_Design	18852.7	100yr	1893.00	0.35	655.37	0.15	0.98	0.01	0.09	0.12	0.43	0.26	0.94
CFR_Design	18469.6	100yr	1893.00	209.22	477.14	0.55	0.93	0.09	0.14	0.15	0.53	0.83	1.21
CFR_Design	18351.3	100yr	1893.00	336.77	344.35	0.66	0.75	0.08	0.10	0.11	0.41	0.86	0.94
CFR_Design	18290.2	100yr	1893.00	435.48	419.83	0.86	1.07	0.05	0.07	0.07	0.26	0.73	0.86
CFR_Design	18044.8	100yr	1893.00	564.69	129.35	0.76	0.89	0.11	0.12	0.14	0.56	0.99	1.08
CFR_Design	17872.7	100yr	1893.00	996.02	0.35	1.22	0.11	0.07	0.01	0.08	0.15	0.89	0.17
CFR_Design	17595.7	100yr	1893.00	1046.46	0.11	1.24	0.37	0.07	0.02	0.08	0.19	0.86	0.32
CFR_Design	17396.7	100yr	1893.00	1110.99		1.27		0.06		0.07	0.18	0.88	
CFR_Design	16918.1	100yr	2171.00	943.82	244.68	1.31	1.28	0.09	0.09	0.11	0.31	1.03	0.99
CFR_Design	16612.2	100yr	2171.00	33.14	824.37	0.40	1.44	0.07	0.26	0.27	0.66	0.73	1.75
CFR_Design	16264.4	100yr	2171.00	378.22	629.74	1.31	1.37	0.12	0.12	0.15	0.40	1.21	1.17
CFR_Design	15947.2	100yr	2171.00	12.92	1199.16	0.19	2.14	0.02	0.20	0.16	0.37	0.38	1.62
CFR_Design	15566.1	100yr	2171.00	336.83	78.32	1.12	0.93	0.29	0.24	0.45	1.19	1.73	1.52
CFR_Design	15091.5	100yr	2171.00	234.92	165.98	1.79	1.14	0.13	0.09	0.17	0.42	1.28	0.94
CFR_Design	14604.7	100yr	2171.00	12.01	1132.20	0.59	1.92	0.05	0.16	0.18	0.35	0.63	1.44
CFR_Design	14218.6	100yr	2171.00	309.70	644.85	0.92	1.88	0.09	0.18	0.16	0.46	1.16	1.47
CFR_Design	13905.5	100yr	2171.00	756.31	37.92	1.37	2.64	0.15	0.24	0.20	0.58	1.35	1.75
CFR_Design	13422.4	100yr	2171.00	12.26	557.44	0.32	0.88	0.06	0.18	0.24	0.73	0.70	1.30
CFR_Design	13012.6	100yr	2171.00	19.46	1049.64	0.31	1.65	0.03	0.15	0.15	0.33	0.57	1.32
CFR_Design	12583.6	100yr	2171.00	709.87	494.03	1.46	1.82	0.09	0.11	0.11	0.22	0.99	1.14
CFR_Design	12145.0	100yr	2171.00	916.01	6.27	1.67	0.46	0.06	0.02	0.07	0.19	0.83	0.35
CFR_Design	11609.7	100yr	2171.00	288.14	447.74	1.20	1.44	0.11	0.13	0.17	0.40	1.08	1.50
CFR_Design	11181.9	100yr	2171.00		168.75		0.81		0.36	0.79	1.33		1.81
CFR_Design	10736.1	100yr	2171.00	156.16	531.74	0.81	1.20	0.08	0.12	0.14	0.40	0.85	1.11
CFR_Design	10137.7	100yr	2171.00		979.78		2.28		0.20	0.23	0.35		1.60
CFR_Design	9823.3	100yr	2171.00		680.17		1.55		0.36	0.48	0.86		2.03
CFR_Design	9326.1	100yr	2171.00	1047.75	0.00	2.16	0.01	0.17		0.20	0.35	1.48	0.04
CFR_Design	9106.3	100yr	2171.00	1129.29	0.44	2.24	0.09	0.16	0.01	0.17	0.25	1.43	0.17
CFR_Design	8951.0	100yr	2171.00	404.93	70.71	1.63	1.26	0.07	0.06	0.10	0.15	0.91	0.77

HEC-RAS Plan: pr River: CFR_CL Reach: CFR_Design Profile: 100yr (Continued)

Reach	River Sta	Profile	Q Total	Q Left	Q Right	Hydr Depth L	Hydr Depth R	Shear LOB	Shear ROB	Shear Total	Shear Chan	Vel Left	Vel Right
			(cfs)	(cfs)	(cfs)	(ft)	(ft)	(lb/sq ft)	(lb/sq ft)	(lb/sq ft)	(lb/sq ft)	(ft/s)	(ft/s)
CFR_Design	8661.2	100yr	2171.00	394.52	48.45	1.57	1.15	0.28	0.21	0.42	0.80	1.87	1.45
CFR_Design	8221.4	100yr	2171.00	0.22	583.21	0.07	1.17	0.02	0.29	0.39	0.90	0.27	1.72
CFR_Design	7755.8	100yr	2171.00		1273.33		2.57		0.09	0.10	0.15		1.09
CFR_Design	7700		Inl Struct										
CFR_Design	7614.0	100yr	2171.00	7.10	1161.18	0.45	2.39	0.02	0.13	0.14	0.23	0.49	1.29
CFR_Design	7214.1	100yr	2171.00	785.23		1.79		0.17		0.22	0.41	1.44	
CFR_Design	6630.6	100yr	2171.00		558.31		1.02		0.23	0.33	0.86		1.51
CFR_Design	6329.6	100yr	2171.00		1067.10		1.96		0.17	0.19	0.31		1.44
CFR_Design	6165		Inl Struct										
CFR_Design	6070.3	100yr	2171.00	55.75	638.66	1.22	2.06	0.08	0.14	0.17	0.26	0.94	1.32
CFR_Design	5559.7	100yr	2171.00	546.24	0.63	1.35	0.41	0.10	0.03	0.13	0.20	1.02	0.45
CFR_Design	5088.6	100yr	2171.00	1170.55	100.59	1.58	0.66	0.10	0.04	0.10	0.28	1.08	0.61
CFR_Design	4683.6	100yr	2171.00	662.77	182.11	1.66	0.56	0.12	0.04	0.09	0.29	1.16	0.61
CFR_Design	4235.7	100yr	2171.00		188.79		0.62		0.04	0.10	0.24		0.66
CFR_Design	3783.9	100yr	2171.00		348.11		0.72		0.11	0.20	0.56		1.23
CFR_Design	3487.5	100yr	2171.00	527.30	181.09	1.17	1.06	0.15	0.14	0.20	0.58	1.26	1.31
CFR_Design	3028.0	100yr	2171.00	846.96	9.62	1.61	0.69	0.15	0.07	0.19	0.38	1.33	0.75
CFR_Design	2786.0	100yr	2171.00	358.75	13.29	1.22	0.47	0.17	0.06	0.25	0.46	1.32	0.70
CFR_Design	2645.3	100yr	2171.00	245.41	352.36	1.80	0.85	0.21	0.10	0.17	0.48	1.56	1.05
CFR_Design	2244.1	100yr	2171.00	0.01	1112.96	0.04	1.07	0.00	0.09	0.11	0.31	0.11	1.03
CFR_Design	1921.5	100yr	2171.00	269.55	654.62	1.53	1.05	0.10	0.07	0.09	0.29	1.04	0.81
CFR_Design	1558.4	100yr	2171.00	879.80	11.76	2.04	0.32	0.09	0.01	0.09	0.23	1.06	0.31
CFR_Design	1224.6	100yr	2171.00	1005.88	258.64	2.38	1.52	0.05	0.03	0.05	0.11	0.85	0.60
CFR_Design	835.5	100yr	2171.00	539.80	104.13	2.17	3.35	0.08	0.13	0.12	0.21	1.03	1.38
CFR_Design	682.5	100yr	2171.00	109.46	439.14	0.97	1.76	0.05	0.10	0.11	0.36	0.72	1.07
CFR_Design	529	100yr	2171.00							0.75	0.75		
CFR_Design	496		Bridge										
CFR_Design	463	100yr	2171.00							0.62	0.62		
CFR_Design	368.0	100yr	2171.00	7.69	349.27	0.39	1.70	0.03	0.14	0.20	0.42	0.48	1.28
CFR_Design	139.6	100yr	2171.00	82.95	124.70	1.21	1.89	0.12	0.19	0.31	0.55	1.13	1.52

Proposed Conditions

100 year Event

HEC-RAS Plan: pr River: CFR_CL Reach: CFR_Design Profile: 10yr

Reach	River Sta	Profile	Q Total	Min Ch El Sta	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Top Width	Vel Chnl	Q Channel	Froude # Chl	Hydr Depth C	Hydr Radius C	Top W Act Chan	Shear Chan
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft)	(ft/s)	(cfs)		(ft)	(ft)	(ft)	(lb/sq ft)
CFR_Design	23282.1	10yr	1216.00	1218.78	4709.25	4715.47		4715.83	0.002594	73.50	4.77	1215.87	0.44	3.61	3.42	70.67	0.55
CFR_Design	23228	10yr	1216.00	48.44	4709.77	4715.45	4713.11	4715.68	0.001552	80.24	3.91	1216.00	0.35	3.87	3.73	80.24	0.36
CFR_Design	23192		Bridge														
CFR_Design	23156	10yr	1216.00	66.62	4709.20	4715.35		4715.55	0.001178	77.68	3.66	1216.00	0.31	4.28	4.15	77.68	0.31
CFR_Design	23100.0	10yr	1216.00	1762.76	4710.58	4714.23	4714.08	4715.31	0.012397	57.71	8.34	1216.00	0.93	2.53	2.45	57.71	1.89
CFR_Design	22956.3	10yr	1216.00	1995.88	4709.50	4714.70		4714.75	0.000743	425.34	2.64	513.38	0.24	3.67	3.60	52.93	0.17
CFR_Design	22606.0	10yr	1216.00	2266.54	4710.59	4714.20		4714.37	0.001970	513.59	3.94	805.46	0.39	3.22	3.15	63.64	0.39
CFR_Design	22349.9	10yr	1216.00	2334.50	4708.62	4713.47		4713.77	0.002899	493.57	4.99	920.68	0.47	3.51	3.37	52.52	0.61
CFR_Design	22047.4	10yr	1216.00	2111.87	4707.88	4713.01		4713.13	0.001473	635.99	3.62	666.52	0.33	3.62	3.45	50.82	0.32
CFR_Design	21661.8	10yr	1216.00	2612.14	4707.98	4712.62		4712.69	0.000964	915.34	3.05	558.53	0.27	3.85	3.67	47.62	0.22
CFR_Design	21288.1	10yr	1216.00	2686.46	4709.10	4712.25		4712.33	0.001519	788.26	3.12	546.71	0.33	2.72	2.70	64.60	0.26
CFR_Design	20885.9	10yr	1216.00	2523.84	4706.91	4711.77		4711.89	0.001070	863.60	3.26	798.27	0.29	3.88	3.75	63.22	0.25
CFR_Design	20452.2	10yr	1216.00	2497.18	4704.59	4711.45		4711.55	0.000741	840.24	3.02	790.01	0.25	4.66	4.41	56.15	0.20
CFR_Design	20152.9	10yr	1216.00	1944.66	4706.09	4710.69		4711.10	0.003486	229.28	5.56	1040.54	0.52	3.54	3.44	52.90	0.75
CFR_Design	19673.0	10yr	1216.00	1999.41	4704.02	4709.85		4710.02	0.001453	406.11	3.67	1017.48	0.34	3.70	3.56	74.96	0.32
CFR_Design	19289.8	10yr	1216.00	1501.03	4704.64	4709.50		4709.56	0.000985	531.86	2.79	572.81	0.27	3.33	3.17	61.57	0.19
CFR_Design	18852.7	10yr	1216.00	1448.54	4702.78	4708.96		4709.12	0.001091	464.90	3.67	922.72	0.30	4.68	4.42	53.75	0.30
CFR_Design	18469.6	10yr	1216.00	1430.10	4705.00	4708.36		4708.58	0.002465	737.27	4.21	947.04	0.43	3.02	2.95	74.49	0.45
CFR_Design	18351.3	10yr	1216.00	1611.47	4703.40	4708.11		4708.30	0.002283	872.74	3.89	983.33	0.41	2.86	2.77	88.35	0.40
CFR_Design	18290.2	10yr	1216.00	1712.05	4702.42	4708.08		4708.19	0.001022	970.14	3.14	849.36	0.28	3.79	3.67	71.37	0.23
CFR_Design	18044.8	10yr	1216.00	1955.43	4702.07	4707.50	4705.82	4707.80	0.002508	691.82	4.82	1014.48	0.44	3.78	3.56	55.68	0.56
CFR_Design	17872.7	10yr	1216.00	2131.20	4703.15	4707.41		4707.47	0.000867	909.46	2.40	754.75	0.25	2.96	2.78	106.27	0.15
CFR_Design	17595.7	10yr	1216.00	2265.13	4703.15	4707.17		4707.25	0.001093	968.42	2.84	724.71	0.28	3.08	3.00	82.93	0.20
CFR_Design	17396.7	10yr	1216.00	2319.37	4702.89	4706.97		4707.05	0.001112	890.90	2.87	685.45	0.29	3.11	3.01	76.83	0.21
CFR_Design	16918.1	10yr	1337.00	2185.89	4701.82	4706.47		4706.57	0.001123	681.59	3.35	743.07	0.30	3.79	3.77	58.56	0.26
CFR_Design	16612.2	10yr	1337.00	1592.47	4701.15	4705.82		4706.06	0.002754	338.35	4.58	952.89	0.45	3.21	3.07	64.88	0.53
CFR_Design	16264.4	10yr	1337.00	1409.21	4700.10	4705.08		4705.28	0.001855	593.28	4.21	965.74	0.38	3.78	3.65	60.57	0.42
CFR_Design	15947.2	10yr	1337.00	1275.10	4700.27	4704.58		4704.72	0.001811	377.57	3.86	735.36	0.36	3.51	3.25	54.35	0.37
CFR_Design	15566.1	10yr	1337.00	1394.03	4698.28	4703.18	4702.16	4703.78	0.004264	178.13	6.42	1243.62	0.57	3.91	3.68	49.50	0.98
CFR_Design	15091.5	10yr	1337.00	1249.55	4695.42	4702.70		4702.87	0.000862	274.39	3.49	1196.52	0.27	5.06	4.88	67.83	0.26
CFR_Design	14604.7	10yr	1337.00	1046.67	4697.51	4702.26		4702.37	0.001407	458.42	3.49	764.75	0.33	3.44	3.39	63.73	0.30
CFR_Design	14218.6	10yr	1337.00	1201.02	4695.79	4701.64		4701.84	0.001567	436.49	4.21	941.32	0.36	4.28	4.14	52.21	0.40
CFR_Design	13905.5	10yr	1337.00	1325.86	4694.55	4701.06		4701.33	0.001710	406.56	4.68	1061.66	0.38	4.72	4.55	48.03	0.49
CFR_Design	13422.4	10yr	1337.00	803.40	4694.12	4699.98		4700.33	0.002582	309.22	4.99	1217.00	0.45	3.83	3.67	63.77	0.59
CFR_Design	13012.6	10yr	1337.00	936.60	4695.50	4699.38		4699.50	0.001538	561.16	3.37	828.66	0.34	3.11	3.01	78.96	0.29
CFR_Design	12583.6	10yr	1337.00	1497.41	4694.36	4698.83		4698.92	0.001314	740.39	3.11	782.47	0.31	3.04	2.99	82.97	0.25
CFR_Design	12145.0	10yr	1337.00	1709.00	4690.77	4698.49		4698.58	0.000604	687.31	2.77	991.22	0.22	4.72	4.51	75.78	0.17
CFR_Design	11609.7	10yr	1337.00	1268.31	4692.95	4697.91		4698.09	0.001602	361.72	3.81	1052.41	0.35	3.63	3.51	75.94	0.35
CFR_Design	11181.9	10yr	1337.00	1011.45	4691.31	4696.41		4696.91	0.005702	182.03	5.75	1302.28	0.63	2.55	2.51	88.85	0.89
CFR_Design	10736.1	10yr	1337.00	969.42	4690.24	4695.29		4695.50	0.001843	492.83	3.96	1130.42	0.38	3.39	3.34	84.18	0.38
CFR_Design	10137.7	10yr	1337.00	576.61	4690.47	4694.55		4694.65	0.001222	293.36	3.16	784.38	0.31	3.31	3.25	74.81	0.25
CFR_Design	9823.3	10yr	1337.00	367.58	4689.60	4693.62		4694.00	0.004165	253.65	5.51	1080.09	0.55	3.06	2.97	64.01	0.77
CFR_Design	9326.1	10yr	1337.00	1083.94	4687.73	4692.76		4692.90	0.001292	552.36	3.64	852.77	0.32	4.05	3.85	57.74	0.31
CFR_Design	9106.3	10yr	1337.00	1055.26	4689.06	4692.53		4692.63	0.001255	1060.24	3.07	761.59	0.31	3.10	3.05	80.03	0.24
CFR_Design	8951.0	10yr	1337.00	937.37	4688.01	4692.40		4692.47	0.000902	1537.55	2.28	1156.78	0.25	2.56	2.50	198.50	0.14
CFR_Design	8661.2	10yr	1337.00	738.60	4686.90	4691.72		4692.04	0.002384	1518.94	4.81	1157.70	0.43	3.94	3.69	60.98	0.55
CFR_Design	8221.4	10yr	1337.00	345.72	4685.71	4690.20	4689.19	4690.67	0.004127	546.89	5.79	1193.87	0.55	3.43	3.23	60.10	0.83
CFR_Design	7755.8	10yr	1337.00	420.10	4685.03	4690.01	4687.95	4690.05	0.000485	977.59	2.21	628.97	0.20	3.88	3.80	73.25	0.12
CFR_Design	7700		Inl Struct														
CFR_Design	7614.0	10yr	1337.00	398.08	4685.44	4689.97		4690.04	0.000790	966.48	2.73	714.20	0.25	3.77	3.60	69.53	0.18
CFR_Design	7214.1	10yr	1337.00	704.44	4685.33	4689.52		4689.66	0.001294	1251.40	3.50	955.78	0.32	3.71	3.61	73.73	0.29
CFR_Design	6630.6	10yr	1337.00	389.47	4683.67	4688.04	4687.17	4688.48	0.003783	1017.34	5.51	1224.16	0.54	3.26	3.20	68.18	0.75
CFR_Design	6329.6	10yr	1337.00	251.60	4683.98	4687.70	4686.80	4687.79	0.001313	823.28	3.11	787.65	0.31	3.10	3.00	81.56	0.25
CFR_Design	6165		Inl Struct														
CFR_Design	6070.3	10yr	1337.00	545.45	4682.94	4687.69		4687.77	0.000872	775.20	2.67	990.01	0.26	3.34	3.24	111.13	0.18
CFR_Design	5559.7	10yr	1337.00	1069.26	4681.52	4687.17		4687.25	0.001211	745.09	2.41	1121.39	0.29	2.20	2.17	211.38	0.16
CFR_Design	5088.6	10yr	1337.00	1226.65	4681.41	4686.62		4686.73	0.001234	791.05	3.44	741.49	0.31	3.89	3.65	55.46	0.28
CFR_Design	4683.6	10yr	1337.00	875.36	4682.02	4686.10		4686.23	0.001267	1877.35	3.36	1022.53	0.31	3.60	3.46	84.58	0.27
CFR_Design	4235.7	10yr	1337.00	265.33	4680.81	4685.56		4685.67	0.001204	1040.04	2.72	1325.49	0.29	2.66	2.61	183.69	0.20
CFR_Design	3783.9	10yr	1337.00	239.20	4680.74	4684.82		4685.02	0.001808	719.80	3.78	1172.88	0.37	3.20	3.16	96.81	0.36
CFR_Design	3487.5	10yr	1337.00	427.08	4679.19	4684.17		4684.44	0.002056	655.89	4.54	1120.28	0.40	4.03	3.78	61.15	0.49
CFR_Design	3028.0	10yr	1337.00	507.11	4679.26	4683.44		4683.60	0.001726	828.10	3.75	993.10	0.36	3.34	3.23	79.43	0.35

HEC-RAS Plan: pr River: CFR_CL Reach: CFR_Design Profile: 10yr (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El Sta	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Top Width	Vel Chnl	Q Channel	Froude # Chl	Hydr Depth C	Hydr Radius C	Top W Act Chan	Shear Chan
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft)	(ft/s)	(cfs)		(ft)	(ft)	(ft)	(lb/sq ft)
CFR_Design	2786.0	10yr	1337.00	396.69	4678.24	4682.95		4683.15	0.002072	573.09	3.75	1236.54	0.38	2.97	2.82	111.14	0.36
CFR_Design	2645.3	10yr	1337.00	196.42	4678.17	4682.73		4682.90	0.001476	624.49	3.68	1065.41	0.34	3.69	3.54	78.55	0.33
CFR_Design	2244.1	10yr	1337.00	86.79	4677.95	4682.07		4682.24	0.002047	667.65	3.99	921.74	0.39	3.22	3.13	71.68	0.40
CFR_Design	1921.5	10yr	1337.00	531.55	4676.06	4681.53		4681.71	0.001514	549.44	3.80	1027.96	0.34	3.80	3.65	71.15	0.34
CFR_Design	1558.4	10yr	1337.00	759.92	4675.85	4681.09		4681.25	0.001104	476.21	3.55	1074.12	0.30	4.39	4.17	68.85	0.29
CFR_Design	1224.6	10yr	1337.00	786.25	4675.55	4680.88		4680.95	0.000634	685.42	2.67	800.69	0.23	4.21	4.12	71.12	0.16
CFR_Design	835.5	10yr	1337.00	448.01	4675.27	4680.55		4680.68	0.000893	809.48	3.14	1137.53	0.27	4.18	4.06	86.68	0.23
CFR_Design	682.5	10yr	1337.00	281.66	4673.19	4680.26		4680.51	0.001153	627.81	4.18	1242.52	0.32	5.33	5.15	55.80	0.37
CFR_Design	529	10yr	1337.00	40.62	4673.72	4679.96	4677.40	4680.29	0.001760	62.94	4.63	1337.00	0.38	4.59	4.38	62.94	0.48
CFR_Design	496		Bridge														
CFR_Design	463	10yr	1337.00	31.70	4673.23	4679.89		4680.16	0.001452	69.14	4.21	1337.00	0.35	4.59	4.39	69.14	0.40
CFR_Design	368.0	10yr	1337.00	202.50	4674.07	4679.74		4680.01	0.001686	733.06	4.23	1302.11	0.37	4.14	3.94	74.35	0.42
CFR_Design	139.6	10yr	1337.00	382.40	4672.96	4679.35	4676.75	4679.64	0.001603	647.38	4.36	1311.71	0.36	4.56	4.28	65.96	0.43

HEC-RAS Plan: pr River: CFR_CL Reach: CFR_Design Profile: 10yr

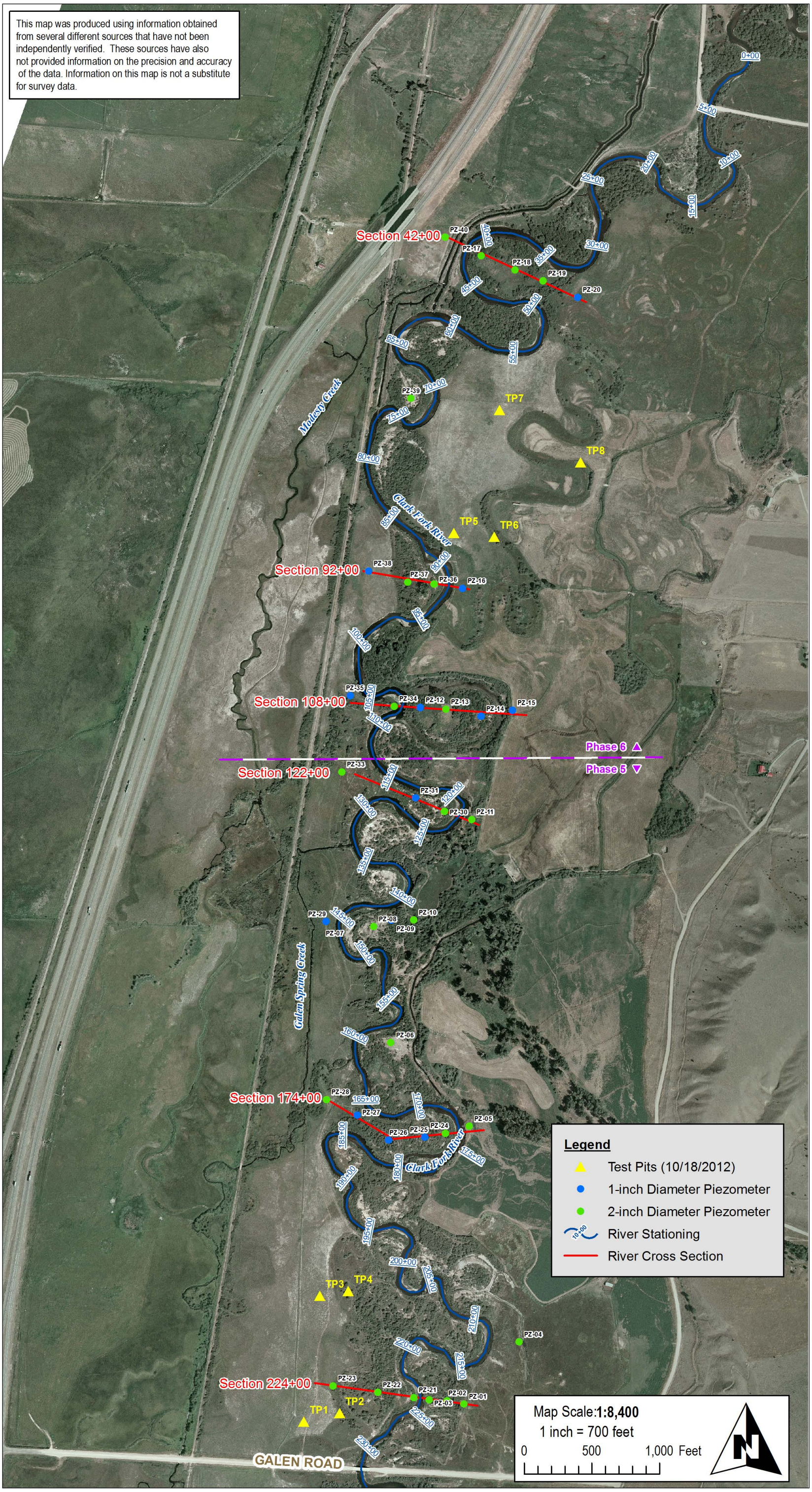
Reach	River Sta	Profile	Q Total	Q Left	Q Right	Hydr Depth L	Hydr Depth R	Shear LOB	Shear ROB	Shear Total	Shear Chan	Vel Left	Vel Right
			(cfs)	(cfs)	(cfs)	(ft)	(ft)	(lb/sq ft)	(lb/sq ft)	(lb/sq ft)	(lb/sq ft)	(ft/s)	(ft/s)
CFR_Design	23282.1	10yr	1216.00		0.13		0.14		0.02	0.53	0.55		0.33
CFR_Design	23228	10yr	1216.00							0.36	0.36		
CFR_Design	23192		Bridge										
CFR_Design	23156	10yr	1216.00							0.31	0.31		
CFR_Design	23100.0	10yr	1216.00							1.89	1.89		
CFR_Design	22956.3	10yr	1216.00	2.41	700.22	0.24	1.96	0.01	0.09	0.09	0.17	0.26	1.07
CFR_Design	22606.0	10yr	1216.00	225.69	184.85	0.72	1.44	0.09	0.18	0.14	0.39	0.88	1.40
CFR_Design	22349.9	10yr	1216.00	118.41	176.90	0.62	0.65	0.11	0.12	0.17	0.61	1.15	1.00
CFR_Design	22047.4	10yr	1216.00	454.23	95.25	1.28	0.50	0.12	0.05	0.10	0.32	1.32	0.60
CFR_Design	21661.8	10yr	1216.00	533.49	123.98	1.03	0.87	0.06	0.05	0.07	0.22	0.78	0.70
CFR_Design	21288.1	10yr	1216.00	668.52	0.77	0.97	0.39	0.09	0.04	0.11	0.26	0.95	0.51
CFR_Design	20885.9	10yr	1216.00	255.59	162.14	0.75	0.73	0.05	0.05	0.06	0.25	0.71	0.69
CFR_Design	20452.2	10yr	1216.00	343.62	82.37	0.94	0.70	0.04	0.03	0.05	0.20	0.65	0.54
CFR_Design	20152.9	10yr	1216.00	29.88	145.59	0.64	0.78	0.14	0.17	0.30	0.75	1.09	1.39
CFR_Design	19673.0	10yr	1216.00	82.82	115.71	0.74	0.78	0.07	0.07	0.12	0.32	0.77	0.80
CFR_Design	19289.8	10yr	1216.00		643.19		1.40		0.09	0.10	0.19		0.97
CFR_Design	18852.7	10yr	1216.00		293.28		0.90		0.06	0.09	0.30		0.79
CFR_Design	18469.6	10yr	1216.00	29.88	239.08	0.22	0.73	0.03	0.11	0.12	0.45	0.45	1.06
CFR_Design	18351.3	10yr	1216.00	67.00	165.67	0.27	0.63	0.04	0.09	0.09	0.40	0.53	0.92
CFR_Design	18290.2	10yr	1216.00	158.23	208.41	0.54	0.85	0.03	0.05	0.06	0.23	0.55	0.72
CFR_Design	18044.8	10yr	1216.00	166.55	34.96	0.42	0.43	0.07	0.07	0.11	0.56	0.77	0.70
CFR_Design	17872.7	10yr	1216.00	461.24	0.01	0.83	0.18	0.04	0.01	0.06	0.15	0.70	0.15
CFR_Design	17595.7	10yr	1216.00	491.28	0.00	0.77	0.09	0.05	0.00	0.07	0.20	0.72	0.14
CFR_Design	17396.7	10yr	1216.00	530.55		0.86		0.06		0.07	0.21	0.76	
CFR_Design	16918.1	10yr	1337.00	483.17	110.75	1.03	0.98	0.07	0.07	0.09	0.26	0.96	0.82
CFR_Design	16612.2	10yr	1337.00		384.11		1.03		0.18	0.25	0.53		1.36
CFR_Design	16264.4	10yr	1337.00	179.39	191.87	1.03	0.64	0.12	0.07	0.12	0.42	1.11	0.79
CFR_Design	15947.2	10yr	1337.00	0.00	601.63	0.03	1.41	0.00	0.16	0.19	0.37	0.11	1.33
CFR_Design	15566.1	10yr	1337.00	73.27	20.11	0.61	0.67	0.16	0.18	0.40	0.98	1.16	1.24
CFR_Design	15091.5	10yr	1337.00	94.51	45.96	1.23	0.70	0.07	0.04	0.10	0.26	0.84	0.57
CFR_Design	14604.7	10yr	1337.00	1.22	571.03	0.28	1.33	0.02	0.12	0.14	0.30	0.38	1.12
CFR_Design	14218.6	10yr	1337.00	95.49	300.19	0.73	1.22	0.07	0.12	0.14	0.40	0.79	1.12
CFR_Design	13905.5	10yr	1337.00	252.45	22.89	0.81	1.97	0.09	0.18	0.14	0.49	0.89	1.47
CFR_Design	13422.4	10yr	1337.00		120.00		0.56		0.09	0.20	0.59		0.87
CFR_Design	13012.6	10yr	1337.00	1.23	507.11	0.17	1.08	0.02	0.10	0.13	0.29	0.30	1.02
CFR_Design	12583.6	10yr	1337.00	278.70	275.82	0.80	1.26	0.07	0.10	0.10	0.25	0.77	1.05
CFR_Design	12145.0	10yr	1337.00	345.73	0.05	0.96	0.09	0.04	0.00	0.05	0.17	0.59	0.12
CFR_Design	11609.7	10yr	1337.00	80.38	204.21	0.68	1.32	0.07	0.13	0.15	0.35	0.76	1.19
CFR_Design	11181.9	10yr	1337.00		34.72		0.38		0.14	0.51	0.89		0.98
CFR_Design	10736.1	10yr	1337.00	43.97	162.61	0.53	0.68	0.06	0.08	0.13	0.38	0.70	0.83
CFR_Design	10137.7	10yr	1337.00		552.62		1.90		0.15	0.17	0.25		1.33
CFR_Design	9823.3	10yr	1337.00		256.91		0.91		0.24	0.37	0.77		1.50
CFR_Design	9326.1	10yr	1337.00	484.23		1.42		0.11		0.15	0.31	1.12	
CFR_Design	9106.3	10yr	1337.00	575.41		1.55		0.12		0.15	0.24	1.17	
CFR_Design	8951.0	10yr	1337.00	159.54	20.68	0.97	0.71	0.05	0.04	0.09	0.14	0.74	0.59

HEC-RAS Plan: pr River: CFR_CL Reach: CFR_Design Profile: 10yr (Continued)

Reach	River Sta	Profile	Q Total	Q Left	Q Right	Hydr Depth L	Hydr Depth R	Shear LOB	Shear ROB	Shear Total	Shear Chan	Vel Left	Vel Right
			(cfs)	(cfs)	(cfs)	(ft)	(ft)	(lb/sq ft)	(lb/sq ft)	(lb/sq ft)	(lb/sq ft)	(ft/s)	(ft/s)
CFR_Design	8661.2	10yr	1337.00	172.03	7.27	1.24	0.40	0.18	0.06	0.29	0.55	1.39	0.66
CFR_Design	8221.4	10yr	1337.00		143.13		0.60		0.15	0.31	0.83		1.13
CFR_Design	7755.8	10yr	1337.00		708.03		1.97		0.06	0.07	0.12		0.86
CFR_Design	7700		Inl Struct										
CFR_Design	7614.0	10yr	1337.00	0.36	622.43	0.20	1.74	0.01	0.09	0.10	0.18	0.24	1.01
CFR_Design	7214.1	10yr	1337.00	381.22		1.36		0.11		0.15	0.29	1.09	
CFR_Design	6630.6	10yr	1337.00		112.85		0.40		0.09	0.20	0.75		0.82
CFR_Design	6329.6	10yr	1337.00		549.35		1.36		0.11	0.14	0.25		1.10
CFR_Design	6165		Inl Struct										
CFR_Design	6070.3	10yr	1337.00	18.37	328.62	0.73	1.53	0.04	0.08	0.11	0.18	0.59	0.97
CFR_Design	5559.7	10yr	1337.00	215.58	0.03	0.76	0.14	0.06	0.01	0.10	0.16	0.72	0.22
CFR_Design	5088.6	10yr	1337.00	574.96	20.55	1.09	0.44	0.08	0.03	0.09	0.28	0.92	0.50
CFR_Design	4683.6	10yr	1337.00	292.50	21.97	1.05	0.27	0.08	0.02	0.09	0.27	0.91	0.50
CFR_Design	4235.7	10yr	1337.00		11.51		0.22		0.02	0.12	0.20		0.36
CFR_Design	3783.9	10yr	1337.00		164.12		1.28		0.14	0.25	0.36		1.24
CFR_Design	3487.5	10yr	1337.00	148.25	68.47	0.58	0.79	0.07	0.10	0.14	0.49	0.78	1.01
CFR_Design	3028.0	10yr	1337.00	342.05	1.86	0.92	0.41	0.10	0.04	0.14	0.35	0.99	0.56
CFR_Design	2786.0	10yr	1337.00	100.36	0.10	0.64	0.17	0.08	0.02	0.19	0.36	0.83	0.35
CFR_Design	2645.3	10yr	1337.00	123.10	148.49	1.39	0.92	0.13	0.08	0.15	0.33	1.17	0.90
CFR_Design	2244.1	10yr	1337.00		415.26		0.65		0.08	0.12	0.40		1.08
CFR_Design	1921.5	10yr	1337.00	54.29	254.75	0.52	0.83	0.05	0.08	0.11	0.34	0.62	0.99
CFR_Design	1558.4	10yr	1337.00	262.42	0.46	0.87	0.57	0.06	0.03	0.09	0.29	0.75	0.50
CFR_Design	1224.6	10yr	1337.00	446.57	89.74	1.33	0.92	0.05	0.04	0.06	0.16	0.75	0.59
CFR_Design	835.5	10yr	1337.00	148.38	51.10	0.97	1.95	0.05	0.11	0.11	0.23	0.73	1.16
CFR_Design	682.5	10yr	1337.00	12.07	82.41	0.58	0.84	0.04	0.06	0.14	0.37	0.58	0.76
CFR_Design	529	10yr	1337.00							0.48	0.48		
CFR_Design	496		Bridge										
CFR_Design	463	10yr	1337.00							0.40	0.40		
CFR_Design	368.0	10yr	1337.00		34.89		0.40		0.04	0.16	0.42		0.55
CFR_Design	139.6	10yr	1337.00	4.66	20.62	0.56	0.64	0.06	0.06	0.27	0.43	0.67	0.74

Appendix B

Borrow Area and Groundwater Investigation



TerraGraphics Environmental Engineering, Inc.
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FILE Montana\CFROU\MXD's\testpits_01072013	Map Projection: NAD83 Montana State Plane	PROJECT NAME Clark Fork River Operable Unit Phases 5 & 6 Part 1, Floodplain Investigation	Borrow Area Test Pit and Piezomenter Location Map
PRINT DATE May 13, 2013	PROJECT MANAGER M. Culpo		
PROJECT NUMBER 10074-3 MDEQ - CFR Investigation - TO #26	CARTOGRAPHER B. Bailey		

Borrow Test Pit Analytical Results

ANALYTICAL SUMMARY REPORT

October 18, 2012

MT DEQ-Federal Superfund
PO Box 200901
Helena, MT 59620-0901

Workorder No.: H12090147 Quote ID: H578 - Clark Fork River O.U Reach A, Phase 5

Project Name: Clark Fork River O.U Reach A, Phase 5 & 6

Energy Laboratories Inc Helena MT received the following 24 samples for MT DEQ-Federal Superfund on 9/11/2012 for analysis.

Sample ID	Client Sample ID	Collect Date	Receive Date	Matrix	Test
H12090147-001	TP1 @ 1 Foot	09/10/12 8:30	09/11/12	Soil	Metals by ICP/ICPMS, Total Metals, NH4Ac Cations, Saturated Paste Coarse Fragments Carbon Nitrogen Ratio Conductivity, Saturated Paste Extract Lime as CaCO3 Nitrate as N, KCL Extract Total Kjeldahl Nitrogen Organic Carbon/Matter Walkely Black pH, Saturated Paste Phosphorus-Olsen Digestion, Total Metals KCL Soil Extract Lime Percentage NaHCO3 Soil Extract NH4AC Soil Extraction Saturated Paste Extraction Total Organic Matter Prep Sodium Adsorption Ratio Sieves
H12090147-002	TP1 @ 4 Feet	09/10/12 8:35	09/11/12	Soil	Same As Above
H12090147-003	TP1 @ 12 Feet	09/10/12 8:48	09/11/12	Soil	Metals by ICP/ICPMS, Total Conductivity, Saturated Paste Extract pH, Saturated Paste Digestion, Total Metals Saturated Paste Extraction Sieves

ANALYTICAL SUMMARY REPORT

H12090147-004	TP2 @ 1 Foot	09/10/12 9:10	09/11/12	Soil	Metals by ICP/ICPMS, Total Metals, NH4Ac Cations, Saturated Paste Coarse Fragments Carbon Nitrogen Ratio Conductivity, Saturated Paste Extract Lime as CaCO3 Nitrate as N, KCL Extract Total Kjeldahl Nitrogen Organic Carbon/Matter Walkely Black pH, Saturated Paste Phosphorus-Olsen Digestion, Total Metals KCL Soil Extract Lime Percentage NaHCO3 Soil Extract NH4AC Soil Extraction Saturated Paste Extraction Total Organic Matter Prep Sodium Adsorption Ratio Sieves
H12090147-005	TP2 @ 4.5 Feet	09/10/12 9:20	09/11/12	Soil	Metals by ICP/ICPMS, Total Conductivity, Saturated Paste Extract pH, Saturated Paste Digestion, Total Metals Saturated Paste Extraction Sieves
H12090147-006	TP2 @ 12 Feet	09/10/12 9:35	09/11/12	Soil	Same As Above
H12090147-007	TP3 @ 2 Feet	09/10/12 10:30	09/11/12	Soil	Metals by ICP/ICPMS, Total Metals, NH4Ac Cations, Saturated Paste Coarse Fragments Carbon Nitrogen Ratio Conductivity, Saturated Paste Extract Lime as CaCO3 Nitrate as N, KCL Extract Total Kjeldahl Nitrogen Organic Carbon/Matter Walkely Black pH, Saturated Paste Phosphorus-Olsen Digestion, Total Metals KCL Soil Extract Lime Percentage NaHCO3 Soil Extract NH4AC Soil Extraction Saturated Paste Extraction Total Organic Matter Prep Sodium Adsorption Ratio Sieves
H12090147-008	TP3 @ 3 Feet	09/10/12 10:35	09/11/12	Soil	Same As Above

ANALYTICAL SUMMARY REPORT

H12090147-009	TP3 @ 11 Feet	09/10/12 11:00	09/11/12	Soil	Metals by ICP/ICPMS, Total Conductivity, Saturated Paste Extract pH, Saturated Paste Digestion, Total Metals Saturated Paste Extraction Sieves
H12090147-010	TP4 @ 1 Foot	09/10/12 9:50	09/11/12	Soil	Metals by ICP/ICPMS, Total Metals, NH4Ac Cations, Saturated Paste Coarse Fragments Carbon Nitrogen Ratio Conductivity, Saturated Paste Extract Lime as CaCO3 Nitrate as N, KCL Extract Total Kjeldahl Nitrogen Organic Carbon/Matter Walkely Black pH, Saturated Paste Phosphorus-Olsen Digestion, Total Metals KCL Soil Extract Lime Percentage NaHCO3 Soil Extract NH4AC Soil Extraction Saturated Paste Extraction Total Organic Matter Prep Sodium Adsorption Ratio Sieves
H12090147-011	TP4 @ 5 Feet	09/10/12 10:00	09/11/12	Soil	Metals by ICP/ICPMS, Total Conductivity, Saturated Paste Extract pH, Saturated Paste Digestion, Total Metals Saturated Paste Extraction Sieves
H12090147-012	TP4 @ 12 Feet	09/10/12 10:15	09/11/12	Soil	Same As Above
H12090147-013	TP5 @ 1 Foot	09/10/12 13:35	09/11/12	Soil	Metals by ICP/ICPMS, Total Metals, NH4Ac Cations, Saturated Paste Coarse Fragments Carbon Nitrogen Ratio Conductivity, Saturated Paste Extract Lime as CaCO3 Nitrate as N, KCL Extract Total Kjeldahl Nitrogen Organic Carbon/Matter Walkely Black pH, Saturated Paste Phosphorus-Olsen Digestion, Total Metals KCL Soil Extract Lime Percentage NaHCO3 Soil Extract NH4AC Soil Extraction Saturated Paste Extraction Total Organic Matter Prep Sodium Adsorption Ratio Sieves

ANALYTICAL SUMMARY REPORT

H12090147-014	TP5 @ 5 Feet	09/10/12 13:40 09/11/12	Soil	Same As Above
H12090147-015	TP5 @ 12.5 Feet	09/10/12 13:55 09/11/12	Soil	Metals by ICP/ICPMS, Total Conductivity, Saturated Paste Extract pH, Saturated Paste Digestion, Total Metals Saturated Paste Extraction Sieves
H12090147-016	TP6 @ 1.5 Feet	09/10/12 14:05 09/11/12	Soil	Metals by ICP/ICPMS, Total Metals, NH4Ac Cations, Saturated Paste Coarse Fragments Carbon Nitrogen Ratio Conductivity, Saturated Paste Extract Lime as CaCO3 Nitrate as N, KCL Extract Total Kjeldahl Nitrogen Organic Carbon/Matter Walkely Black pH, Saturated Paste Phosphorus-Olsen Digestion, Total Metals KCL Soil Extract Lime Percentage NaHCO3 Soil Extract NH4AC Soil Extraction Saturated Paste Extraction Total Organic Matter Prep Sodium Adsorption Ratio Sieves
H12090147-017	TP6 @ 3 Feet	09/10/12 14:08 09/11/12	Soil	Metals by ICP/ICPMS, Total Conductivity, Saturated Paste Extract pH, Saturated Paste Digestion, Total Metals Saturated Paste Extraction Sieves
H12090147-018	TP6 @ 12 Feet	09/10/12 14:16 09/11/12	Soil	Same As Above

ANALYTICAL SUMMARY REPORT

H12090147-019	TP7 @ 1.5 Feet	09/10/12 14:30 09/11/12	Soil	Metals by ICP/ICPMS, Total Metals, NH4Ac Cations, Saturated Paste Coarse Fragments Carbon Nitrogen Ratio Conductivity, Saturated Paste Extract Lime as CaCO3 Nitrate as N, KCL Extract Total Kjeldahl Nitrogen Organic Carbon/Matter Walkely Black pH, Saturated Paste Phosphorus-Olsen Digestion, Total Metals KCL Soil Extract Lime Percentage NaHCO3 Soil Extract NH4AC Soil Extraction Saturated Paste Extraction Total Organic Matter Prep Sodium Adsorption Ratio Sieves
H12090147-020	TP7 @ 4.5 Feet	09/10/12 14:35 09/11/12	Soil	Same As Above
H12090147-021	TP7 @ 12 Feet	09/10/12 14:42 09/11/12	Soil	Metals by ICP/ICPMS, Total Conductivity, Saturated Paste Extract pH, Saturated Paste Digestion, Total Metals Saturated Paste Extraction Sieves
H12090147-022	TP8 @ 2 Feet	09/10/12 14:55 09/11/12	Soil	Metals by ICP/ICPMS, Total Metals, NH4Ac Cations, Saturated Paste Coarse Fragments Carbon Nitrogen Ratio Conductivity, Saturated Paste Extract Lime as CaCO3 Nitrate as N, KCL Extract Total Kjeldahl Nitrogen Organic Carbon/Matter Walkely Black pH, Saturated Paste Phosphorus-Olsen Digestion, Total Metals KCL Soil Extract Lime Percentage NaHCO3 Soil Extract NH4AC Soil Extraction Saturated Paste Extraction Total Organic Matter Prep Sodium Adsorption Ratio Sieves
H12090147-023	TP8 @ 3.5 Feet	09/10/12 15:00 09/11/12	Soil	Metals by ICP/ICPMS, Total Conductivity, Saturated Paste Extract pH, Saturated Paste Digestion, Total Metals Saturated Paste Extraction Sieves

ANALYTICAL SUMMARY REPORT

H12090147-024	TP8 @ 12 Feet	09/10/12 15:15 09/11/12	Soil	Same As Above

The analyses presented in this report were performed by Energy Laboratories, Inc., 3161 E. Lyndale Ave., Helena, MT 59604, unless otherwise noted. Any exceptions or problems with the analyses are noted in the Laboratory Analytical Report, the QA/QC Summary Report, or the Case Narrative.

The results as reported relate only to the item(s) submitted for testing.

If you have any questions regarding these test results, please call.

Report Approved By:

CLIENT: MT DEQ-Federal Superfund
Project: Clark Fork River O.U Reach A, Phase 5 & 6
Sample Delivery Group: H12090147

Report Date: 11/07/12

CASE NARRATIVE

Additional analysis requested by Jeremy Mickey on 9/19/12. Wj Attached is the graphing report completed by Pioneer Technical Services. Wj 11/7/12

LABORATORY ANALYTICAL REPORT

Prepared by Helena, MT Branch

Client: MT DEQ-Federal Superfund
Project: Clark Fork River O.U Reach A, Phase 5 & 6
Workorder: H12090147

Report Date: 11/07/12
Date Received: 09/11/12

		Analysis		2_000 Inch Sieve	1_500 Inch Sieve	1_000 Inch Sieve	0_750 Inch Sieve	0_500 Inch Sieve	0_250 Inch Sieve	No_ 10 Sieve	No_ 40 Sieve	No_ 60 Sieve	No_ 100 Sieve	No_ 200 Sieve
		Units		wt% retained	wt% retained	wt% retained	wt% retained	wt% retained	wt% retained	wt% retained	wt% retained	wt% retained	wt% retained	wt% retained
Sample ID	**Client Sample ID**	**Up**	**Low**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**
H12090147-001	TP1 @ 1 Foot	0	0	< 0.1	< 0.1	< 0.1	1.9	0.3	0.1	0.7	6.2	8.6	10.2	12.7
H12090147-002	TP1 @ 4 Feet	0	0	< 0.1	< 0.1	1.9	0.9	< 0.1	0.6	1.0	8.8	13.0	15.1	17.1
H12090147-003	TP1 @ 12 Feet	0	0	40.2	8.5	6.3	5.0	6.8	7.0	7.5	11.9	3.1	1.7	0.9
H12090147-004	TP2 @ 1 Foot	0	0	< 0.1	< 0.1	< 0.1	1.2	3.1	2.7	2.2	4.4	4.6	9.5	17.5
H12090147-005	TP2 @ 4.5 Feet	0	0	35.6	15.0	7.1	4.9	4.9	5.9	7.1	11.1	2.7	1.9	1.5
H12090147-006	TP2 @ 12 Feet	0	0	21.6	7.7	10.5	6.2	6.4	9.1	11.2	14.6	3.0	2.3	2.1
H12090147-007	TP3 @ 2 Feet	0	0	12.4	1.9	9.9	4.1	4.9	6.4	12.0	4.6	3.1	4.1	5.0
H12090147-008	TP3 @ 3 Feet	0	0	< 0.1	6.1	14.9	5.8	5.7	6.7	5.9	8.0	5.5	5.3	5.9
H12090147-009	TP3 @ 11 Feet	0	0	35.6	12.3	11.6	5.5	5.4	7.0	7.2	10.5	2.4	1.1	0.5
H12090147-010	TP4 @ 1 Foot	0	0	< 0.1	< 0.1	2.0	< 0.1	1.7	3.3	11.0	10.6	7.0	9.4	13.0
H12090147-011	TP4 @ 5 Feet	0	0	43.1	9.6	8.8	3.7	4.0	5.4	8.6	12.0	1.9	0.9	0.5
H12090147-012	TP4 @ 12 Feet	0	0	33.7	7.9	14.0	5.2	5.7	6.6	10.4	11.6	2.3	1.2	0.5
H12090147-013	TP5 @ 1 Foot	0	0	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.9	9.1	11.6	11.1	13.6
H12090147-014	TP5 @ 5 Feet	0	0	3.1	0.4	4.3	3.8	6.0	7.9	16.8	17.2	6.4	5.5	6.6
H12090147-015	TP5 @ 12.5 Feet	0	0	26.6	5.2	11.3	5.8	7.6	9.6	9.6	15.0	4.3	1.9	1.0
H12090147-016	TP6 @ 1.5 Feet	0	0	< 0.1	< 0.1	< 0.1	< 0.1	0.7	2.4	12.5	32.6	25.9	12.0	4.9
H12090147-017	TP6 @ 3 Feet	0	0	< 0.1	5.8	18.0	10.6	11.9	12.2	12.9	18.4	5.7	2.7	0.8
H12090147-018	TP6 @ 12 Feet	0	0	11.9	2.4	12.7	6.3	7.0	8.8	12.2	29.3	6.1	2.3	0.5
H12090147-019	TP7 @ 1.5 Feet	0	0	< 0.1	< 0.1	< 0.1	3.8	0.6	1.3	2.4	10.5	12.6	13.2	15.1
H12090147-020	TP7 @ 4.5 Feet	0	0	< 0.1	4.2	2.4	0.7	0.5	3.7	3.8	10.1	10.5	11.4	13.0
H12090147-021	TP7 @ 12 Feet	0	0	17.2	8.7	15.8	6.3	7.9	9.7	9.0	17.5	2.8	2.6	1.4
H12090147-022	TP8 @ 2 Feet	0	0	< 0.1	< 0.1	< 0.1	< 0.1	1.4	3.7	16.5	43.1	13.5	4.8	3.2
H12090147-023	TP8 @ 3.5 Feet	0	0	5.1	5.3	2.2	6.2	7.0	14.5	27.9	19.2	4.7	2.5	1.3
H12090147-024	TP8 @ 12 Feet	0	0	21.5	8.2	9.0	6.5	5.9	11.1	13.5	15.8	3.7	2.3	1.1

LABORATORY ANALYTICAL REPORT

Prepared by Helena, MT Branch

Client: MT DEQ-Federal Superfund
Project: Clark Fork River O.U Reach A, Phase 5 & 6
Workorder: H12090147

Report Date: 11/07/12
Date Received: 09/11/12

		Analysis		Pan	Coarse Frags	Carbon Nitrogen	pH-SatPst	COND	Ca-SatPst	Mg-SatPst	Na-SatPst	SAR	K, available	K-Ext
		Units		wt% retained	%		s_u_	mmhos/cm	meq/l	meq/l	meq/l	unitless	mg/kg	meq/100g
Sample ID	**Client Sample ID**	**Up**	**Low**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**
H12090147-001	TP1 @ 1 Foot	0	0	59.3	3	8.8	8.7	4.1	1.01	1.24	25.1	23.7		8.3
H12090147-002	TP1 @ 4 Feet	0	0	41.6	4	8.3	8.0	1.4	2.11	1.81	5.67	4.0		2.4
H12090147-003	TP1 @ 12 Feet	0	0	1.0			7.8	0.9						
H12090147-004	TP2 @ 1 Foot	0	0	54.9	9	5.9	7.6	0.5	2.40	1.00	1.59	1.2		0.73
H12090147-005	TP2 @ 4.5 Feet	0	0	2.3			7.7	1.0						
H12090147-006	TP2 @ 12 Feet	0	0	5.2			7.7	1.0						
H12090147-007	TP3 @ 2 Feet	0	0	31.7	52	7.2	7.8	0.8	1.83	1.18	2.61	2.1		2.5
H12090147-008	TP3 @ 3 Feet	0	0	30.3	45	6.5	7.7	0.7	1.77	1.13	2.02	1.7	760	
H12090147-009	TP3 @ 11 Feet	0	0	0.8			7.4	2.0						
H12090147-010	TP4 @ 1 Foot	0	0	41.9	18	8.0	7.4	1.0	5.59	2.05	1.99	1.0		0.87
H12090147-011	TP4 @ 5 Feet	0	0	1.4			7.7	1.1						
H12090147-012	TP4 @ 12 Feet	0	0	0.9			7.5	1.9						
H12090147-013	TP5 @ 1 Foot	0	0	53.8	< 2	7.9	7.6	2.7	13.0	7.55	8.19	2.6		1.2
H12090147-014	TP5 @ 5 Feet	0	0	21.9	42	5.5	7.4	3.7	23.3	8.96	11.2	2.8		0.47
H12090147-015	TP5 @ 12.5 Feet	0	0	2.2			7.5	1.6						
H12090147-016	TP6 @ 1.5 Feet	0	0	8.9	16	7.2	6.9	1.3	9.66	2.28	2.02	0.8		0.28
H12090147-017	TP6 @ 3 Feet	0	0	1.0			6.2	2.4						
H12090147-018	TP6 @ 12 Feet	0	0	0.6			7.5	0.7						
H12090147-019	TP7 @ 1.5 Feet	0	0	40.6	8	9.5	7.6	5.4	13.7	13.6	25.3	6.9		3.0
H12090147-020	TP7 @ 4.5 Feet	0	0	39.8	15	6.5	7.5	4.0	20.5	10.3	11.3	2.9		2.1
H12090147-021	TP7 @ 12 Feet	0	0	1.0			7.4	2.2						
H12090147-022	TP8 @ 2 Feet	0	0	13.9	22	12.9	6.1	2.5	22.5	6.09	1.67	0.4		0.31
H12090147-023	TP8 @ 3.5 Feet	0	0	3.8			7.4	0.9						
H12090147-024	TP8 @ 12 Feet	0	0	1.5			7.6	0.7						

LABORATORY ANALYTICAL REPORT

Prepared by Helena, MT Branch

Client: MT DEQ-Federal Superfund
Project: Clark Fork River O.U Reach A, Phase 5 & 6
Workorder: H12090147

Report Date: 11/07/12
Date Received: 09/11/12

		Analysis		K	OM-WB	OC	Lime	Olsen Phos-Olsen	NO3	TKN	As-T	Cd-T	Cu-T	Pb-T
		Units		mg/kg	%	%	%	mg/kg	mg/kg Dry	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Sample ID	Client Sample ID	Up	Low	Results	Results	Results	Results	Results	Results	Results	Results	Results	Results	Results
H12090147-001	TP1 @ 1 Foot	0	0	3300	2.1	1.2	50.2	2	1.1	1370	26	< 1	20	< 5
H12090147-002	TP1 @ 4 Feet	0	0	940	1.7	1.0	49.6	2	1.2	1180	10	< 1	13	11
H12090147-003	TP1 @ 12 Feet	0	0								5	< 1	12	7
H12090147-004	TP2 @ 1 Foot	0	0	290	0.8	0.5	29.8	< 1	1.8	784	< 5	< 1	21	14
H12090147-005	TP2 @ 4.5 Feet	0	0								9	< 1	13	11
H12090147-006	TP2 @ 12 Feet	0	0								5	< 1	15	13
H12090147-007	TP3 @ 2 Feet	0	0	960	1.0	0.6	47.9	1	1.6	784	9	< 1	18	12
H12090147-008	TP3 @ 3 Feet	0	0	760	1.0	0.6	53.9	1	1.5	924	9	< 1	12	12
H12090147-009	TP3 @ 11 Feet	0	0								< 5	< 1	8	13
H12090147-010	TP4 @ 1 Foot	0	0	340	4.6	2.7	8.79	2	1.5	3300	34	4	513	37
H12090147-011	TP4 @ 5 Feet	0	0								9	< 1	48	16
H12090147-012	TP4 @ 12 Feet	0	0								7	< 1	57	8
H12090147-013	TP5 @ 1 Foot	0	0	490	2.5	1.4	37.3	< 1	1.2	1820	10	< 1	23	6
H12090147-014	TP5 @ 5 Feet	0	0	180	0.6	0.4	10.5	< 1	1.0	672	7	< 1	18	12
H12090147-015	TP5 @ 12.5 Feet	0	0								8	< 1	15	6
H12090147-016	TP6 @ 1.5 Feet	0	0	110	1.0	0.6	0.61	1	< 1.0	840	< 5	< 1	11	< 5
H12090147-017	TP6 @ 3 Feet	0	0								9	< 1	6	< 5
H12090147-018	TP6 @ 12 Feet	0	0								< 5	< 1	8	< 5
H12090147-019	TP7 @ 1.5 Feet	0	0	1200	1.7	1.0	44.2	1	1.0	1060	< 5	< 1	16	14
H12090147-020	TP7 @ 4.5 Feet	0	0	800	1.2	0.7	23.6	1	1.0	1060	17	< 1	28	16
H12090147-021	TP7 @ 12 Feet	0	0								9	< 1	14	7
H12090147-022	TP8 @ 2 Feet	0	0	120	3.1	1.8	0.86	1	< 1.0	1370	30	< 1	59	16
H12090147-023	TP8 @ 3.5 Feet	0	0								< 5	< 1	20	7
H12090147-024	TP8 @ 12 Feet	0	0								< 5	< 1	15	6

LABORATORY ANALYTICAL REPORT

Prepared by Helena, MT Branch

Client: MT DEQ-Federal Superfund
Project: Clark Fork River O.U Reach A, Phase 5 & 6
Workorder: H12090147

Report Date: 11/07/12
Date Received: 09/11/12

		Analysis		Zn-T
		Units		mg/kg
Sample ID	**Client Sample ID**	**Up**	**Low**	**Results**
H12090147-001	TP1 @ 1 Foot	0	0	34
H12090147-002	TP1 @ 4 Feet	0	0	28
H12090147-003	TP1 @ 12 Feet	0	0	20
H12090147-004	TP2 @ 1 Foot	0	0	40
H12090147-005	TP2 @ 4.5 Feet	0	0	28
H12090147-006	TP2 @ 12 Feet	0	0	27
H12090147-007	TP3 @ 2 Feet	0	0	38
H12090147-008	TP3 @ 3 Feet	0	0	30
H12090147-009	TP3 @ 11 Feet	0	0	23
H12090147-010	TP4 @ 1 Foot	0	0	1210
H12090147-011	TP4 @ 5 Feet	0	0	42
H12090147-012	TP4 @ 12 Feet	0	0	54
H12090147-013	TP5 @ 1 Foot	0	0	37
H12090147-014	TP5 @ 5 Feet	0	0	36
H12090147-015	TP5 @ 12.5 Feet	0	0	24
H12090147-016	TP6 @ 1.5 Feet	0	0	25
H12090147-017	TP6 @ 3 Feet	0	0	17
H12090147-018	TP6 @ 12 Feet	0	0	14
H12090147-019	TP7 @ 1.5 Feet	0	0	32
H12090147-020	TP7 @ 4.5 Feet	0	0	44
H12090147-021	TP7 @ 12 Feet	0	0	27
H12090147-022	TP8 @ 2 Feet	0	0	97
H12090147-023	TP8 @ 3.5 Feet	0	0	47
H12090147-024	TP8 @ 12 Feet	0	0	35

QA/QC Summary Report

Prepared by Helena, MT Branch

Client: MT DEQ-Federal Superfund **Report Date:** 10/18/12

Project: Clark Fork River O.U Reach A, Phase 5 & 6 **Work Order:** H12090147

Analyte	Count	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: ASA24-5									Analytical Run: FIA202-HE_120927B	
Sample ID: ICV		Initial Calibration Verification Standard							09/27/12 10:39	
Phosphorus, Olsen		4.8	mg/kg	1.0	96	90	110			
Sample ID: ICB		Initial Calibration Blank, Instrument Blank							09/27/12 10:43	
Phosphorus, Olsen		0.043	mg/kg	1.0		0	0			
Method: ASA24-5									Batch: 18127	
Sample ID: MB-18127		Method Blank				Run: FIA202-HE_120927B			09/27/12 11:06	
Phosphorus, Olsen		0.5	mg/kg	0.08						
Sample ID: LCS-18127		Laboratory Control Sample				Run: FIA202-HE_120927B			09/27/12 11:07	
Phosphorus, Olsen		1.6	mg/kg	1.0	82	70	130			
Sample ID: H12090147-001AMS		Sample Matrix Spike				Run: FIA202-HE_120927B			09/27/12 11:09	
Phosphorus, Olsen		52	mg/kg	1.0	101	80	120			
Sample ID: H12090147-001AMSD		Sample Matrix Spike Duplicate				Run: FIA202-HE_120927B			09/27/12 11:10	
Phosphorus, Olsen		53	mg/kg	1.0	103	80	120	2.1	20	
Sample ID: H12090147-010ADUP		Sample Duplicate				Run: FIA202-HE_120927B			09/27/12 11:16	
Phosphorus, Olsen		2.2	mg/kg	1.0				9.2	30	
Sample ID: H12090147-020AMS		Sample Matrix Spike				Run: FIA202-HE_120927B			09/27/12 11:24	
Phosphorus, Olsen		48	mg/kg	1.0	94	80	120			
Sample ID: H12090147-020AMSD		Sample Matrix Spike Duplicate				Run: FIA202-HE_120927B			09/27/12 11:25	
Phosphorus, Olsen		48	mg/kg	1.0	95	80	120	0.8	20	
Sample ID: H12090147-020ADUP		Sample Duplicate				Run: FIA202-HE_120927B			09/27/12 11:26	
Phosphorus, Olsen		1.5	mg/kg	1.0				24	30	

Qualifiers:

RL - Analyte reporting limit.

ND - Not detected at the reporting limit.

QA/QC Summary Report

Prepared by Helena, MT Branch

Client: MT DEQ-Federal Superfund **Report Date:** 10/18/12

Project: Clark Fork River O.U Reach A, Phase 5 & 6 **Work Order:** H12090147

Analyte	Count	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: ASA29-3										Batch: 18131
Sample ID: LCS-18131		Laboratory Control Sample				Run: MISC SOILS_120927A				09/27/12 11:32
Organic Matter		1.32	%	0.020	106	70	130			
Sample ID: MBLK-18131		Method Blank				Run: MISC SOILS_120927A				09/27/12 11:32
Organic Matter		ND	%	0.009						
Sample ID: H12090147-010ADUP	2	Sample Duplicate				Run: MISC SOILS_120927A				09/27/12 11:32
Organic Carbon		2.62	%	0.10				1.4	20	
Organic Matter		4.50	%	0.17						
Sample ID: H12090147-020ADUP	2	Sample Duplicate				Run: MISC SOILS_120927A				09/27/12 11:32
Organic Carbon		0.695	%	0.10				0.0	20	
Organic Matter		1.19	%	0.17						

Qualifiers:

RL - Analyte reporting limit.

ND - Not detected at the reporting limit.

QA/QC Summary Report

Prepared by Helena, MT Branch

Client: MT DEQ-Federal Superfund
Report Date: 10/18/12
Project: Clark Fork River O.U Reach A, Phase 5 & 6
Work Order: H12090147

Analyte	Count	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: ASA31-3										Batch: 18184
Sample ID: LCS-181841209281000		Laboratory Control Sample				Run: MISC WC_120928A				09/28/12 10:00
Total Kjeldahl Nitrogen		924	mg/kg	10	99	70	130			
Sample ID: MB-18184		Method Blank				Run: MISC WC_120928A				09/28/12 10:00
Total Kjeldahl Nitrogen		ND	mg/kg	10						
Sample ID: H12090418-001AMS		Sample Matrix Spike				Run: MISC WC_120928A				09/28/12 10:00
Total Kjeldahl Nitrogen		2910	mg/kg	10	73	50	150			
Sample ID: H12090418-001AMSD		Sample Matrix Spike Duplicate				Run: MISC WC_120928A				09/28/12 10:00
Total Kjeldahl Nitrogen		2860	mg/kg	10	71	50	150			

Qualifiers:

RL - Analyte reporting limit.

ND - Not detected at the reporting limit.

QA/QC Summary Report

Prepared by Helena, MT Branch

Client: MT DEQ-Federal Superfund **Report Date:** 10/18/12

Project: Clark Fork River O.U Reach A, Phase 5 & 6 **Work Order:** H12090147

Analyte	Count	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: ASA33-8									Analytical Run: FIA203-HE_121004B	
Sample ID: ICV		Initial Calibration Verification Standard							10/04/12 09:47	
Nitrate as N, KCL Extract		1.0	mg/kg	1.0	103	90	110			
Sample ID: ICB		Initial Calibration Blank, Instrument Blank							10/04/12 09:51	
Nitrate as N, KCL Extract		-0.019	mg/kg	1.0		0	0			
Sample ID: CCV		Continuing Calibration Verification Standard							10/04/12 11:02	
Nitrate as N, KCL Extract		0.47	mg/kg	1.0	94	90	110			
Sample ID: CCV		Continuing Calibration Verification Standard							10/04/12 11:23	
Nitrate as N, KCL Extract		0.47	mg/kg	1.0	95	90	110			
Method: ASA33-8									Batch: 18180	
Sample ID: H12090147-010ADUP		Sample Duplicate				Run: FIA203-HE_121004B			10/04/12 11:13	
Nitrate as N, KCL Extract		1.5	mg/kg Dry	1.0				1.0	30	
Sample ID: H12090147-001AMS		Sample Matrix Spike				Run: FIA203-HE_121004B			10/04/12 11:19	
Nitrate as N, KCL Extract		5.6	mg/kg Dry	1.0	91	80	120			
Sample ID: H12090147-001AMSD		Sample Matrix Spike Duplicate				Run: FIA203-HE_121004B			10/04/12 11:20	
Nitrate as N, KCL Extract		5.8	mg/kg Dry	1.0	93	80	120	2.2	30	
Sample ID: H12090147-020ADUP		Sample Duplicate				Run: FIA203-HE_121004B			10/04/12 11:25	
Nitrate as N, KCL Extract		1.0	mg/kg Dry	1.0				0.0	30	
Sample ID: H12090147-020AMS		Sample Matrix Spike				Run: FIA203-HE_121004B			10/04/12 11:28	
Nitrate as N, KCL Extract		5.5	mg/kg Dry	1.0	89	80	120			
Sample ID: H12090147-020AMSD		Sample Matrix Spike Duplicate				Run: FIA203-HE_121004B			10/04/12 11:29	
Nitrate as N, KCL Extract		5.5	mg/kg Dry	1.0	89	80	120	0.4	30	

Qualifiers:

RL - Analyte reporting limit.

ND - Not detected at the reporting limit.

QA/QC Summary Report

Prepared by Helena, MT Branch

Client: MT DEQ-Federal Superfund **Report Date:** 10/18/12

Project: Clark Fork River O.U Reach A, Phase 5 & 6 **Work Order:** H12090147

Analyte	Count	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: ASAM10-3								Analytical Run: SOIL EC_120926A		
Sample ID: ICV_1_120924_1		Initial Calibration Verification Standard							09/25/12 11:38	
Conductivity, sat. paste		20.6	mmhos/cm	0.10	103	90	110			
Sample ID: CCV_1_120924_1		Continuing Calibration Verification Standard							09/25/12 11:18	
Conductivity, sat. paste		1.45	mmhos/cm	0.10	103	90	110			
Sample ID: CCV1_1_120924_1		Continuing Calibration Verification Standard							09/25/12 11:18	
Conductivity, sat. paste		5.29	mmhos/cm	0.10	106	90	110			
Sample ID: ICV_1_120924_1		Initial Calibration Verification Standard							09/25/12 11:18	
Conductivity, sat. paste		21.1	mmhos/cm	0.10	105	90	110			
Sample ID: CCV_3_120924_1		Continuing Calibration Verification Standard							09/25/12 11:26	
Conductivity, sat. paste		1.43	mmhos/cm	0.10	102	90	110			
Sample ID: CCV_4_120924_1		Continuing Calibration Verification Standard							09/25/12 11:33	
Conductivity, sat. paste		1.44	mmhos/cm	0.10	102	90	110			
Method: ASAM10-3								Batch: 120924_1_COND-S-PASTE		
Sample ID: LCS-18102		Laboratory Control Sample				Run: SOIL EC_120926A			09/25/12 11:38	
Conductivity, sat. paste		4.20	mmhos/cm	0.10	89	80	120			
Sample ID: H12090147-010ADUP		Sample Duplicate				Run: SOIL EC_120926A			09/25/12 11:26	
Conductivity, sat. paste		1.00	mmhos/cm	0.10				1.2	20	
Sample ID: H12090147-020ADUP		Sample Duplicate				Run: SOIL EC_120926A			09/25/12 11:33	
Conductivity, sat. paste		3.96	mmhos/cm	0.10				0.1	20	

Qualifiers:

RL - Analyte reporting limit.

ND - Not detected at the reporting limit.

QA/QC Summary Report

Prepared by Helena, MT Branch

Client: MT DEQ-Federal Superfund **Report Date:** 10/18/12

Project: Clark Fork River O.U Reach A, Phase 5 & 6 **Work Order:** H12090147

Analyte	Count	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: ASAM10-3.2								Analytical Run: SOIL PH METER_120926A		
Sample ID: ICV_1_120924_1		Initial Calibration Verification Standard							09/25/12 08:22	
pH, sat. paste		10.0	s.u.	0.10	100	98	102			
Sample ID: CCV_1_120924_1		Continuing Calibration Verification Standard							09/25/12 07:58	
pH, sat. paste		7.00	s.u.	0.10	100	95	105			
Sample ID: CCV1_1_120924_1		Continuing Calibration Verification Standard							09/25/12 07:59	
pH, sat. paste		4.03	s.u.	0.10	101	95	105			
Sample ID: ICV_1_120924_1		Initial Calibration Verification Standard							09/25/12 07:59	
pH, sat. paste		10.0	s.u.	0.10	100	98	102			
Sample ID: CCV_3_120924_1		Continuing Calibration Verification Standard							09/25/12 08:07	
pH, sat. paste		7.01	s.u.	0.10	100	95	105			
Sample ID: CCV_4_120924_1		Continuing Calibration Verification Standard							09/25/12 08:15	
pH, sat. paste		7.00	s.u.	0.10	100	95	105			
Method: ASAM10-3.2										Batch: 18089
Sample ID: LCS-18089		Laboratory Control Sample				Run: SOIL PH METER_120926A			09/25/12 08:00	
pH, sat. paste		7.57	s.u.	0.10	100	90	110			
Sample ID: H12090147-010ADUP		Sample Duplicate				Run: SOIL PH METER_120926A			09/25/12 08:07	
pH, sat. paste		7.44	s.u.	0.10				0.1	30	
Sample ID: H12090147-020ADUP		Sample Duplicate				Run: SOIL PH METER_120926A			09/25/12 08:15	
pH, sat. paste		7.48	s.u.	0.10				0.3	30	

Qualifiers:

RL - Analyte reporting limit.

ND - Not detected at the reporting limit.

QA/QC Summary Report

Prepared by Helena, MT Branch

Client: MT DEQ-Federal Superfund **Report Date:** 10/18/12

Project: Clark Fork River O.U Reach A, Phase 5 & 6 **Work Order:** H12090147

Analyte	Count	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: E200.7									Analytical Run: ICP2-HE_120926B	
Sample ID: ICV	8	Initial Calibration Verification Standard							09/26/12 09:28	
Arsenic		0.813	mg/L	0.0092	102	90	110			
Cadmium		0.393	mg/L	0.0010	98	90	110			
Calcium		39.8	mg/L	1.0	100	90	110			
Copper		0.780	mg/L	0.010	98	90	110			
Lead		0.812	mg/L	0.013	101	90	110			
Magnesium		39.9	mg/L	1.0	100	90	110			
Sodium		40.2	mg/L	1.0	101	90	110			
Zinc		0.807	mg/L	0.010	101	90	110			
Sample ID: ICSA	8	Interference Check Sample A							09/26/12 09:43	
Arsenic		-0.00699	mg/L	0.0092		0	0			
Cadmium		0.000700	mg/L	0.0010		0	0			
Calcium		472	mg/L	1.0	94	80	120			
Copper		0.00196	mg/L	0.010		0	0			
Lead		0.0170	mg/L	0.013		0	0			
Magnesium		505	mg/L	1.0	101	80	120			
Sodium		0.0525	mg/L	1.0		0	0			
Zinc		0.00555	mg/L	0.010		0	0			
Sample ID: ICSAB	8	Interference Check Sample AB							09/26/12 09:47	
Arsenic		1.04	mg/L	0.0092	104	80	120			
Cadmium		0.904	mg/L	0.0010	90	80	120			
Calcium		469	mg/L	1.0	94	80	120			
Copper		0.493	mg/L	0.010	99	80	120			
Lead		0.958	mg/L	0.013	96	80	120			
Magnesium		503	mg/L	1.0	101	80	120			
Sodium		21.2	mg/L	1.0	106	80	120			
Zinc		1.00	mg/L	0.010	100	80	120			

Qualifiers:

RL - Analyte reporting limit.

ND - Not detected at the reporting limit.

QA/QC Summary Report

Prepared by Helena, MT Branch

Client: MT DEQ-Federal Superfund **Report Date:** 10/18/12

Project: Clark Fork River O.U Reach A, Phase 5 & 6 **Work Order:** H12090147

Analyte	Count	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: E200.7									Analytical Run: ICP2-HE_121001B	
Sample ID: ICV	3	Initial Calibration Verification Standard							10/01/12 10:00	
Arsenic		0.789	mg/L	0.0092	99	90	110			
Lead		0.771	mg/L	0.013	96	90	110			
Potassium		38.8	mg/L	1.0	97	90	110			
Sample ID: ICV	3	Initial Calibration Verification Standard							10/01/12 10:11	
Arsenic		0.792	mg/L	0.0092	99	90	110			
Lead		0.780	mg/L	0.013	98	90	110			
Potassium		38.4	mg/L	1.0	96	90	110			
Sample ID: ICSA	3	Interference Check Sample A							10/01/12 10:26	
Arsenic		-0.0244	mg/L	0.0092		0	0			
Lead		0.0259	mg/L	0.013		0	0			
Potassium		-0.0390	mg/L	1.0		0	0			
Sample ID: ICSAB	3	Interference Check Sample AB							10/01/12 10:30	
Arsenic		1.05	mg/L	0.0092	105	80	120			
Lead		0.966	mg/L	0.013	97	80	120			
Potassium		21.2	mg/L	1.0	106	80	120			
Method: E200.7									Analytical Run: ICP2-HE_121005B	
Sample ID: ICV	3	Initial Calibration Verification Standard							10/05/12 10:44	
Calcium		39.5	mg/L	1.0	99	90	110			
Magnesium		39.4	mg/L	1.0	99	90	110			
Sodium		40.4	mg/L	1.0	101	90	110			
Sample ID: ICSA	3	Interference Check Sample A							10/05/12 10:59	
Calcium		454	mg/L	1.0	91	80	120			
Magnesium		480	mg/L	1.0	96	80	120			
Sodium		0.0641	mg/L	1.0		0	0			
Sample ID: ICSAB	3	Interference Check Sample AB							10/05/12 11:03	
Calcium		456	mg/L	1.0	91	80	120			
Magnesium		476	mg/L	1.0	95	80	120			
Sodium		21.8	mg/L	1.0	109	80	120			

Qualifiers:

RL - Analyte reporting limit.

ND - Not detected at the reporting limit.

QA/QC Summary Report

Prepared by Helena, MT Branch

Client: MT DEQ-Federal Superfund **Report Date:** 10/18/12

Project: Clark Fork River O.U Reach A, Phase 5 & 6 **Work Order:** H12090147

Analyte	Count	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: SW6010B										Batch: 18089
Sample ID: MB-18089	6	Method Blank				Run: ICP2-HE_120926B				09/26/12 20:00
Calcium		0.04	mg/L	0.02						
Magnesium		ND	mg/L	0.007						
Sodium		ND	mg/L	0.02						
Calcium, sat. paste		0.002	meq/L	0.001						
Magnesium, sat. paste		ND	meq/L	0.0006						
Sodium, sat. paste		ND	meq/L	0.0008						
Sample ID: LCS-18089	6	Laboratory Control Sample				Run: ICP2-HE_120926B				09/26/12 20:04
Calcium		444	mg/L	1.0	106	70	130			
Magnesium		166	mg/L	1.0	96	70	130			
Sodium		419	mg/L	1.0	98	70	130			
Calcium, sat. paste		22.2	meq/L	0.050	106	70	130			
Magnesium, sat. paste		13.7	meq/L	0.082	96	70	130			
Sodium, sat. paste		18.2	meq/L	0.044	98	70	130			
Sample ID: H12090147-022AMS2	6	Sample Matrix Spike				Run: ICP2-HE_120926B				09/26/12 21:21
Calcium		543	mg/L	1.0		75	125			A
Magnesium		171	mg/L	1.0	97	75	125			
Sodium		143	mg/L	1.0	105	75	125			
Calcium, sat. paste		27.1	meq/L	0.050		75	125			A
Magnesium, sat. paste		14.1	meq/L	0.082	97	75	125			
Sodium, sat. paste		6.22	meq/L	0.044	105	75	125			
Sample ID: H12090147-022AMSD2	6	Sample Matrix Spike Duplicate				Run: ICP2-HE_120926B				09/26/12 21:24
Calcium		540	mg/L	1.0		75	125	0.5	20	A
Magnesium		171	mg/L	1.0	97	75	125	0.2	20	
Sodium		139	mg/L	1.0	101	75	125	2.8	20	
Calcium, sat. paste		26.9	meq/L	0.050		75	125	0.5	20	A
Magnesium, sat. paste		14.1	meq/L	0.082	97	75	125	0.2	20	
Sodium, sat. paste		6.05	meq/L	0.044	101	75	125	2.8	20	
Method: SW6010B										Batch: 18101
Sample ID: MB-18101	5	Method Blank				Run: ICP2-HE_120926B				09/26/12 18:12
Arsenic		ND	mg/kg	0.4						
Cadmium		ND	mg/kg	0.01						
Copper		0.4	mg/kg	0.2						
Lead		ND	mg/kg	1						
Zinc		ND	mg/kg	0.1						
Sample ID: LFB-18101	5	Laboratory Fortified Blank				Run: ICP2-HE_120926B				09/26/12 18:15
Arsenic		50.0	mg/kg	1.0	100	80	120			
Cadmium		24.3	mg/kg	1.0	97	80	120			
Copper		50.4	mg/kg	1.0	100	80	120			
Lead		49.2	mg/kg	1.0	98	80	120			
Zinc		50.4	mg/kg	1.0	101	80	120			

Qualifiers:

RL - Analyte reporting limit.

ND - Not detected at the reporting limit.

A - The analyte level was greater than four times the spike level. In accordance with the method % recovery is not calculated.

QA/QC Summary Report

Prepared by Helena, MT Branch

Client: MT DEQ-Federal Superfund **Report Date:** 10/18/12

Project: Clark Fork River O.U Reach A, Phase 5 & 6 **Work Order:** H12090147

Analyte	Count	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: SW6010B										Batch: 18101
Sample ID: LCS-18101	5	Laboratory Control Sample				Run: ICP2-HE_120926B				09/26/12 18:19
Arsenic		268	mg/kg	1.5	79	72.3	106.4			
Cadmium		115	mg/kg	1.0	85	73	105.1			
Copper		241	mg/kg	1.0	87	77.5	109.6			
Lead		178	mg/kg	3.1	96	75.9	108.6			
Zinc		183	mg/kg	1.0	87	74.2	109.9			
Sample ID: H12090147-018AMS	5	Sample Matrix Spike				Run: ICP2-HE_120926B				09/26/12 19:53
Arsenic		51.4	mg/kg	1.5	105	75	125			
Cadmium		23.9	mg/kg	1.0	98	75	125			
Copper		57.8	mg/kg	1.0	102	75	125			
Lead		57.5	mg/kg	3.0	117	75	125			
Zinc		63.9	mg/kg	1.0	102	75	125			
Sample ID: H12090147-018AMSD	5	Sample Matrix Spike Duplicate				Run: ICP2-HE_120926B				09/26/12 19:57
Arsenic		51.3	mg/kg	1.5	105	75	125			
Cadmium		24.3	mg/kg	1.0	99	75	125			
Copper		60.3	mg/kg	1.0	107	75	125			
Lead		53.3	mg/kg	3.1	109	75	125			
Zinc		65.8	mg/kg	1.0	106	75	125			
Method: SW6010B										Batch: 18103
Sample ID: MB-18103	5	Method Blank				Run: ICP2-HE_120926B				09/26/12 15:51
Arsenic		ND	mg/kg	0.4						
Cadmium		ND	mg/kg	0.01						
Copper		0.3	mg/kg	0.2						
Lead		ND	mg/kg	1						
Zinc		0.2	mg/kg	0.1						
Sample ID: LFB-18103	5	Laboratory Fortified Blank				Run: ICP2-HE_120926B				09/26/12 15:55
Arsenic		49.8	mg/kg	1.0	100	80	120			
Cadmium		24.8	mg/kg	1.0	99	80	120			
Copper		49.9	mg/kg	1.0	99	80	120			
Lead		50.5	mg/kg	1.0	101	80	120			
Zinc		51.5	mg/kg	1.0	103	80	120			
Sample ID: LCS-18103	5	Laboratory Control Sample				Run: ICP2-HE_120926B				09/26/12 16:06
Arsenic		291	mg/kg	1.5	86	72.3	106.4			
Cadmium		124	mg/kg	1.0	92	73	105.1			
Copper		253	mg/kg	1.0	91	77.5	109.6			
Lead		186	mg/kg	3.1	100	75.9	108.6			
Zinc		201	mg/kg	1.0	95	74.2	109.9			
Sample ID: H12090366-002AMS	5	Sample Matrix Spike				Run: ICP2-HE_120926B				09/26/12 16:24
Arsenic		26.1	mg/kg	1.0	99	75	125			
Cadmium		11.7	mg/kg	1.0	94	75	125			
Copper		36.3	mg/kg	1.0	96	75	125			

Qualifiers:

RL - Analyte reporting limit.

ND - Not detected at the reporting limit.

QA/QC Summary Report

Prepared by Helena, MT Branch

Client: MT DEQ-Federal Superfund **Report Date:** 10/18/12

Project: Clark Fork River O.U Reach A, Phase 5 & 6 **Work Order:** H12090147

Analyte	Count	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: SW6010B										Batch: 18103
Sample ID: H12090366-002AMS	5	Sample Matrix Spike				Run: ICP2-HE_120926B			09/26/12 16:24	
Lead		47.5	mg/kg	1.5	96	75	125			
Zinc		73.5	mg/kg	1.0	109	75	125			
Sample ID: H12090366-002AMSD	5	Sample Matrix Spike Duplicate				Run: ICP2-HE_120926B			09/26/12 16:28	
Arsenic		25.9	mg/kg	1.0	99	75	125	0.6	20	
Cadmium		12.0	mg/kg	1.0	96	75	125	2.0	20	
Copper		35.9	mg/kg	1.0	95	75	125	0.9	20	
Lead		48.4	mg/kg	1.5	99	75	125	1.9	20	
Zinc		70.8	mg/kg	1.0	98	75	125	3.8	20	
Sample ID: H12090366-002AMS	5	Sample Matrix Spike				Run: ICP2-HE_120926B			09/26/12 17:05	
Arsenic		25.1	mg/kg	1.0	101	75	125			
Cadmium		11.5	mg/kg	1.0	93	75	125			
Copper		35.7	mg/kg	1.0	94	75	125			
Lead		48.4	mg/kg	1.5	86	75	125			
Zinc		72.2	mg/kg	1.0	99	75	125			
Sample ID: H12090366-002AMSD	5	Sample Matrix Spike Duplicate				Run: ICP2-HE_120926B			09/26/12 17:08	
Arsenic		26.9	mg/kg	1.0	108	75	125	6.7	20	
Cadmium		11.8	mg/kg	1.0	95	75	125	2.3	20	
Copper		36.4	mg/kg	1.0	97	75	125	1.9	20	
Lead		47.8	mg/kg	1.5	84	75	125	1.3	20	
Zinc		69.9	mg/kg	1.0	90	75	125	3.2	20	
Sample ID: H12090147-024AMS	5	Sample Matrix Spike				Run: ICP2-HE_120926B			09/26/12 18:04	
Arsenic		49.1	mg/kg	1.5	94	75	125			
Cadmium		23.3	mg/kg	1.0	93	75	125			
Copper		64.3	mg/kg	1.0	100	75	125			
Lead		55.3	mg/kg	3.1	91	75	125			
Zinc		78.8	mg/kg	1.0	89	75	125			
Sample ID: H12090147-024AMSD	5	Sample Matrix Spike Duplicate				Run: ICP2-HE_120926B			09/26/12 18:08	
Arsenic		52.6	mg/kg	1.5	101	75	125	6.8	20	
Cadmium		24.0	mg/kg	1.0	96	75	125	3.1	20	
Copper		63.3	mg/kg	1.0	98	75	125	1.5	20	
Lead		56.8	mg/kg	3.1	94	75	125	2.6	20	
Zinc		79.9	mg/kg	1.0	91	75	125	1.3	20	

Qualifiers:

RL - Analyte reporting limit.

ND - Not detected at the reporting limit.

QA/QC Summary Report

Prepared by Helena, MT Branch

Client: MT DEQ-Federal Superfund **Report Date:** 10/18/12

Project: Clark Fork River O.U Reach A, Phase 5 & 6 **Work Order:** H12090147

Analyte	Count	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: SW6010B										Batch: 18101
Sample ID: MB-18101	5	Method Blank				Run: ICP2-HE_121001B				10/02/12 05:23
Arsenic		ND	mg/kg	0.4						
Cadmium		ND	mg/kg	0.01						
Copper		ND	mg/kg	0.2						
Lead		ND	mg/kg	1						
Zinc		0.2	mg/kg	0.1						
Method: SW6010B										Batch: 18103
Sample ID: MB-18103	5	Method Blank				Run: ICP2-HE_121001B				10/02/12 06:46
Arsenic		ND	mg/kg	0.4						
Cadmium		ND	mg/kg	0.01						
Copper		ND	mg/kg	0.2						
Lead		ND	mg/kg	1						
Zinc		0.2	mg/kg	0.1						
Method: SW6010B										Batch: 18128
Sample ID: MB-18128	3	Method Blank				Run: ICP2-HE_121001B				10/01/12 21:20
Potassium		0.8	mg/L	0.02						
Potassium, Available		0.8	mg/kg	0.02						
Potassium, Extractable		0.002	meq/100g	5E-05						
Sample ID: LCS-18128	3	Laboratory Control Sample				Run: ICP2-HE_121001B				10/01/12 21:24
Potassium		175	mg/L	1.0	98	70	130			
Potassium, Available		175	mg/kg	1.00	98	70	130			
Potassium, Extractable		0.45	meq/100g		98	70	130			
Sample ID: H12090283-001AMS2	3	Sample Matrix Spike				Run: ICP2-HE_121001B				10/01/12 21:36
Potassium		519	mg/L	1.0	91	75	125			
Potassium, Available		518	mg/kg	1.00	90	75	125			
Potassium, Extractable		1.33	meq/100g		91	75	125			
Sample ID: H12090283-001AMSD2	3	Sample Matrix Spike Duplicate				Run: ICP2-HE_121001B				10/01/12 21:39
Potassium		524	mg/L	1.0	92	75	125	1.0	20	
Potassium, Available		523	mg/kg	1.00	92	75	125	1.0	20	
Potassium, Extractable		1.34	meq/100g		92	75	125	1.0	20	
Sample ID: H12090147-001AMS2	3	Sample Matrix Spike				Run: ICP2-HE_121001B				10/01/12 23:27
Potassium		3600	mg/kg	1.0		75	125			A
Potassium, Available		3600	mg/kg	1.00	7	75	125			S
Potassium, Extractable		9.3	meq/100g	0.0026	7	75	125			S
Sample ID: H12090147-001AMSD2	3	Sample Matrix Spike Duplicate				Run: ICP2-HE_121001B				10/01/12 23:31
Potassium		3800	mg/kg	1.0		75	125	3.9	20	A
Potassium, Available		3800	mg/kg	1.00	10	75	125	3.9	20	S
Potassium, Extractable		9.7	meq/100g	0.0026	10	75	125	3.9	20	S

Qualifiers:

RL - Analyte reporting limit.

ND - Not detected at the reporting limit.

A - The analyte level was greater than four times the spike level. In accordance with the method % recovery is not calculated.

S - Spike recovery outside of advisory limits.

QA/QC Summary Report

Prepared by Helena, MT Branch

Client: MT DEQ-Federal Superfund **Report Date:** 10/18/12

Project: Clark Fork River O.U Reach A, Phase 5 & 6 **Work Order:** H12090147

Analyte	Count	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: SW6010B										Batch: 18089
Sample ID: MB-18089	6	Method Blank				Run: ICP2-HE_121005B				10/05/12 22:24
Calcium		0.04	mg/L	0.02						
Magnesium		ND	mg/L	0.007						
Sodium		ND	mg/L	0.02						
Calcium, sat. paste		0.002	meq/L	0.001						
Magnesium, sat. paste		ND	meq/L	0.0006						
Sodium, sat. paste		ND	meq/L	0.0008						

Qualifiers:

RL - Analyte reporting limit.

ND - Not detected at the reporting limit.

QA/QC Summary Report

Prepared by Helena, MT Branch

Client: MT DEQ-Federal Superfund
Report Date: 10/18/12
Project: Clark Fork River O.U Reach A, Phase 5 & 6
Work Order: H12090147

Analyte	Count	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: USDA20b										Batch: R83502
Sample ID: LCS-18089		Laboratory Control Sample				Run: MISC SOILS_121008A				10/04/12 10:35
Sodium Adsorption Ratio (SAR)		4.30	unitless	0.10	97	80	120			

Qualifiers:

RL - Analyte reporting limit.

ND - Not detected at the reporting limit.

QA/QC Summary Report

Prepared by Helena, MT Branch

Client: MT DEQ-Federal Superfund **Report Date:** 10/18/12

Project: Clark Fork River O.U Reach A, Phase 5 & 6 **Work Order:** H12090147

Analyte	Count	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: USDA23c										Batch: 18091
Sample ID: LCS-18091	2	Laboratory Control Sample				Run: MAN-TECH_120925A			09/25/12 07:25	
Neutralization Potential		73.7	Tons/1000T	0.10	103	70	130			
Lime as CaCO3		7.37	%	0.010	103	70	130			
Sample ID: H12090147-010ADUP	2	Sample Duplicate				Run: MAN-TECH_120925A			09/25/12 07:51	
Neutralization Potential		87.5	Tons/1000T	0.10				0.5	20	
Lime as CaCO3		8.75	%	0.010				0.5	20	
Method: USDA23c										Batch: 18091
Sample ID: H12090147-020ADUP	2	Sample Duplicate				Run: MAN-TECH_120926A			09/26/12 08:05	
Neutralization Potential		226	Tons/1000T	0.10				4.1	20	
Lime as CaCO3		22.6	%	0.010				4.1	20	
Method: USDA23c										Batch: 18116
Sample ID: LCS-18116	2	Laboratory Control Sample				Run: MAN-TECH_120926A			09/26/12 07:31	
Neutralization Potential		70.0	Tons/1000T	0.10	98	70	130			
Lime as CaCO3		7.00	%	0.010	98	70	130			
Method: USDA23c										Batch: 18143
Sample ID: LCS-18143	2	Laboratory Control Sample				Run: MAN-TECH_120927A			09/27/12 07:14	
Neutralization Potential		70.2	Tons/1000T	0.10	98	70	130			
Lime as CaCO3		7.02	%	0.010	98	70	130			
Sample ID: H12090147-013ADUP	2	Sample Duplicate				Run: MAN-TECH_120927A			09/27/12 08:06	
Neutralization Potential		374	Tons/1000T	0.10				0.3	20	
Lime as CaCO3		37.4	%	0.010				0.3	20	

Qualifiers:

RL - Analyte reporting limit.

ND - Not detected at the reporting limit.

Standard Reporting Procedures

Lab measurement of analytes considered field parameters that require analysis within 15 minutes of sampling such as pH, Dissolved Oxygen and Residual Chlorine, are qualified as being analyzed outside of recommended holding time.

Solid/soil samples are reported on a wet weight basis (as received) unless specifically indicated. If moisture corrected, data units are typically noted as –dry. For agricultural and mining soil parameters/characteristics, all samples are dried and ground prior to sample analysis.

Workorder Receipt Checklist

MT DEQ-Federal Superfund H12090147

Login completed by: Tracy L. Lorash
Date Received: 9/11/2012
Reviewed by: BL2000\sdull
Received by: wjj
Reviewed Date: 9/14/2012
Carrier name: Hand Del

Shipping container/cooler in good condition?	Yes ☑	No ☐	Not Present ☐
Custody seals intact on shipping container/cooler?	Yes ☐	No ☐	Not Present ☑
Custody seals intact on sample bottles?	Yes ☐	No ☐	Not Present ☑
Chain of custody present?	Yes ☑	No ☐	
Chain of custody signed when relinquished and received?	Yes ☑	No ☐	
Chain of custody agrees with sample labels?	Yes ☐	No ☑	
Samples in proper container/bottle?	Yes ☑	No ☐	
Sample containers intact?	Yes ☑	No ☐	
Sufficient sample volume for indicated test?	Yes ☑	No ☐	
All samples received within holding time? (Exclude analyses that are considered field parameters such as pH, DO, Res Cl, Sulfite, Ferrous Iron, etc.)	Yes ☑	No ☐	
Temp Blank received?	Yes ☐	No ☐	Not Applicable ☑
Container/Temp Blank temperature:	18.5°C No Ice		
Water - VOA vials have zero headspace?	Yes ☐	No ☐	No VOA vials submitted ☑
Water - pH acceptable upon receipt?	Yes ☐	No ☐	Not Applicable ☑

Contact and Corrective Action Comments:

No collection times on buckets - took from COC. Sample ID on COC is TP4 @ 1 Foot - ID on bucket is TP4. Logged in with ID from COC. TI 9/11/12.

TerraGraphics
ENVIRONMENTAL ENGINEERING
15 W 6th Avenue, Power Block 3rd Floor W
HELENA, MT 59601
(406) 441-5441 Fax (406) 441-5443

CHAIN OF CUSTODY RECORD

H12090147

Data to: TerraGraphics
Invoice to: MDEQ

Project Name: Clark Fork River O.U. Reach A Phase 5 & 6
Quote # H-578

TO: Energy Lab

Lab ID	Sample Date	Sample Time	SAMPLE DESCRIPTION: SOIL	WATER	HNO3 Preserved	Analysis (see Quote): Zn	Cu	Cd	Pb	As, Total	Organic Matter (%)	S.C.	Soil pH	Sieve Analysis
TP1 @ 1 foot	9/10/2012	830	X			X	X	X	X	X		X	X	X
TP1 @ 4 feet	9/10/2012	835	X			X	X	X	X	X		X	X	X
TP1 @ 12 feet	9/10/2012	848	X			X	X	X	X	X		X	X	X
TP2 @ 1 foot	9/10/2012	910	X			X	X	X	X	X		X	X	X
TP2 @ 4.5 feet	9/10/2012	920	X			X	X	X	X	X		X	X	X
TP2 @ 12 feet	9/10/2012	935	X			X	X	X	X	X		X	X	X
TP3 @ 2 feet	9/10/2012	1030	X			X	X	X	X	X		X	X	X
TP3 @ 3 feet	9/10/2012	1035	X			X	X	X	X	X		X	X	X
TP3 @ 11 feet	9/10/2012	1100	X			X	X	X	X	X		X	X	X
TP4 @ 1 foot	9/10/2012	950	X			X	X	X	X	X		X	X	X
TP4 @ 5 feet	9/10/2012	1000	X			X	X	X	X	X		X	X	X
TP4 @ 12 feet	9/10/2012	1015	X			X	X	X	X	X		X	X	X
TP5 @ 1 foot	9/10/2012	1335	X			X	X	X	X	X		X	X	X
TP5 @ 5 feet	9/10/2012	1340	X			X	X	X	X	X		X	X	X
TP5 @ 12.5 feet	9/10/2012	1355	X			X	X	X	X	X		X	X	X
TP6 @ 1.5 feet	9/10/2012	1405	X			X	X	X	X	X		X	X	X
TP6 @ 3 feet	9/10/2012	1408	X			X	X	X	X	X		X	X	X
TP6 @ 12 feet	9/10/2012	1416	X			X	X	X	X	X		X	X	X
TP7 @ 1.5 feet	9/10/2012	1430	X			X	X	X	X	X		X	X	X
TP7 @ 4.5 feet	9/10/2012	1435	X			X	X	X	X	X		X	X	X
TP7 @ 12 feet	9/10/2012	1442	X			X	X	X	X	X		X	X	X
TP8 @ 2 feet	9/10/2012	1455	X			X	X	X	X	X		X	X	X
TP8 @ 3.5 feet	9/10/2012	1500	X			X	X	X	X	X		X	X	X
TP8 @ 12 feet	9/10/2012	1515	X			X	X	X	X	X		X	X	X

Relinquished By: (Signature)	Date/Time	Received By: (Signature)	Date/Time
[signature]	9/10/12 14:11	[signature]	9-11-12 14[illegible]
Relinquished By: (Signature)	Date/Time	Received By: (Signature)	Date/Time

Normal T.A.T.
No Hydrometer Analysis needed on backfill samples

Temp 18.5

REMARKS: Perform and report lab QA/QC on soil samples from this batch only

Ø ICE. - Samples in buckets

Borrow Test Pit Field Logs

TerraGraphics Environmental Engineering, Inc.

Project No.: T0-31

PROJECT: Phase 5-6 Design Investigation	Log of Boring No.: ~~TP-01~~ TP1
BORING LOCATION: Dry Cottonwood Ranch	ELEVATION AND DATUM:
DRILLING CONTRACTOR: NA	STARTED - DATE: 9-10-12 TIME: 8:25 / COMPLETED - DATE: 9-10-12 TIME: 8:48
DRILLER: NA	TOTAL DEPTH (ft): 12' / WELL DEPTH(ft): NA / MEASURING POINT: NA
DRILLING METHOD: excavator	DEPTH TO WATER (ft): 6.5 / TIME: 8:50
DRILLING EQUIPMENT: Olsen excavating	LOGGED BY: BS
SAMPLING METHOD: grab	REVIEWED BY: JM

Well Construction Detail	PID/FID (ppm)	SAMPLES: Blows Per Foot	SAMPLES: Sample ID and Time	DEPTH (feet)	GRAPHIC	CLASS	DESCRIPTION (Group Symbol (e.g. SM), Color, Group Name (e.g. Silty Sand), Particle Size Range, Consistency (hard soft), Moisture Content, and others)
							-6" topsoil sandy loam w/silt organics no staining no tailings
			TP-01@ 1'	1			fine sand w/silt
							Lt Brown
				2			organics present
							no tailings
				3			no staining
			TP-01@ 4'	4			-4'
							River gravel
				5			coarse sand w/gravel up to 10" diameter
							grey
				6			
					▽		6.5' ground water
				7			
				8			-8' pit caving badly
				9			
				10			
				11			
			TP-01@ 12'	12			-12' base of excavation
							caving too badly to go deeper
				13			
				14			
				15			
				16			
				17			
				18			
				19			
				20			

Well Construction Legend:

- Concrete:
- Bentonite Chips:
- Slotted Well Screen:
- Filter Sand:
- ▽ Approximate Depth to Groundwater

Notes: Pit caving badly
Base of excavation 12'
ground water 6.5'
river gravel 4'

TerraGraphics Environmental Engineering, Inc.

Project No.: TD.31

PROJECT: Phase 5.6 Design Investigation	Log of Boring No.: ~~TP-02~~ TP2
BORING LOCATION: Dry Cottonwood Ranch	ELEVATION AND DATUM:
DRILLING CONTRACTOR: NA	STARTED - DATE: 9.10.12 TIME: 9:05 / COMPLETED - DATE: 9.10.12 TIME: 9:35
DRILLER: NA	TOTAL DEPTH (ft): 12' / WELL DEPTH(ft): NA / MEASURING POINT: NA
DRILLING METHOD: excavator	DEPTH TO WATER (ft): 5' / TIME: 9:15
DRILLING EQUIPMENT: Olsson excavating	LOGGED BY: BS
SAMPLING METHOD: grab	REVIEWED BY: JM.

Well Construction Detail	PID/FID (ppm)	SAMPLES: Blows Per Foot	SAMPLES: Sample ID and Time	DEPTH (feet)	GRAPHIC	CLASS	DESCRIPTION (Group Symbol (e.g. SM), Color, Group Name (e.g. Silty Sand), Particle Size Range, Consistency (hard soft), Moisture Content, and others)
							-6" topsoil sandy loam w/ silt brown organics present no staining no tailings
			TP.02 @ 1'	1			-1' sandy silt organics present -1' Brown no tailing no staining
				2			
				3			-3.5' River gravel Coarse Sand w/gravel up to 6" diameter moist
				4			
			TP.02 @4.5'	5			-4.5' Sample -5' ground water
				6			
				7			
				8			-8' pit caving badly
				9			
				10			
				11			
			~~B~~ TP.02 @12'	12			-12' bottom of excavation pit caving too badly to go deeper
				13			Coarse sand w/gravel up to 10" diameter Saturated
				14			
				15			
				16			
				17			
				18			
				19			
				20			

Well Construction Legend:

- Concrete:
- Bentonite Chips:
- Slotted Well Screen:
- Filter Sand:
- Approximate Depth to Groundwater

Notes: Pit caving badly
Base of excavation 12'
Ground water 5' river gravel 3.5'

TerraGraphics Environmental Engineering, Inc.

Project No.: T.O. - 31

PROJECT: Phase 5-6 Design Investigation	Log of Boring No.: ~~TP-03~~ TP3
BORING LOCATION: Dry Cottonwood Bench	ELEVATION AND DATUM:
DRILLING CONTRACTOR: NA	STARTED - DATE: 9.10.12 TIME: 10:25 / COMPLETED - DATE: 9.10.12 TIME: 11:00
DRILLER: NA	TOTAL DEPTH (ft): 11' / WELL DEPTH(ft): NA / MEASURING POINT: NA
DRILLING METHOD: excavator	DEPTH TO WATER (ft): 6' / TIME: 10:30
DRILLING EQUIPMENT: Olsson excavating	LOGGED BY: BS
SAMPLING METHOD: grab	REVIEWED BY: J.M.

Well Construction Detail	PID/FID (ppm)	SAMPLES: Blows Per Foot	SAMPLES: Sample ID and Time	DEPTH (feet)	GRAPHIC	CLASS	DESCRIPTION (Group Symbol (e.g. SM), Color, Group Name (e.g. Silty Sand), Particle Size Range, Consistency (hard soft), Moisture Content, and others)
							topsoil silty loam w/ sand organics present NOS staining
							6"
				1			silt w/ fine sand gravel up to 3" diameter organics present Brown
			TP-03 @ 2'	2			
			TP-03 3'	3			
							3.5' River gravel
				4			Coarse sand w/ gravel up to 8" diameter
				5			
				6	▽		6' Pit caving badly ground water
				7			
				8			
				9			
				10			
			TP-03 @ 11'	11			11' base of excavation
							Coarse sand w/ gravel up to 10" diameter
				12			
				13			
				14			
				15			
				16			
				17			
				18			
				19			
				20			

Well Construction Legend:

- Concrete:
- Bentonite Chips:
- Slotted Well Screen:
- Filter Sand:
- ▽ Approximate Depth to Groundwater

Notes: Pit caving
Base excavation 11'
Ground water 6'
River gravel 3.5'

TerraGraphics Environmental Engineering, Inc.

Project No.: T.O. - 31

PROJECT: Phase 5-6 Design Investigation	Log of Boring No.: ~~TP-04~~ TP4
BORING LOCATION: Dry Cottonwood Ranch	ELEVATION AND DATUM:
DRILLING CONTRACTOR: NA	STARTED - DATE: 9-10-12 TIME: 9:45 / COMPLETED - DATE: 9-10-12 TIME: 10:15
DRILLER: NA	TOTAL DEPTH (ft): 12' / WELL DEPTH(ft): NA / MEASURING POINT: NA
DRILLING METHOD: excavator	DEPTH TO WATER (ft): 4' / TIME: 9:55
DRILLING EQUIPMENT: Olsson excavating	LOGGED BY: BS
SAMPLING METHOD: grab	REVIEWED BY: J.M

Well Construction Detail	PID/FID (ppm)	SAMPLES: Blows Per Foot	SAMPLES: Sample ID and Time	DEPTH (feet)	GRAPHIC	CLASS	DESCRIPTION (Group Symbol (e.g. SM), Color, Group Name (e.g. Silty Sand), Particle Size Range, Consistency (hard soft), Moisture Content, and others)
							Topsoil ~~sandy~~ silty loam organics present Tan
							-6"
			TP-4 @ 1'	1			-1' Silty loam w/clay, organics, DK. brown No staining No Tailing
							Silty Sand w/gravel up to 1" diameter
				2			moist organics present No staining
							No tailings DK. Brown
				3			
				4	▽		-4' River gravel
							ground water
							coarse sand w/gravel up to 6"
			TP-4 @ 5'	5			
				6			
				7			-7' pit caving badly
				8			
				9			
				10			
				11			
			TP-4 @ 12'	12			-12' ~~bottom~~ base of excavation
							Pit caving too badly to
							go deeper
				13			Coarse Sand w/gravel up to 10" diameter
				14			
				15			
				16			
				17			
				18			
				19			
				20			

Well Construction Legend:

- Concrete:
- Bentonite Chips:
- Slotted Well Screen:
- Filter Sand:
- ▽ Approximate Depth to Groundwater

Notes: Pit caving badly
Base of excavation 12'
ground water 4'
River gravel 4'

TerraGraphics Environmental Engineering, Inc.

Project No.: T.O. 31

PROJECT: Phase 5-6 Design Investigation	Log of Boring No.: TP-05
BORING LOCATION: Dry Cottonwood Ranch	ELEVATION AND DATUM:
DRILLING CONTRACTOR: NA	STARTED - DATE: 9.10.12 TIME: 13:30 / COMPLETED - DATE: 9.10.12 TIME: 13:55
DRILLER: NA	TOTAL DEPTH (ft): 12.5' / WELL DEPTH(ft): NA / MEASURING POINT: NA
DRILLING METHOD: excavator	DEPTH TO WATER (ft): 7' / TIME: 13:40
DRILLING EQUIPMENT: Olsson excavating	LOGGED BY: B.S.
SAMPLING METHOD: grab	REVIEWED BY: J.M.

Well Construction Detail	PID/FID (ppm)	SAMPLES: Blows Per Foot	SAMPLES: Sample ID and Time	DEPTH (feet)	GRAPHIC	CLASS	DESCRIPTION (Group Symbol (e.g. SM), Color, Group Name (e.g. Silty Sand), Particle Size Range, Consistency (hard soft), Moisture Content, and others)
							Topsoil Silty loamy sand organics No staining/No tailings
			TP-05 @1'	1			-3" -1' Silt w/ fine sand organics no staining no tailings
				2			
				3			
				4			
			TP-05 @5'	5			-5' Med sand w/silt & gravel up to 1" diameter organics present No Tailings no staining
				6			-6' River gravel
				7			-7' ground water
				8			-8' pit caving badly
				9			
				10			
				11			
				12			
			TP-05 @12.5'	13			-12.5' base of excavation Coarse sand w/ gravel up to 10" diameter
				14			
				15			
				16			
				17			
				18			
				19			
				20			

Well Construction Legend:

- Concrete:
- Bentonite Chips:
- Slotted Well Screen:
- Filter Sand:
- Approximate Depth to Groundwater

Notes: Pit caving
Base of excavation 12.5'
Ground water 7'
Filter gravel 6'

TerraGraphics Environmental Engineering, Inc.

Project No.: TD. 31

PROJECT: Phase 5-6 Design Investigation	Log of Boring No.: TP-6n
BORING LOCATION: Dry cottonwood Ranch	ELEVATION AND DATUM:
DRILLING CONTRACTOR: NA	STARTED - DATE: 9.10.13 TIME: 14:00 / COMPLETED - DATE: 9.10.13 TIME: 14:16
DRILLER: NA	TOTAL DEPTH (ft): 12' / WELL DEPTH(ft): NA / MEASURING POINT: NA
DRILLING METHOD: excavator	DEPTH TO WATER (ft): 3' / TIME: 14:08
DRILLING EQUIPMENT: Olsson excavating	LOGGED BY: BS.
SAMPLING METHOD: grab	REVIEWED BY: JM.

Well Construction Detail	PID/FID (ppm)	SAMPLES: Blows Per Foot	SAMPLES: Sample ID and Time	DEPTH (feet)	GRAPHIC	CLASS	DESCRIPTION (Group Symbol (e.g. SM), Color, Group Name (e.g. Silty Sand), Particle Size Range, Consistency (hard soft), Moisture Content, and others)
							Topsoil Silt loam w/ sand organics Dk. Brown
				1			No Tailings No staining
							-1' med-coarse sand grey No Tailing no staining
			TP-6n @1.5'	2			-1.5' organics present.
			TP-6 @3'	3	▽		-3' River gravel coarse sand w/ gravel up to 2" diameter
							ground water
				4			
				5			- 5' sand caving into pit badly
				6			
				7			
				8			
				9			
				10			
				11			
			TP6n @12'	12			-12' Base of excavation
							Coarse sand w/ gravel up to 10"
				13			
				14			
				15			
				16			
				17			
				18			
				19			
				20			

Well Construction Legend:

- Concrete:
- Bentonite Chips:
- Slotted Well Screen:
- Filter Sand:
- ▽ Approximate Depth to Groundwater

Notes: Sand caving badly
Base of excavation 12'
ground water 3'
rip rap gravel 3'

TerraGraphics Environmental Engineering, Inc.

Project No.: T.O. 31

PROJECT: Phase 5-6 Design Investigation	Log of Boring No.: TP-07
BORING LOCATION: Dry cottonwood Ranch	ELEVATION AND DATUM:
DRILLING CONTRACTOR: NA	STARTED - DATE: 9.10.12 TIME: 14:26 / COMPLETED - DATE: 9.10.12 TIME: 14:42
DRILLER: NA	TOTAL DEPTH (ft): 12' / WELL DEPTH(ft): NA / MEASURING POINT: NA
DRILLING METHOD: excavator	DEPTH TO WATER (ft): 6.5' / TIME: 14:37
DRILLING EQUIPMENT: Olsson excavating	LOGGED BY: BS
SAMPLING METHOD: grab	REVIEWED BY: J.M.

Well Construction Detail	PID/FID (ppm)	SAMPLES: Blows Per Foot	SAMPLES: Sample ID and Time	DEPTH (feet)	GRAPHIC	CLASS	DESCRIPTION (Group Symbol (e.g. SM), Color, Group Name (e.g. Silty Sand), Particle Size Range, Consistency (hard soft), Moisture Content, and others)
							topsoil silty loam organics present NO Tailings NO Staining tan
				1			-1' fine sand w/silt gravel up to 1" diameter NO Tailings no staining organics Tan
			TP07 @ 1.5'	2			
				3			
				4			
			TP07 @ 4.5'	5			-4.5' fine sand w/ silt gravel up to 3" diameter Tan
				6			-6' River gravel coarse sand w/ gravel up to 4" diameter
				7			-6.5' ground water -7' pit caving badly
				8			
				9			
				10			
				11			
			TP07 @ 12'	12			-12' coarse sand w/gravel up to 10"
				13			
				14			
				15			
				16			
				17			
				18			
				19			
				20			

Well Construction Legend:

- Concrete:
- Bentonite Chips:
- Slotted Well Screen:
- Filter Sand:
- ▽ Approximate Depth to Groundwater

Notes: pit caving badly
Base of excavation 12'
Ground water 6.5'
River gravel 6'

TerraGraphics Environmental Engineering, Inc.

Project No.: T.O. - 31

PROJECT: Phase 5-6 Design Investigation	Log of Boring No.: TP. 08
BORING LOCATION: Dry Cottonwood Ranch	ELEVATION AND DATUM:
DRILLING CONTRACTOR: NA	STARTED - DATE: 9.10.12 TIME: 14:54 / COMPLETED - DATE: 9.10.12 TIME: 15:15
DRILLER: NA	TOTAL DEPTH (ft): 12' / WELL DEPTH(ft): NA / MEASURING POINT: NA
DRILLING METHOD: Excavator	DEPTH TO WATER (ft): 2.5' / TIME: 15:07
DRILLING EQUIPMENT: Olsson excavating	LOGGED BY: BS
SAMPLING METHOD: Grab	REVIEWED BY: J.M.

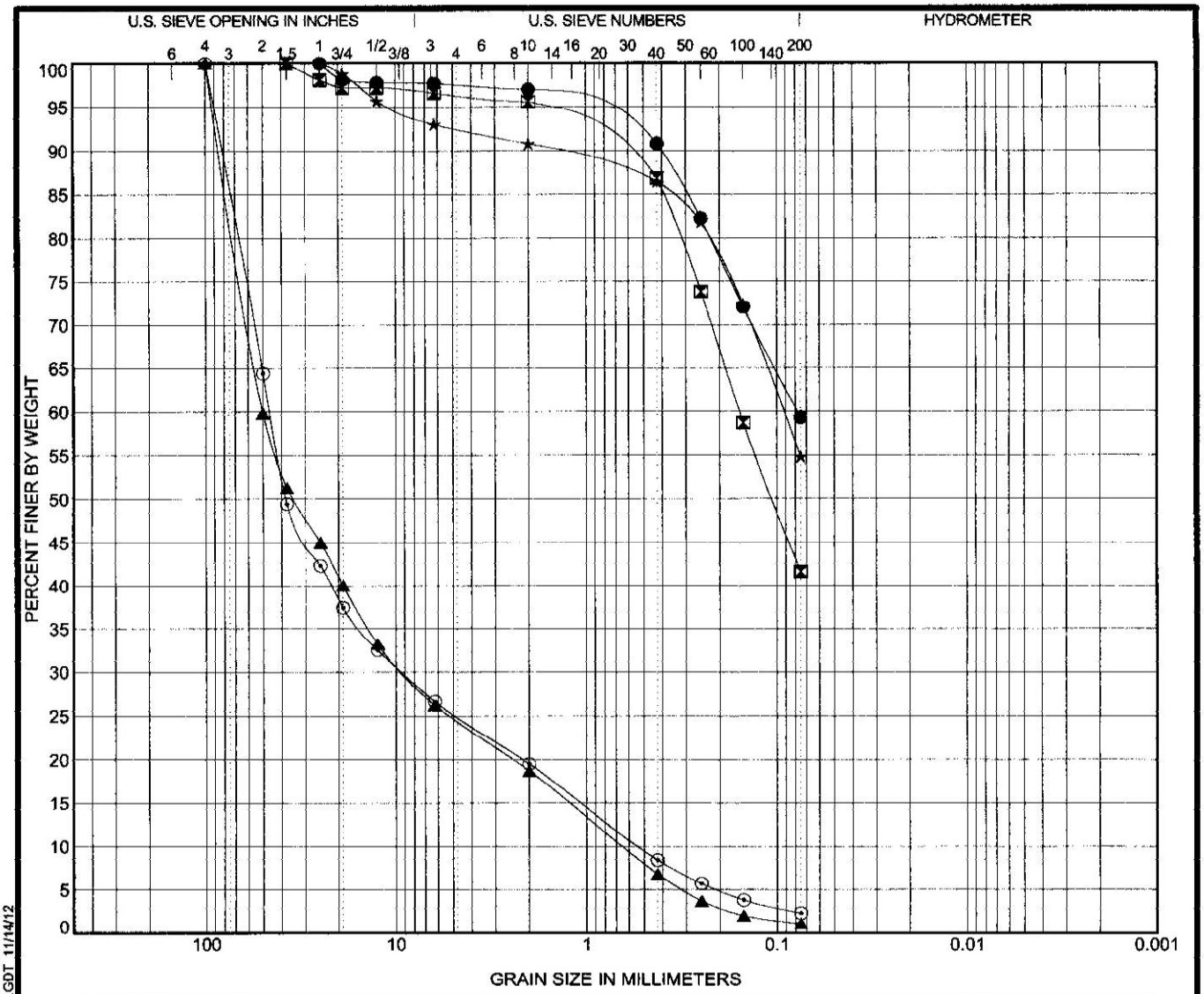
Well Construction Detail	PID/FID (ppm)	SAMPLES: Blows Per Foot	SAMPLES: Sample ID and Time	DEPTH (feet)	GRAPHIC	CLASS	DESCRIPTION (Group Symbol (e.g. SM), Color, Group Name (e.g. Silty Sand), Particle Size Range, Consistency (hard soft), Moisture Content, and others)
							Topsoil Silty loam w/ fine sand Dk. Brown organics No Tailings No staining
				1			1'
							1.5' Coarse to med sand No Tailings No staining organics present grey
			TP 8 @ 2'	2			
					▽		2.5' ground water
				3			3' River gravel
			TP8@ 3.5'				3.5' Coarse sand w/ gravel up to 2"
				4			
				5			5' Caving badly
				6			
				7			
				8			
				9			
				10			
				11			
			TP 8@ 12'	12			12' base of excavation Coarse sand w/ Rock up to 10"
				13			
				14			
				15			
				16			
				17			
				18			
				19			
				20			

Well Construction Legend:

- Concrete:
- Bentonite Chips:
- Slotted Well Screen:
- Filter Sand:
- ▽ Approximate Depth to Groundwater

Notes: pit caving
base of excavation 12'
ground water 2.5'
River gravel 3'

Borrow Test Pit Gradations



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	LL	PL	PI	Cc	Cu
●	TP-1	1.0						
⊠	TP-1	4.0						
▲	TP-1	12.0					2.56	77.84
★	TP-2	1.0						
⊙	TP-2	4.5					3.56	86.49

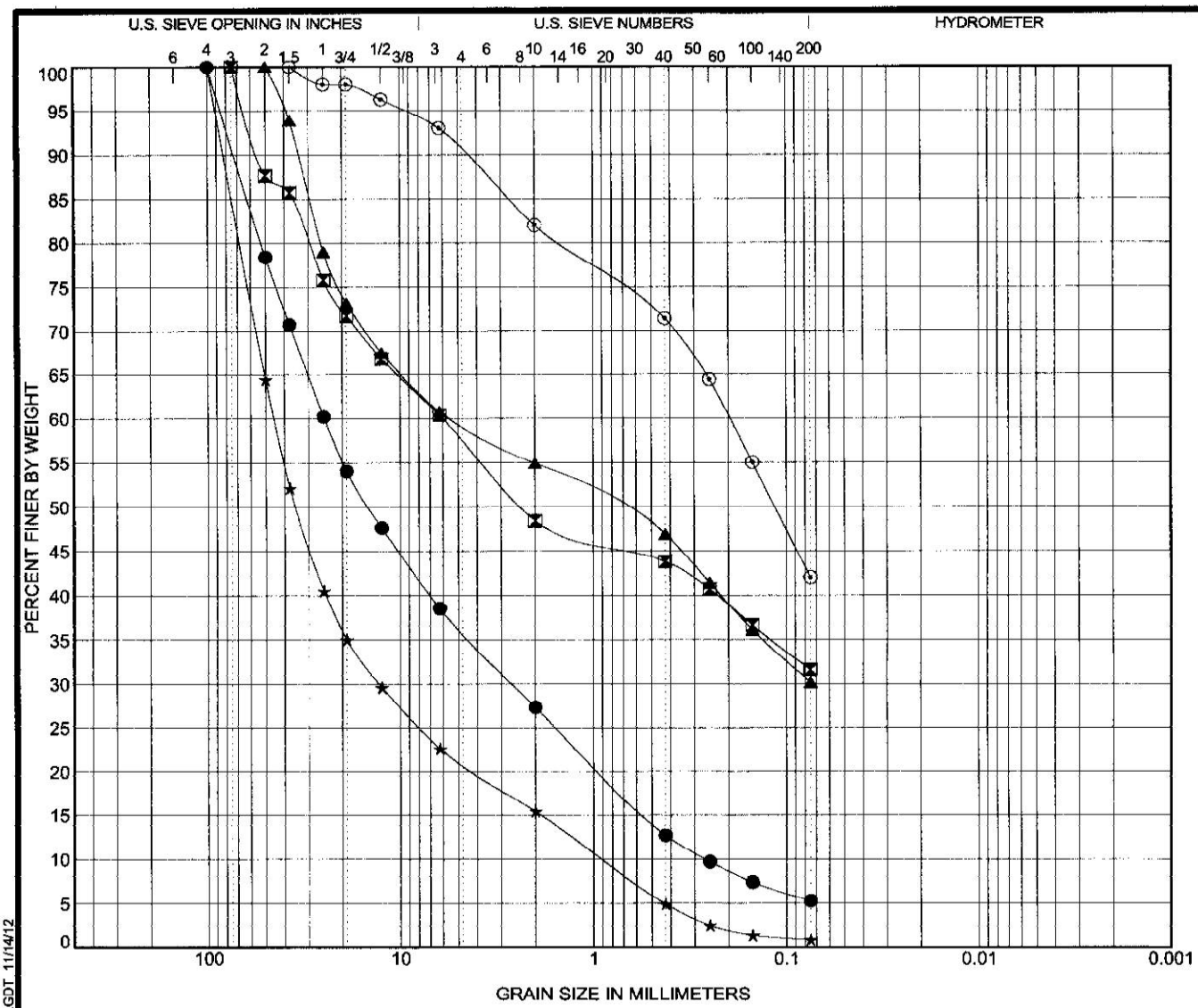
	Specimen Identification		D100	D50	D15	D10	%Gravel	%Sand	%Silt	%Clay
●	TP-1	1.0	25				2.5	38.2	59.3	
⊠	TP-1	4.0	37.5	0.105			3.6	54.8	41.6	
▲	TP-1	12.0	100	34.49	1.236	0.645	58.9	23.3	1.1	
★	TP-2	1.0	25				7.5	37.7	54.8	
⊙	TP-2	4.5	100	37.934	1.067	0.531	60.3	22.6	2.3	

GRAIN SIZE DISTRIBUTION

Project: Energy Labs - MT DEQ

Number: H-1090147

US_GRAIN_SIZE_AASHTO_ENERGY_CLARK FORK RIVER O.U RACH A_PHASE 5&6.GPJ PIONEER.GDT 11/14/12



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	LL	PL	PI	Cc	Cu
●	TP-2	12.0					1.06	94.00
⊠	TP-3	2.0						
▲	TP-3	3.0						
★	TP-3	11.0					4.09	50.02
⊙	TP-4	1.0						

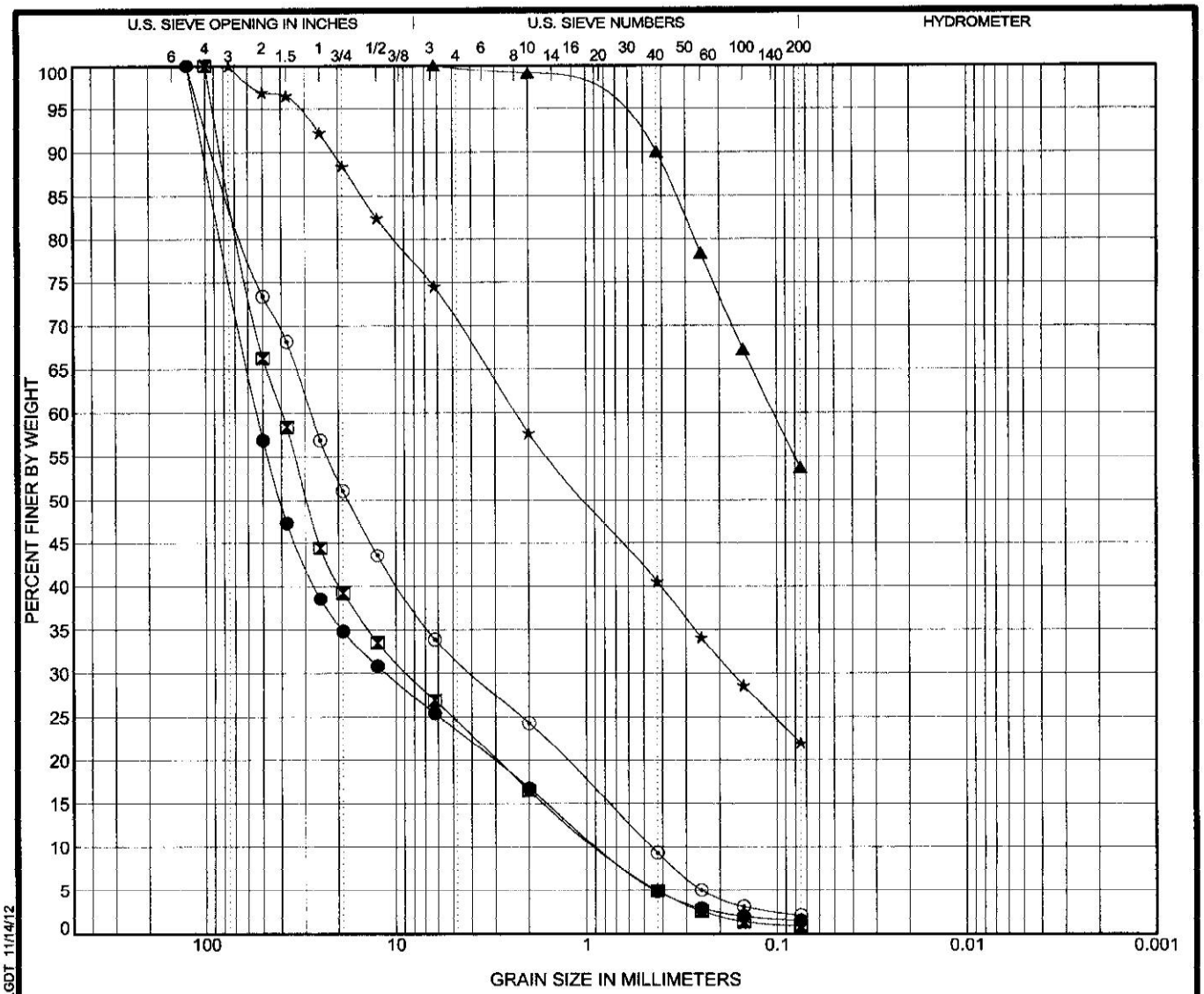
	Specimen Identification		D100	D50	D15	D10	%Gravel	%Sand	%Silt	%Clay
●	TP-2	12.0	100	14.625	0.542	0.264	55.2	30.5	5.3	
⊠	TP-3	2.0	75	2.328			42.5	25.9	31.6	
▲	TP-3	3.0	50	0.775			40.6	29.2	30.2	
★	TP-3	11.0	100	34.846	1.885	0.902	64.4	20.0	0.9	
⊙	TP-4	1.0	37.5	0.115			9.6	48.4	42.0	

GRAIN SIZE DISTRIBUTION

Project: Energy Labs - MT DEQ

Number: H-1090147

US GRAIN SIZE AASHTO ENERGY CLARK FORK RIVER O.U RACH A, PHASE 5&6.GPJ PIONEER.GDT 11/14/12



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	LL	PL	PI	Cc	Cu
●	TP-4	5.0					2.87	64.23
⊠	TP-4	12.0					2.24	47.34
▲	TP-5	1.0						
★	TP-5	5.0						
⊙	TP-5	12.5					1.21	61.16

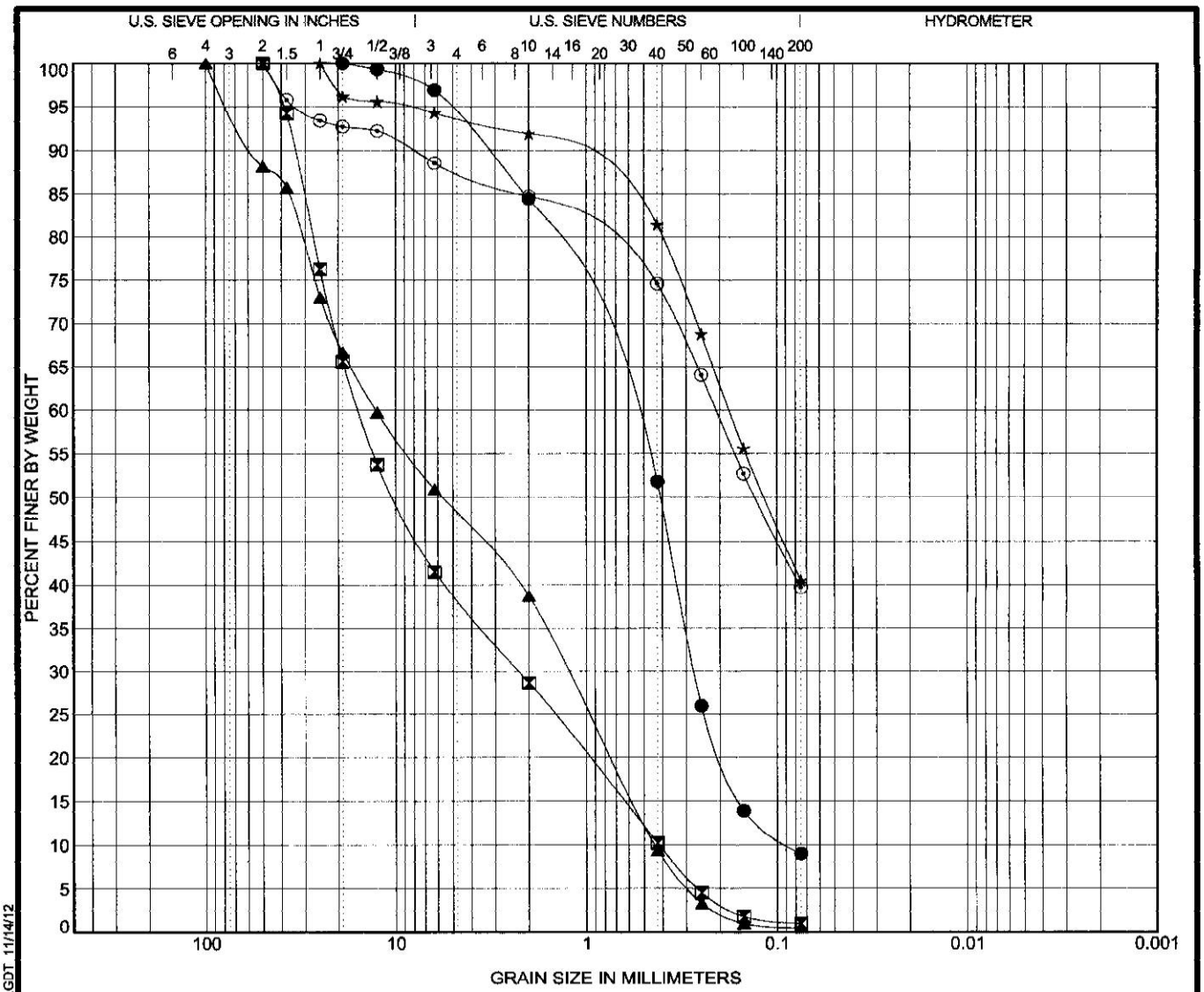
	Specimen Identification		D100	D50	D15	D10	%Gravel	%Sand	%Silt	%Clay
●	TP-4	5.0	125	40.66	1.585	0.832	52.6	21.8	1.5	
⊠	TP-4	12.0	100	29.402	1.637	0.84	61.6	23.5	0.9	
▲	TP-5	1.0	6.25				0.2	46.1	53.7	
★	TP-5	5.0	75	1			29.5	48.5	22.0	
⊙	TP-5	12.5	125	17.883	0.766	0.457	53.6	29.5	2.1	

GRAIN SIZE DISTRIBUTION

Project: Energy Labs - MT DEQ

Number: H-1090147

US GRAIN SIZE AASHTO ENERGY CLARK FORK RIVER O.U RACH A PHASE 5&6.GPJ PIONEER.GDT 11/14/12



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	LL	PL	PI	Cc	Cu
●	TP-6	1.5					1.36	7.26
⊠	TP-6	3.0					0.79	37.40
▲	TP-6	12.0					0.29	29.01
★	TP-7	1.5						
⊙	TP-7	4.5						

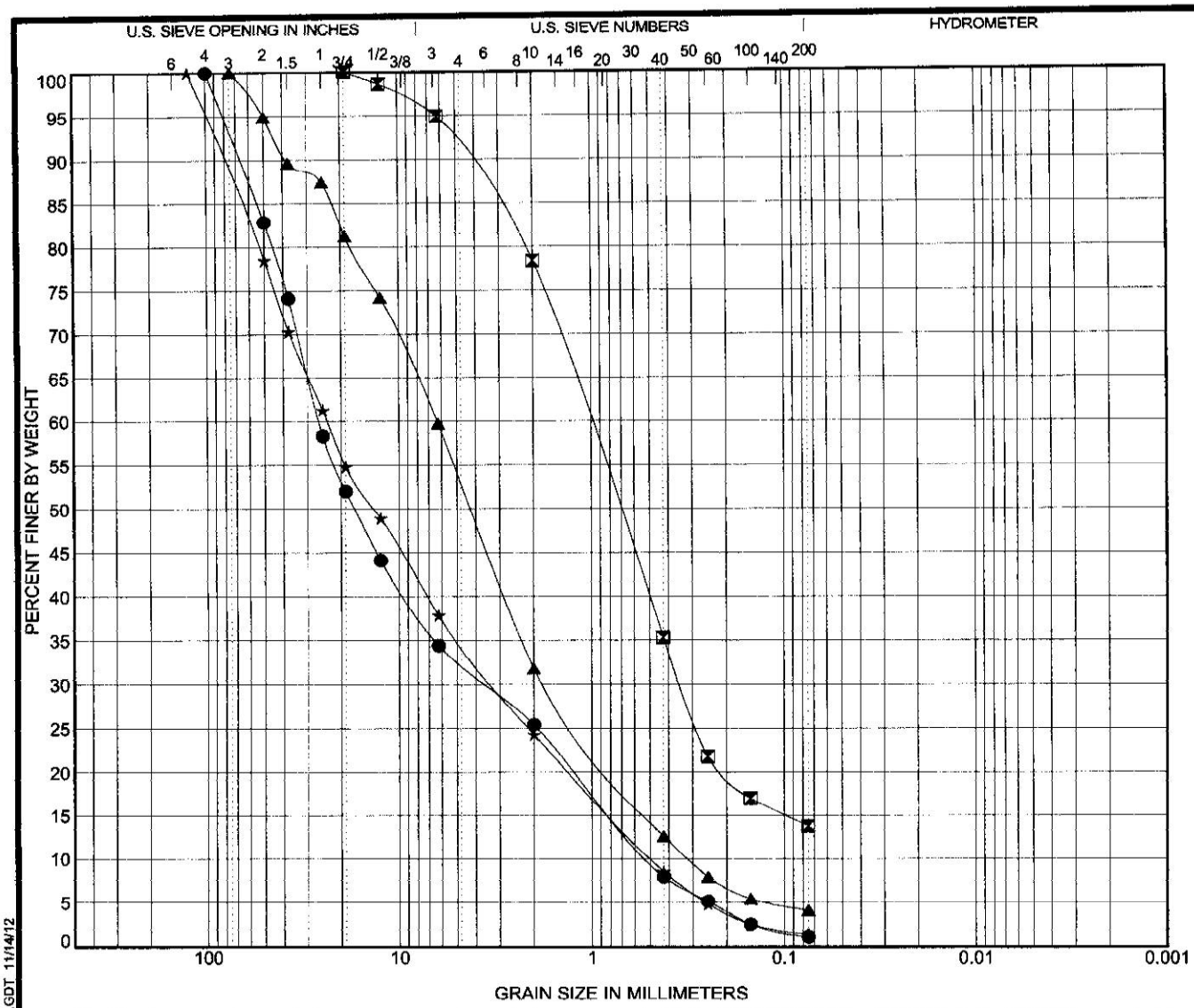
	Specimen Identification		D100	D50	D15	D10	%Gravel	%Sand	%Silt	%Clay
●	TP-6	1.5	19	0.41	0.157	0.086	6.1	84.9	9.0	
⊠	TP-6	3.0	50	10.13	0.637	0.417	61.6	37.4	1.0	
▲	TP-6	12.0	100	5.746	0.571	0.439	47.1	47.5	0.5	
★	TP-7	1.5	25	0.116			6.3	53.2	40.5	
⊙	TP-7	4.5	50	0.13			12.4	47.9	39.7	

GRAIN SIZE DISTRIBUTION

Project: Energy Labs - MT DEQ

Number: H-1090147

US_GRAIN_SIZE_AASHTO_ENERGY_CLARK FORK RIVER O.U RACH A, PHASE 5&6.GPJ PIONEER.GDT 11/14/12



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	LL	PL	PI	Cc	Cu
●	TP-7	12.0					0.96	51.02
⊠	TP-8	2.0						
▲	TP-8	3.5					1.49	20.01
★	TP-8	12.0					0.90	48.07

	Specimen Identification		D100	D50	D15	D10	%Gravel	%Sand	%Silt	%Clay
●	TP-7	12.0	100	17.089	0.797	0.512	60.6	31.1	1.1	
⊠	TP-8	2.0	19	0.721	0.097		9.1	77.1	13.8	
▲	TP-8	3.5	75	4.206	0.516	0.317	47.0	48.9	4.1	
★	TP-8	12.0	125	13.515	0.804	0.492	53.5	33.1	1.4	

GRAIN SIZE DISTRIBUTION

Project: Energy Labs - MT DEQ

Number: H-1090147

US GRAIN SIZE AASHTO ENERGY CLARK FORK RIVER O.U RACH A, PHASE 5&8.GPJ PIONEER.GDT 11/14/12

Borrow Test Pit Vegetation Results

ANALYTICAL SUMMARY REPORT

October 11, 2012

MT DEQ-Federal Superfund
PO Box 200901
Helena, MT 59620-0901

Workorder No.: H12090415

Project Name: TO31 Phase 5/6 Design Investigation

Energy Laboratories Inc Helena MT received the following 8 samples for MT DEQ-Federal Superfund on 9/25/2012 for analysis.

Sample ID	Client Sample ID	Collect Date	Receive Date	Matrix	Test
H12090415-001	TP6	09/24/12 12:08	09/25/12	Soil	8151-Herbicides, Chlorinated Moisture Sonication Extraction
H12090415-002	TP5	09/24/12 12:05	09/25/12	Soil	Same As Above
H12090415-003	TP3	09/24/12 11:26	09/25/12	Soil	Same As Above
H12090415-004	TP2	09/24/12 11:20	09/25/12	Soil	Same As Above
H12090415-005	TP4	09/24/12 11:32	09/25/12	Soil	Same As Above
H12090415-006	TP1	09/24/12 11:11	09/25/12	Soil	Same As Above
H12090415-007	TP7	09/24/12 12:21	09/25/12	Soil	Same As Above
H12090415-008	TP8	09/24/12 12:15	09/25/12	Soil	Same As Above

The analyses presented in this report were performed by Energy Laboratories, Inc., 3161 E. Lyndale Ave., Helena, MT 59604, unless otherwise noted. Any exceptions or problems with the analyses are noted in the Laboratory Analytical Report, the QA/QC Summary Report, or the Case Narrative.

The results as reported relate only to the item(s) submitted for testing.

If you have any questions regarding these test results, please call.

Report Approved By:

CLIENT: MT DEQ-Federal Superfund
Project: TO31 Phase 5/6 Design Investigation
Sample Delivery Group: H12090415

Report Date: 10/11/12

CASE NARRATIVE

Tests associated with analyst identified as ELI-B were subcontracted to Energy Laboratories, 1120 S. 27th St., Billings, MT, EPA Number MT00005.

LABORATORY ANALYTICAL REPORT

Prepared by Helena, MT Branch

Client: MT DEQ-Federal Superfund
Project: TO31 Phase 5/6 Design Investigation
Lab ID: H12090415-001
Client Sample ID TP6

Report Date: 10/11/12
Collection Date: 09/24/12 12:08
DateReceived: 09/25/12
Matrix: Soil

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL CHARACTERISTICS							
Moisture	78	wt%		0.2		SW3550A	09/28/12 08:33 / eli-b2
HERBICIDES, CHLORINATED							
2,4,5-T	ND	mg/kg		0.0040		SW8151A	10/02/12 17:15 / eli-b
2,4,5-TP (Silvex)	ND	mg/kg		0.0040		SW8151A	10/02/12 17:15 / eli-b
2,4-D	ND	mg/kg		0.020		SW8151A	10/02/12 17:15 / eli-b
2,4-DB	ND	mg/kg		0.050		SW8151A	10/02/12 17:15 / eli-b
3,5-Dichlorobenzoic Acid	ND	mg/kg		0.010		SW8151A	10/02/12 17:15 / eli-b
4-Nitrophenol	ND	mg/kg		0.010		SW8151A	10/02/12 17:15 / eli-b
Acifluorfen	ND	mg/kg		0.010		SW8151A	10/02/12 17:15 / eli-b
Bentazon	ND	mg/kg		0.050		SW8151A	10/02/12 17:15 / eli-b
Chloramben	ND	mg/kg		0.010		SW8151A	10/02/12 17:15 / eli-b
Dacthal	ND	mg/kg		0.020		SW8151A	10/02/12 17:15 / eli-b
Dalapon	ND	mg/kg		0.050		SW8151A	10/02/12 17:15 / eli-b
Dicamba	ND	mg/kg		0.0050		SW8151A	10/02/12 17:15 / eli-b
Dichlorprop	ND	mg/kg		0.020		SW8151A	10/02/12 17:15 / eli-b
Dinoseb	ND	mg/kg		0.020		SW8151A	10/02/12 17:15 / eli-b
MCPA	ND	mg/kg		4.0		SW8151A	10/02/12 17:15 / eli-b
MCPP	ND	mg/kg		4.0		SW8151A	10/02/12 17:15 / eli-b
Pentachlorophenol	ND	mg/kg		0.0020		SW8151A	10/02/12 17:15 / eli-b
Picloram	ND	mg/kg		0.010		SW8151A	10/02/12 17:15 / eli-b
Surr: DCAA	103	%REC		53-114		SW8151A	10/02/12 17:15 / eli-b

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Helena, MT Branch

Client: MT DEQ-Federal Superfund
Project: TO31 Phase 5/6 Design Investigation
Lab ID: H12090415-002
Client Sample ID TP5

Report Date: 10/11/12
Collection Date: 09/24/12 12:05
DateReceived: 09/25/12
Matrix: Soil

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL CHARACTERISTICS							
Moisture	19	wt%		0.2		SW3550A	09/28/12 08:34 / eli-b2
HERBICIDES, CHLORINATED							
2,4,5-T	ND	mg/kg		0.0040		SW8151A	10/02/12 17:48 / eli-b
2,4,5-TP (Silvex)	ND	mg/kg		0.0040		SW8151A	10/02/12 17:48 / eli-b
2,4-D	ND	mg/kg		0.020		SW8151A	10/02/12 17:48 / eli-b
2,4-DB	ND	mg/kg		0.050		SW8151A	10/02/12 17:48 / eli-b
3,5-Dichlorobenzoic Acid	ND	mg/kg		0.010		SW8151A	10/02/12 17:48 / eli-b
4-Nitrophenol	ND	mg/kg		0.010		SW8151A	10/02/12 17:48 / eli-b
Acifluorfen	ND	mg/kg		0.010		SW8151A	10/02/12 17:48 / eli-b
Bentazon	ND	mg/kg		0.050		SW8151A	10/02/12 17:48 / eli-b
Chloramben	ND	mg/kg		0.010		SW8151A	10/02/12 17:48 / eli-b
Dacthal	ND	mg/kg		0.020		SW8151A	10/02/12 17:48 / eli-b
Dalapon	ND	mg/kg		0.050		SW8151A	10/02/12 17:48 / eli-b
Dicamba	ND	mg/kg		0.0050		SW8151A	10/02/12 17:48 / eli-b
Dichlorprop	ND	mg/kg		0.020		SW8151A	10/02/12 17:48 / eli-b
Dinoseb	ND	mg/kg		0.020		SW8151A	10/02/12 17:48 / eli-b
MCPA	ND	mg/kg		4.0		SW8151A	10/02/12 17:48 / eli-b
MCPP	ND	mg/kg		4.0		SW8151A	10/02/12 17:48 / eli-b
Pentachlorophenol	ND	mg/kg		0.0020		SW8151A	10/02/12 17:48 / eli-b
Picloram	ND	mg/kg		0.010		SW8151A	10/02/12 17:48 / eli-b
Surr: DCAA	78.0	%REC		53-114		SW8151A	10/02/12 17:48 / eli-b

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Helena, MT Branch

Client: MT DEQ-Federal Superfund
Project: TO31 Phase 5/6 Design Investigation
Lab ID: H12090415-003
Client Sample ID TP3

Report Date: 10/11/12
Collection Date: 09/24/12 11:26
DateReceived: 09/25/12
Matrix: Soil

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL CHARACTERISTICS							
Moisture	24	wt%		0.2		SW3550A	09/28/12 08:41 / eli-b2
HERBICIDES, CHLORINATED							
2,4,5-T	ND	mg/kg		0.0040		SW8151A	10/02/12 21:06 / eli-b
2,4,5-TP (Silvex)	ND	mg/kg		0.0040		SW8151A	10/02/12 21:06 / eli-b
2,4-D	0.43	mg/kg		0.20		SW8151A	10/08/12 15:51 / eli-b
2,4-DB	ND	mg/kg		0.050		SW8151A	10/02/12 21:06 / eli-b
3,5-Dichlorobenzoic Acid	ND	mg/kg		0.010		SW8151A	10/02/12 21:06 / eli-b
4-Nitrophenol	ND	mg/kg		0.010		SW8151A	10/02/12 21:06 / eli-b
Acifluorfen	ND	mg/kg		0.010		SW8151A	10/02/12 21:06 / eli-b
Bentazon	ND	mg/kg		0.050		SW8151A	10/02/12 21:06 / eli-b
Chloramben	ND	mg/kg		0.010		SW8151A	10/02/12 21:06 / eli-b
Dacthal	ND	mg/kg	1	0.020		SW8151A	10/02/12 21:06 / eli-b
Dalapon	ND	mg/kg		0.050		SW8151A	10/02/12 21:06 / eli-b
Dicamba	ND	mg/kg		0.0050		SW8151A	10/02/12 21:06 / eli-b
Dichlorprop	ND	mg/kg		0.020		SW8151A	10/02/12 21:06 / eli-b
Dinoseb	ND	mg/kg		0.020		SW8151A	10/02/12 21:06 / eli-b
MCPA	ND	mg/kg		4.0		SW8151A	10/02/12 21:06 / eli-b
MCPP	ND	mg/kg		4.0		SW8151A	10/02/12 21:06 / eli-b
Pentachlorophenol	ND	mg/kg		0.0020		SW8151A	10/02/12 21:06 / eli-b
Picloram	ND	mg/kg		0.010		SW8151A	10/02/12 21:06 / eli-b
Surr: DCAA	81.0	%REC		53-114		SW8151A	10/02/12 21:06 / eli-b

-1=The analyte was not recovered in the Matrix Spike and Matrix Spike Duplicate of this sample. Results are suspect.

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Helena, MT Branch

Client: MT DEQ-Federal Superfund
Project: TO31 Phase 5/6 Design Investigation
Lab ID: H12090415-004
Client Sample ID TP2

Report Date: 10/11/12
Collection Date: 09/24/12 11:20
DateReceived: 09/25/12
Matrix: Soil

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL CHARACTERISTICS							
Moisture	18	wt%		0.2		SW3550A	09/28/12 08:53 / eli-b2
HERBICIDES, CHLORINATED							
2,4,5-T	ND	mg/kg		0.0040		SW8151A	10/02/12 18:21 / eli-b
2,4,5-TP (Silvex)	ND	mg/kg		0.0040		SW8151A	10/02/12 18:21 / eli-b
2,4-D	ND	mg/kg		0.020		SW8151A	10/02/12 18:21 / eli-b
2,4-DB	ND	mg/kg		0.050		SW8151A	10/02/12 18:21 / eli-b
3,5-Dichlorobenzoic Acid	ND	mg/kg		0.010		SW8151A	10/02/12 18:21 / eli-b
4-Nitrophenol	ND	mg/kg		0.010		SW8151A	10/02/12 18:21 / eli-b
Acifluorfen	ND	mg/kg		0.010		SW8151A	10/02/12 18:21 / eli-b
Bentazon	ND	mg/kg		0.050		SW8151A	10/02/12 18:21 / eli-b
Chloramben	ND	mg/kg		0.010		SW8151A	10/02/12 18:21 / eli-b
Dacthal	ND	mg/kg		0.020		SW8151A	10/02/12 18:21 / eli-b
Dalapon	ND	mg/kg		0.050		SW8151A	10/02/12 18:21 / eli-b
Dicamba	ND	mg/kg		0.0050		SW8151A	10/02/12 18:21 / eli-b
Dichlorprop	ND	mg/kg		0.020		SW8151A	10/02/12 18:21 / eli-b
Dinoseb	ND	mg/kg		0.020		SW8151A	10/02/12 18:21 / eli-b
MCPA	ND	mg/kg		4.0		SW8151A	10/02/12 18:21 / eli-b
MCPP	ND	mg/kg		4.0		SW8151A	10/02/12 18:21 / eli-b
Pentachlorophenol	ND	mg/kg		0.0020		SW8151A	10/02/12 18:21 / eli-b
Picloram	ND	mg/kg		0.010		SW8151A	10/02/12 18:21 / eli-b
Surr: DCAA	73.0	%REC		53-114		SW8151A	10/02/12 18:21 / eli-b

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Helena, MT Branch

Client: MT DEQ-Federal Superfund
Project: TO31 Phase 5/6 Design Investigation
Lab ID: H12090415-005
Client Sample ID TP4

Report Date: 10/11/12
Collection Date: 09/24/12 11:32
DateReceived: 09/25/12
Matrix: Soil

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL CHARACTERISTICS							
Moisture	6.0	wt%		0.2		SW3550A	09/28/12 08:57 / eli-b2
HERBICIDES, CHLORINATED							
2,4,5-T	ND	mg/kg		0.0040		SW8151A	10/02/12 18:54 / eli-b
2,4,5-TP (Silvex)	ND	mg/kg		0.0040		SW8151A	10/02/12 18:54 / eli-b
2,4-D	ND	mg/kg		0.020		SW8151A	10/02/12 18:54 / eli-b
2,4-DB	ND	mg/kg		0.050		SW8151A	10/02/12 18:54 / eli-b
3,5-Dichlorobenzoic Acid	ND	mg/kg		0.010		SW8151A	10/02/12 18:54 / eli-b
4-Nitrophenol	ND	mg/kg		0.010		SW8151A	10/02/12 18:54 / eli-b
Acifluorfen	ND	mg/kg		0.010		SW8151A	10/02/12 18:54 / eli-b
Bentazon	ND	mg/kg		0.050		SW8151A	10/02/12 18:54 / eli-b
Chloramben	ND	mg/kg		0.010		SW8151A	10/02/12 18:54 / eli-b
Dacthal	ND	mg/kg		0.020		SW8151A	10/02/12 18:54 / eli-b
Dalapon	ND	mg/kg		0.050		SW8151A	10/02/12 18:54 / eli-b
Dicamba	ND	mg/kg		0.0050		SW8151A	10/02/12 18:54 / eli-b
Dichlorprop	ND	mg/kg		0.020		SW8151A	10/02/12 18:54 / eli-b
Dinoseb	ND	mg/kg		0.020		SW8151A	10/02/12 18:54 / eli-b
MCPA	ND	mg/kg		4.0		SW8151A	10/02/12 18:54 / eli-b
MCPP	ND	mg/kg		4.0		SW8151A	10/02/12 18:54 / eli-b
Pentachlorophenol	ND	mg/kg		0.0020		SW8151A	10/02/12 18:54 / eli-b
Picloram	ND	mg/kg		0.010		SW8151A	10/02/12 18:54 / eli-b
Surr: DCAA	97.0	%REC		53-114		SW8151A	10/02/12 18:54 / eli-b

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Helena, MT Branch

Client: MT DEQ-Federal Superfund
Project: TO31 Phase 5/6 Design Investigation
Lab ID: H12090415-006
Client Sample ID TP1

Report Date: 10/11/12
Collection Date: 09/24/12 11:11
DateReceived: 09/25/12
Matrix: Soil

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL CHARACTERISTICS							
Moisture	16	wt%		0.2		SW3550A	09/28/12 09:02 / eli-b2
HERBICIDES, CHLORINATED							
2,4,5-T	ND	mg/kg		0.0040		SW8151A	10/02/12 19:27 / eli-b
2,4,5-TP (Silvex)	ND	mg/kg		0.0040		SW8151A	10/02/12 19:27 / eli-b
2,4-D	ND	mg/kg		0.020		SW8151A	10/02/12 19:27 / eli-b
2,4-DB	ND	mg/kg		0.050		SW8151A	10/02/12 19:27 / eli-b
3,5-Dichlorobenzoic Acid	ND	mg/kg		0.010		SW8151A	10/02/12 19:27 / eli-b
4-Nitrophenol	ND	mg/kg		0.010		SW8151A	10/02/12 19:27 / eli-b
Acifluorfen	ND	mg/kg		0.010		SW8151A	10/02/12 19:27 / eli-b
Bentazon	ND	mg/kg		0.050		SW8151A	10/02/12 19:27 / eli-b
Chloramben	ND	mg/kg		0.010		SW8151A	10/02/12 19:27 / eli-b
Dacthal	ND	mg/kg		0.020		SW8151A	10/02/12 19:27 / eli-b
Dalapon	ND	mg/kg		0.050		SW8151A	10/02/12 19:27 / eli-b
Dicamba	ND	mg/kg		0.0050		SW8151A	10/02/12 19:27 / eli-b
Dichlorprop	ND	mg/kg		0.020		SW8151A	10/02/12 19:27 / eli-b
Dinoseb	ND	mg/kg		0.020		SW8151A	10/02/12 19:27 / eli-b
MCPA	ND	mg/kg		4.0		SW8151A	10/02/12 19:27 / eli-b
MCPP	ND	mg/kg		4.0		SW8151A	10/02/12 19:27 / eli-b
Pentachlorophenol	ND	mg/kg		0.0020		SW8151A	10/02/12 19:27 / eli-b
Picloram	ND	mg/kg		0.010		SW8151A	10/02/12 19:27 / eli-b
Surr: DCAA	69.0	%REC		53-114		SW8151A	10/02/12 19:27 / eli-b

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Helena, MT Branch

Client: MT DEQ-Federal Superfund
Project: TO31 Phase 5/6 Design Investigation
Lab ID: H12090415-007
Client Sample ID TP7

Report Date: 10/11/12
Collection Date: 09/24/12 12:21
DateReceived: 09/25/12
Matrix: Soil

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL CHARACTERISTICS							
Moisture	52	wt%		0.2		SW3550A	09/28/12 09:06 / eli-b2
HERBICIDES, CHLORINATED							
2,4,5-T	ND	mg/kg		0.0040		SW8151A	10/02/12 20:00 / eli-b
2,4,5-TP (Silvex)	ND	mg/kg		0.0040		SW8151A	10/02/12 20:00 / eli-b
2,4-D	0.39	mg/kg		0.020		SW8151A	10/02/12 20:00 / eli-b
2,4-DB	ND	mg/kg		0.050		SW8151A	10/02/12 20:00 / eli-b
3,5-Dichlorobenzoic Acid	ND	mg/kg		0.010		SW8151A	10/02/12 20:00 / eli-b
4-Nitrophenol	ND	mg/kg		0.010		SW8151A	10/02/12 20:00 / eli-b
Acifluorfen	ND	mg/kg		0.010		SW8151A	10/02/12 20:00 / eli-b
Bentazon	ND	mg/kg		0.050		SW8151A	10/02/12 20:00 / eli-b
Chloramben	ND	mg/kg		0.010		SW8151A	10/02/12 20:00 / eli-b
Dacthal	ND	mg/kg		0.020		SW8151A	10/02/12 20:00 / eli-b
Dalapon	ND	mg/kg		0.050		SW8151A	10/02/12 20:00 / eli-b
Dicamba	ND	mg/kg		0.0050		SW8151A	10/02/12 20:00 / eli-b
Dichlorprop	ND	mg/kg		0.020		SW8151A	10/02/12 20:00 / eli-b
Dinoseb	ND	mg/kg		0.020		SW8151A	10/02/12 20:00 / eli-b
MCPA	ND	mg/kg		4.0		SW8151A	10/02/12 20:00 / eli-b
MCPP	ND	mg/kg		4.0		SW8151A	10/02/12 20:00 / eli-b
Pentachlorophenol	ND	mg/kg		0.0020		SW8151A	10/02/12 20:00 / eli-b
Picloram	ND	mg/kg		0.010		SW8151A	10/02/12 20:00 / eli-b
Surr: DCAA	89.0	%REC		53-114		SW8151A	10/02/12 20:00 / eli-b

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Helena, MT Branch

Client: MT DEQ-Federal Superfund
Project: TO31 Phase 5/6 Design Investigation
Lab ID: H12090415-008
Client Sample ID TP8

Report Date: 10/11/12
Collection Date: 09/24/12 12:15
DateReceived: 09/25/12
Matrix: Soil

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL CHARACTERISTICS							
Moisture	15	wt%		0.2		SW3550A	09/28/12 09:13 / eli-b2
HERBICIDES, CHLORINATED							
2,4,5-T	ND	mg/kg		0.0040		SW8151A	10/02/12 20:33 / eli-b
2,4,5-TP (Silvex)	ND	mg/kg		0.0040		SW8151A	10/02/12 20:33 / eli-b
2,4-D	0.12	mg/kg		0.020		SW8151A	10/02/12 20:33 / eli-b
2,4-DB	ND	mg/kg		0.050		SW8151A	10/02/12 20:33 / eli-b
3,5-Dichlorobenzoic Acid	ND	mg/kg		0.010		SW8151A	10/02/12 20:33 / eli-b
4-Nitrophenol	ND	mg/kg		0.010		SW8151A	10/02/12 20:33 / eli-b
Acifluorfen	ND	mg/kg		0.010		SW8151A	10/02/12 20:33 / eli-b
Bentazon	ND	mg/kg		0.050		SW8151A	10/02/12 20:33 / eli-b
Chloramben	ND	mg/kg		0.010		SW8151A	10/02/12 20:33 / eli-b
Dacthal	ND	mg/kg		0.020		SW8151A	10/02/12 20:33 / eli-b
Dalapon	ND	mg/kg		0.050		SW8151A	10/02/12 20:33 / eli-b
Dicamba	ND	mg/kg		0.0050		SW8151A	10/02/12 20:33 / eli-b
Dichlorprop	ND	mg/kg		0.020		SW8151A	10/02/12 20:33 / eli-b
Dinoseb	ND	mg/kg		0.020		SW8151A	10/02/12 20:33 / eli-b
MCPA	ND	mg/kg		4.0		SW8151A	10/02/12 20:33 / eli-b
MCPP	ND	mg/kg		4.0		SW8151A	10/02/12 20:33 / eli-b
Pentachlorophenol	ND	mg/kg		0.0020		SW8151A	10/02/12 20:33 / eli-b
Picloram	ND	mg/kg		0.010		SW8151A	10/02/12 20:33 / eli-b
Surr: DCAA	78.0	%REC		53-114		SW8151A	10/02/12 20:33 / eli-b

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

QA/QC Summary Report

Prepared by Helena, MT Branch

Client: MT DEQ-Federal Superfund **Report Date:** 10/11/12

Project: TO31 Phase 5/6 Design Investigation **Work Order:** H12090415

Analyte	Count	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: SW8151A										Batch: B_65804
Sample ID: MB-65804	19	Method Blank				Run: SUB-B192918				10/02/12 15:37
2,4,5-T		ND	mg/kg	0.0040						
2,4,5-TP (Silvex)		ND	mg/kg	0.0040						
2,4-D		ND	mg/kg	0.020						
2,4-DB		ND	mg/kg	0.050						
3,5-Dichlorobenzoic Acid		ND	mg/kg	0.010						
4-Nitrophenol		ND	mg/kg	0.010						
Acifluorfen		ND	mg/kg	0.010						
Bentazon		ND	mg/kg	0.050						
Chloramben		ND	mg/kg	0.010						
Dacthal		ND	mg/kg	0.020						
Dalapon		ND	mg/kg	0.050						
Dicamba		ND	mg/kg	0.0050						
Dichlorprop		ND	mg/kg	0.020						
Dinoseb		ND	mg/kg	0.020						
MCPA		ND	mg/kg	4.0						
MCPP		ND	mg/kg	4.0						
Pentachlorophenol		ND	mg/kg	0.0020						
Picloram		ND	mg/kg	0.010						
Surr: DCAA				0.0020	108	53	114			
Sample ID: LCS-65804	19	Laboratory Control Sample				Run: SUB-B192918				10/02/12 16:10
2,4,5-T		0.0898	mg/kg	0.0040	90	16	120			
2,4,5-TP (Silvex)		0.0888	mg/kg	0.0040	89	32	119			
2,4-D		0.110	mg/kg	0.020	110	25	117			
2,4-DB		0.110	mg/kg	0.050	110	10	147			
3,5-Dichlorobenzoic Acid		0.0980	mg/kg	0.010	98	53	116			
4-Nitrophenol		0.0718	mg/kg	0.010	72	9	94			
Acifluorfen		0.106	mg/kg	0.010	106	55	121			
Bentazon		0.0836	mg/kg	0.050	84	41	125			
Chloramben		0.0456	mg/kg	0.010	46	7	131			
Dacthal		0.108	mg/kg	0.020	108	68	127			
Dalapon		0.0682	mg/kg	0.050	68	32	119			
Dicamba		0.0948	mg/kg	0.0050	95	62	119			
Dichlorprop		0.111	mg/kg	0.020	111	28	134			
Dinoseb		0.0125	mg/kg	0.020	13	7	112			
MCPA		8.84	mg/kg	4.0	88	11	120			
MCPP		7.80	mg/kg	4.0	78	8	134			
Pentachlorophenol		0.0832	mg/kg	0.0020	83	52	101			
Picloram		0.0862	mg/kg	0.010	86	60	119			
Surr: DCAA				0.0020	117	53	114			S
Sample ID: H12090415-003A	18	Sample Matrix Spike				Run: SUB-B192918				10/02/12 21:39
2,4,5-T		0.0620	mg/kg	0.0040	62	16	120			
2,4,5-TP (Silvex)		0.0640	mg/kg	0.0040	64	32	119			
2,4-DB		0.0774	mg/kg	0.050	77	10	147			

Qualifiers:

RL - Analyte reporting limit.

ND - Not detected at the reporting limit.

S - Spike recovery outside of advisory limits.

QA/QC Summary Report

Prepared by Helena, MT Branch

Client: MT DEQ-Federal Superfund **Report Date:** 10/11/12

Project: TO31 Phase 5/6 Design Investigation **Work Order:** H12090415

Analyte	Count	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: SW8151A										Batch: B_65804
Sample ID: H12090415-003A	18	Sample Matrix Spike				Run: SUB-B192918				10/02/12 21:39
3,5-Dichlorobenzoic Acid		0.0850	mg/kg	0.010	85	53	116			
4-Nitrophenol		0.0720	mg/kg	0.010	72	9	94			
Acifluorfen		0.0776	mg/kg	0.010	78	55	121			
Bentazon		0.0718	mg/kg	0.050	72	41	125			
Chloramben		0.0498	mg/kg	0.010	50	7	131			
Dacthal		ND	mg/kg	0.020		68	127			S
Dalapon		0.0582	mg/kg	0.050	58	32	119			
Dicamba		0.0780	mg/kg	0.0050	78	62	119			
Dichlorprop		0.0870	mg/kg	0.020	87	28	134			
Dinoseb		0.0142	mg/kg	0.020	14	7	112			
MCPA		7.18	mg/kg	4.0	72	11	120			
MCPP		6.40	mg/kg	4.0	64	8	134			
Pentachlorophenol		0.0644	mg/kg	0.0020	64	52	101			
Picloram		0.0296	mg/kg	0.010	30	60	119			S
Surr: DCAA				0.0020	91	53	114			
Sample ID: H12090415-003A	18	Sample Matrix Spike Duplicate				Run: SUB-B192918				10/02/12 22:12
2,4,5-T		0.0656	mg/kg	0.0040	66	16	120	5.6	40	
2,4,5-TP (Silvex)		0.0664	mg/kg	0.0040	66	32	119	3.7	40	
2,4-DB		0.0852	mg/kg	0.050	85	10	147	9.6	40	
3,5-Dichlorobenzoic Acid		0.0892	mg/kg	0.010	89	53	116	4.8	40	
4-Nitrophenol		0.0788	mg/kg	0.010	79	9	94	9.0	40	
Acifluorfen		0.0618	mg/kg	0.010	62	55	121	23	40	
Bentazon		0.0734	mg/kg	0.050	73	41	125	2.2	40	
Chloramben		0.0488	mg/kg	0.010	49	7	131	2.0	40	
Dacthal		ND	mg/kg	0.020		68	127		40	S
Dalapon		0.0464	mg/kg	0.050	46	32	119		40	
Dicamba		0.0826	mg/kg	0.0050	83	62	119	5.7	40	
Dichlorprop		0.0896	mg/kg	0.020	90	28	134	2.9	40	
Dinoseb		0.0112	mg/kg	0.020	11	7	112		40	
MCPA		7.56	mg/kg	4.0	76	11	120	5.2	40	
MCPP		6.82	mg/kg	4.0	68	8	134	6.4	40	
Pentachlorophenol		0.0652	mg/kg	0.0020	65	52	101	1.2	40	
Picloram		0.0284	mg/kg	0.010	28	60	119	4.1	40	S
Surr: DCAA				0.0020	98	53	114			
Sample ID: H12090415-003A		Sample Duplicate				Run: SUB-B193077				10/08/12 16:24
2,4-D		0.590	mg/kg	0.20				11	40	
Sample ID: H12090415-003A		Sample Duplicate				Run: SUB-B193077				10/08/12 16:57
2,4-D		0.0720	mg/kg	0.20				150	40	R 1

- Because the sample amount was significantly higher than the spike amount, the MS and MSD spike samples for this analyte are calculated as Duplicate samples based o the spike amount added plus the original sample concentration.
- 1 = The amount found in this duplicate analysis for this analyte was significantly less than the amount found for the other duplicate analysis and the original sample analysis. This may indicate some non-homogeneity for the sample matrix.

Qualifiers:

RL - Analyte reporting limit.

ND - Not detected at the reporting limit.

R - RPD exceeds advisory limit.

S - Spike recovery outside of advisory limits.

Standard Reporting Procedures

Lab measurement of analytes considered field parameters that require analysis within 15 minutes of sampling such as pH, Dissolved Oxygen and Residual Chlorine, are qualified as being analyzed outside of recommended holding time.

Solid/soil samples are reported on a wet weight basis (as received) unless specifically indicated. If moisture corrected, data units are typically noted as –dry. For agricultural and mining soil parameters/characteristics, all samples are dried and ground prior to sample analysis.

Workorder Receipt Checklist

MT DEQ-Federal Superfund H12090415

Login completed by: Wanda Johnson
Date Received: 9/25/2012
Reviewed by: BL2000\kwiegand
Received by: elm
Reviewed Date: 10/1/2012
Carrier name: Hand Del

Shipping container/cooler in good condition?	Yes ☑	No ☐	Not Present ☐
Custody seals intact on shipping container/cooler?	Yes ☑	No ☐	Not Present ☐
Custody seals intact on sample bottles?	Yes ☐	No ☐	Not Present ☑
Chain of custody present?	Yes ☑	No ☐	
Chain of custody signed when relinquished and received?	Yes ☑	No ☐	
Chain of custody agrees with sample labels?	Yes ☑	No ☐	
Samples in proper container/bottle?	Yes ☑	No ☐	
Sample containers intact?	Yes ☑	No ☐	
Sufficient sample volume for indicated test?	Yes ☑	No ☐	
All samples received within holding time? (Exclude analyses that are considered field parameters such as pH, DO, Res Cl, Sulfite, Ferrous Iron, etc.)	Yes ☑	No ☐	
Temp Blank received?	Yes ☑	No ☐	Not Applicable ☐
Container/Temp Blank temperature:	7.4°C On Ice		
Water - VOA vials have zero headspace?	Yes ☐	No ☐	No VOA vials submitted ☑
Water - pH acceptable upon receipt?	Yes ☐	No ☐	Not Applicable ☑

Contact and Corrective Action Comments:

None

Chain of Custody and Analytical Request Record

PLEASE PRINT (Provide as much information as possible.)

Company Name:	Project Name, PWS, Permit, Etc.	Sample Origin	EPA/State Compliance:
TerraGraphics	TO 31 - Phase 5/6 Design Investigation	State: MT	Yes ☐ No ☐

Report Mail Address:	Contact Name:	Phone/Fax:	Email:	Sampler: (Please Print)
90 N. Frontage Road, Deer Lodge MT	Jeremy Mickey	406-360-6505	jeremy.mickey@terragraphics.com	Becky Smith

Invoice Address:	Invoice Contact & Phone:	Purchase Order:	Quote/Bottle Order:
DEQ	Brian Bartkowiak 406-461-3070		10734

Special Report/Formats:

☐ DW
☐ POTW/WWTP
☐ State: _____
☐ Other: _____
☐ EDD/EDT (Electronic Data) Format: _____
☐ LEVEL IV
☐ NELAC

ANALYSIS REQUESTED

SAMPLE IDENTIFICATION (Name, Location, Interval, etc.)	Collection Date	Collection Time	MATRIX (Number of Containers; Sample Type: A W S V B O DW; Air Water Soils/Solids Vegetation Bioassay Other DW - Drinking Water)	8151 - Herbicides								SEE ATTACHED	Standard Turnaround (TAT)	RUSH	Comments:
1 TP6	9/24/12	12:08	soil	x									x		
2 TP5		12:05		x									x		
3 TP3		11:26		x									x		
4 TP2		11:20		x									x		
5 TP4		11:32		x									x		
6 TP1		11:11		x									x		
7 TP7		12:21		x									x		
8 TP8		12:15		x									x		
9															
10															

Contact ELI prior to **RUSH** sample submittal for charges and scheduling – See Instruction Page

Shipped by: Hand
Cooler ID(s): 1
Receipt Temp: 7.4 °C TBD
On Ice: (Y) N
Custody Seal: On Bottle (Y) N; On Cooler (Y) N
Intact (Y) N
Signature Match (Y) N

LABORATORY USE ONLY: H12090415

Custody Record MUST be Signed

Relinquished by (print):	Date/Time:	Signature:	Received by (print):	Date/Time:	Signature:
Becky Smith	9.25.12 ~~9:42~~ 10:58	Becky Smith			
Relinquished by (print):	Date/Time:	Signature:	Received by (print):	Date/Time:	Signature:
			Received by Laboratory:	Date/Time: 9/25/12 10:58	Signature:

Sample Disposal: Return to Client: _____ Lab Disposal: X

In certain circumstances, samples submitted to Energy Laboratories, Inc. may be subcontracted to other certified laboratories in order to complete the analysis requested. This serves as notice of this possibility. All sub-contract data will be clearly notated on your analytical report. Visit our web site at www.energylab.com for additional information, downloadable fee schedule, forms, and links.

Groundwater Elevation Monitoring

Clark Fork River, Phase 5 and 6, Groundwater Monitoring
Preliminary Design Report
Task Order 31, Project Number 12007
1/1/2013

Location	Date	Time	DTW (feet btc)	Ground Elevation	TOC Elevation	Water Table Elevation	DTW (feet bgs)
PZ01	6/18/2012	952	4.66	4714.376	4718.07	4713.41	0.97
PZ02	6/18/2012	957	4.3	4714.039	4717.622	4713.32	0.72
PZ03	6/18/2012	1000	5.27	4714.542	4718.321	4713.05	1.49
PZ04	6/18/2012	1010	3.31	4712.436	4716.343	4713.03	-0.60
PZ05	6/18/2012	1022	9.83	4713.65	4716.549	4706.72	6.93
PZ06	6/18/2012	1041	5.55	4704.67	4708.522	4702.97	1.70
PZ07	6/18/2012	1055	5.59	4702.175	4706.017	4700.43	1.75
PZ08	6/18/2012	1051	5.2	4702.425	4705.751	4700.55	1.87
PZ09	6/18/2012	1059	6.04	4702.506	4706.046	4700.01	2.50
PZ10	6/18/2012	1046	5.81	4702.938	4706.854	4701.04	1.89
PZ11	6/18/2012	1035	5.57	4700.344	4702.923	4697.35	2.99
PZ12	6/18/2012	1117	6.29	4696.81	4700.504	4694.21	2.60
PZ13	6/18/2012	1122	6.14	4697.566	4700.557	4694.42	3.15
PZ14	6/18/2012	1126	5.09	4695.894	4699.771	4694.68	1.21
PZ15	6/18/2012	1135	5.69	4697.961	4700.687	4695.00	2.96
PZ16	6/18/2012	1141	5.15	4693.068	4696.341	4691.19	1.88
PZ17	6/18/2012	1159	4.63	4686.004	4688.518	4683.89	2.12
PZ18	6/18/2012	1203	5.12	4685.445	4688.355	4683.24	2.21
PZ19	6/18/2012	1206	7.16	4686.689	4689.894	4682.73	3.95
PZ20	6/18/2012	1213	6.8	4686.303	4689.853	4683.05	3.25
PZ21	6/18/2012	1229	4.7	4714.56	4717.564	4712.86	1.70
PZ22	6/18/2012	1234	4.55	4714.213	4717.317	4712.77	1.45
PZ23	6/18/2012	1238	4.7	4714.626	4717.813	4713.11	1.51
PZ24	6/18/2012	1259	4.96	4707.355	4710.676	4705.72	1.64
PZ25	6/18/2012	1302	4.82	4707.255	4710.234	4705.41	1.84
PZ26	6/18/2012	1307	5.47	4707.687	4711.068	4705.60	2.09
PZ27	6/18/2012	1310	6.2	4707.652	4711.034	4704.83	2.82
PZ28	6/18/2012	1246	5.23	4707.357	4710.351	4705.12	2.24
PZ29	6/18/2012	1340	5.66	4703.131	4706.208	4700.55	2.58
PZ30	6/18/2012	1400	6.69	4699.837	4703.487	4696.80	3.04
PZ31	6/18/2012	1356	6.29	4699.268	4702.871	4696.58	2.69
PZ32	6/18/2012	1353	6.46	4699.036	4702.353	4695.89	3.14
PZ33	6/18/2012	1328	6.3	4699.738	4702.577	4696.28	3.46
PZ34	6/18/2012	1406	4.3	4695.549	4698.336	4694.04	1.51
PZ35	6/18/2012	1411	5.89	4696.837	4699.887	4694.00	2.84
PZ36	6/18/2012	1414	4.3	4692.204	4695.195	4690.90	1.31
PZ37	6/18/2012	1417	5.2	4692.446	4695.728	4690.53	1.92
PZ38	6/18/2012	1420	8.25	4695.753	4699.581	4691.33	4.42
PZ39	6/18/2012	1426	6.43	4689.866	4693.779	4687.35	2.52
PZ40	6/18/2012	1433	6.14	4689.383	4692.619	4686.48	2.90
		Averages	5.64	4701.09	4704.40	4698.76	2.33

Clark Fork River, Phase 5 and 6, Groundwater Monitoring
Preliminary Design Report
Task Order 31, Project Number 12007
1/1/2013

Location	Date	Time	DTW (feet btc)	Ground Elevation	TOC Elevation	Water Table Elevation	DTW (feet bgs)
PZ01	8/1/2012	1006	5.90	4714.376	4718.07	4712.17	2.21
PZ02	8/1/2012	1012	5.64	4714.039	4717.622	4711.98	2.06
PZ03	8/1/2012	1014	6.88	4714.542	4718.321	4711.44	3.10
PZ04	8/1/2012	1020	4.46	4712.436	4716.343	4711.88	0.55
PZ05	8/1/2012	1028	11.30	4713.65	4716.549	4705.25	8.40
PZ06	8/1/2012	1101	6.65	4704.67	4708.522	4701.87	2.80
PZ07	8/1/2012	1115	6.67	4702.175	4706.017	4699.35	2.83
PZ08	8/1/2012	1118	6.40	4702.425	4705.751	4699.35	3.07
PZ09	8/1/2012	1121	7.32	4702.506	4706.046	4698.73	3.78
PZ10	8/1/2012	1124	7.10	4702.938	4706.854	4699.75	3.18
PZ11	8/1/2012	1127	6.51	4700.344	4702.923	4696.41	3.93
PZ12	8/1/2012	1130	6.24	4696.81	4700.504	4694.26	2.55
PZ13	8/1/2012	1132	6.91	4697.566	4700.557	4693.65	3.92
PZ14	8/1/2012	1135	5.61	4695.894	4699.771	4694.16	1.73
PZ15	8/1/2012	1138	5.75	4697.961	4700.687	4694.94	3.02
PZ16	8/1/2012	1142	5.91	4693.068	4696.341	4690.43	2.64
PZ17	8/1/2012	1150	5.60	4686.004	4688.518	4682.92	3.09
PZ18	8/1/2012	1153	6.11	4685.445	4688.355	4682.25	3.20
PZ19	8/1/2012	1155	8.05	4686.689	4689.894	4681.84	4.85
PZ20	8/1/2012	1159	7.30	4686.303	4689.853	4682.55	3.75
PZ21	8/1/2012	1213	6.32	4714.56	4717.564	4711.24	3.32
PZ22	8/1/2012	1217	5.85	4714.213	4717.317	4711.47	2.75
PZ23	8/1/2012	1220	5.50	4714.626	4717.813	4712.31	2.31
PZ24	8/1/2012	1234	6.13	4707.355	4710.676	4704.55	2.81
PZ25	8/1/2012	1241	5.90	4707.255	4710.234	4704.33	2.92
PZ26	8/1/2012	1244	6.55	4707.687	4711.068	4704.52	3.17
PZ27	8/1/2012	1247	6.60	4707.652	4711.034	4704.43	3.22
PZ28	8/1/2012	Piezometer damaged by cattle. No water level collected.					
PZ29	8/1/2012	1318	6.41	4703.131	4706.208	4699.80	3.33
PZ30	8/1/2012	1402	7.77	4699.837	4703.487	4695.72	4.12
PZ31	8/1/2012	1358	7.86	4699.268	4702.871	4695.01	4.26
PZ32	8/1/2012	1355	7.55	4699.036	4702.353	4694.80	4.23
PZ33	8/1/2012	1343	7.10	4699.738	4702.577	4695.48	4.26
PZ34	8/1/2012	1408	5.35	4695.549	4698.336	4692.99	2.56
PZ35	8/1/2012	1411	6.62	4696.837	4699.887	4693.27	3.57
PZ36	8/1/2012	1414	5.22	4692.204	4695.195	4689.98	2.23
PZ37	8/1/2012	1418	6.00	4692.446	4695.728	4689.73	2.72
PZ38	8/1/2012	1351	9.12	4695.753	4699.581	4690.46	5.29
PZ39	8/1/2012	1423	7.14	4689.866	4693.779	4686.64	3.23
PZ40	8/1/2012	1428	6.06	4689.383	4692.619	4686.56	2.82
		Averages	6.43	4583.41	4586.65	4697.65	3.28

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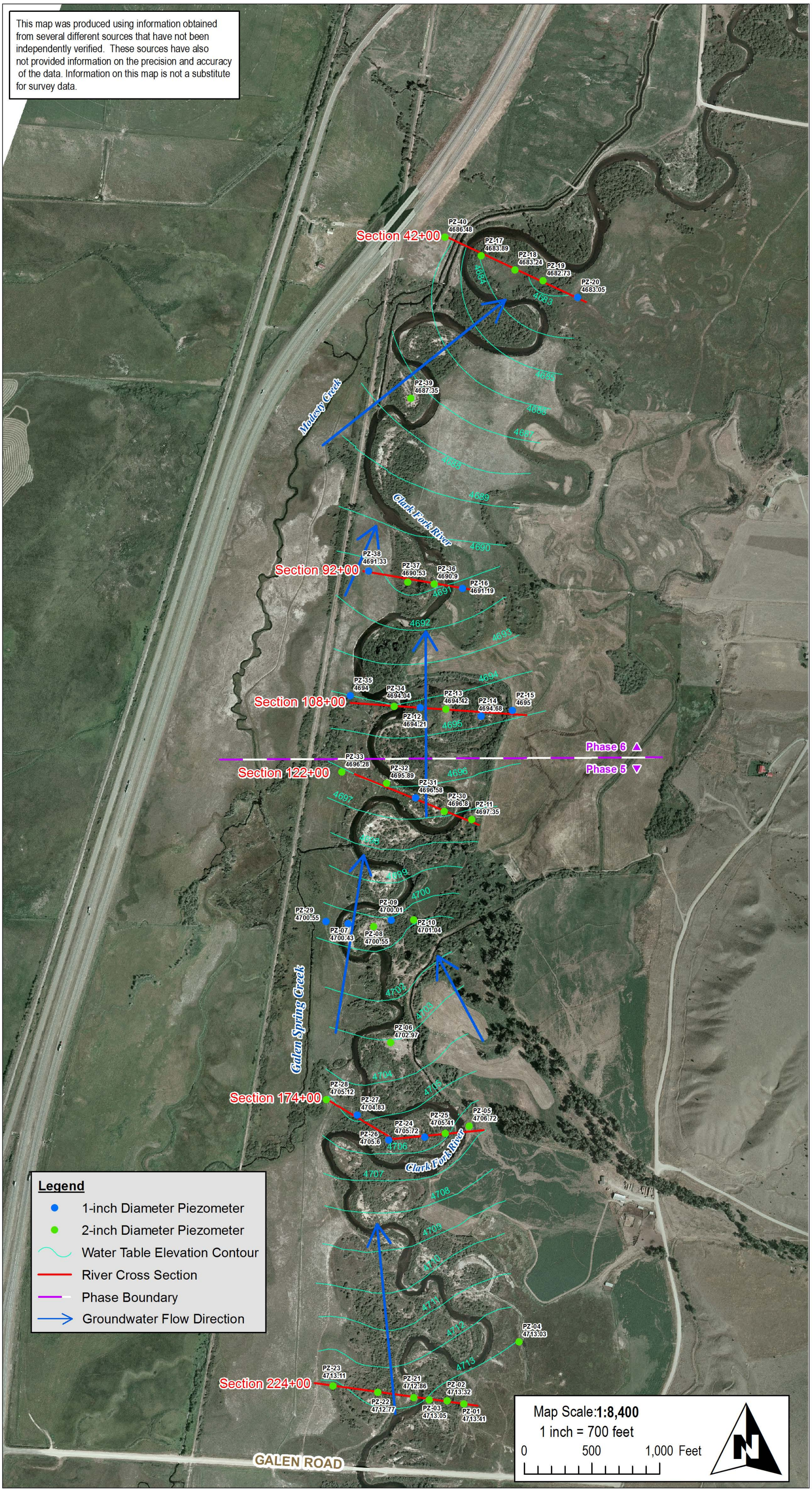
1/1/2013

Location	Date	Time	DTW (feet btc)	Ground Elevation	TOC Elevation	Water Table Elevation	DTW (feet bgs)
PZ01	8/29/2012	1015	6.31	4714.376	4718.07	4711.76	2.62
PZ02	8/29/2012	1020	5.92	4714.039	4717.622	4711.70	2.34
PZ03	8/29/2012	1022	7.04	4714.542	4718.321	4711.28	3.26
PZ04	8/29/2012	1037	5.14	4712.436	4716.343	4711.20	1.23
PZ05	8/29/2012	1053	11.30	4713.65	4716.549	4705.25	8.40
PZ06	8/29/2012	1108	6.84	4704.67	4708.522	4701.68	2.99
PZ07	8/29/2012	1116	6.75	4702.175	4706.017	4699.27	2.91
PZ08	8/29/2012	1119	6.49	4702.425	4705.751	4699.26	3.16
PZ09	8/29/2012	1122	7.48	4702.506	4706.046	4698.57	3.94
PZ10	8/29/2012	1135	7.43	4702.938	4706.854	4699.42	3.51
PZ11	8/29/2012	1139	6.93	4700.344	4702.923	4695.99	4.35
PZ12	8/29/2012	1145	7.85	4696.81	4700.504	4692.65	4.16
PZ13	8/29/2012	1147	7.86	4697.566	4700.557	4692.70	4.87
PZ14	8/29/2012	1150	7.01	4695.894	4699.771	4692.76	3.13
PZ15	8/29/2012	1212	8.06	4697.961	4700.687	4692.63	5.33
PZ16	8/29/2012	1216	6.37	4693.068	4696.341	4689.97	3.10
PZ17	8/29/2012	1225	5.68	4686.004	4688.518	4682.84	3.17
PZ18	8/29/2012	1227	6.24	4685.445	4688.355	4682.12	3.33
PZ19	8/29/2012	1228	8.28	4686.689	4689.894	4681.61	5.07
PZ20	8/29/2012	1232	8.06	4686.303	4689.853	4681.79	4.51
PZ21	8/29/2012	1343	6.46	4714.56	4717.564	4711.10	3.46
PZ22	8/29/2012	1347	6.01	4714.213	4717.317	4711.31	2.91
PZ23	8/29/2012	1350	5.63	4714.626	4717.813	4712.18	2.44
PZ24	8/29/2012	1411	6.29	4707.355	4710.676	4704.39	2.97
PZ25	8/29/2012	1407	6.06	4707.255	4710.234	4704.17	3.08
PZ26	8/29/2012	1403	6.67	4707.687	4711.068	4704.40	3.29
PZ27	8/29/2012	1400	6.75	4707.652	4711.034	4704.28	3.37
PZ28	8/29/2012	1416	5.98	4707.357	4710.351	4704.37	2.99
PZ29	8/29/2012	1422	6.11	4703.131	4706.208	4700.10	3.03
PZ30	8/29/2012	1318	7.97	4699.837	4703.487	4695.52	4.32
PZ31	8/29/2012	1316	8.05	4699.268	4702.871	4694.82	4.45
PZ32	8/29/2012	1314	7.72	4699.036	4702.353	4694.63	4.40
PZ33	8/29/2012	1330	6.85	4699.738	4702.577	4695.73	4.01
PZ34	8/29/2012	1308	5.50	4695.549	4698.336	4692.84	2.71
PZ35	8/29/2012	1306	6.66	4696.837	4699.887	4693.23	3.61
PZ36	8/29/2012	1303	5.42	4692.204	4695.195	4689.78	2.43
PZ37	8/29/2012	1301	6.14	4692.446	4695.728	4689.59	2.86
PZ38	8/29/2012	1258	9.08	4695.753	4699.581	4690.50	5.25
PZ39	8/29/2012	1250	7.20	4689.866	4693.779	4686.58	3.29
PZ40	8/29/2012	1245	5.91	4689.383	4692.619	4686.71	2.67
		Averages	6.89	4701.09	4704.40	4697.34	3.59



TerraGraphics Environmental Engineering, Inc. www.TerraGraphics.com	File: Montana\CFROU\MXD's\WTE_0618_20130114	Map Projection: NAD83 Montana State Plane	Project Name: Clark Fork River Operable Unit Phases 5 & 6 Part 1, Floodplain Investigation	**Water Table Map June 18, 2012**
	Print Date: May 13, 2013	Project Manager: M. Culpo		
	Project Number: 10074-3 MDEQ - CFR Investigation - TO #26	Cartographer: B. Bailey		

This map was produced using information obtained from several different sources that have not been independently verified. These sources have also not provided information on the precision and accuracy of the data. Information on this map is not a substitute for survey data.

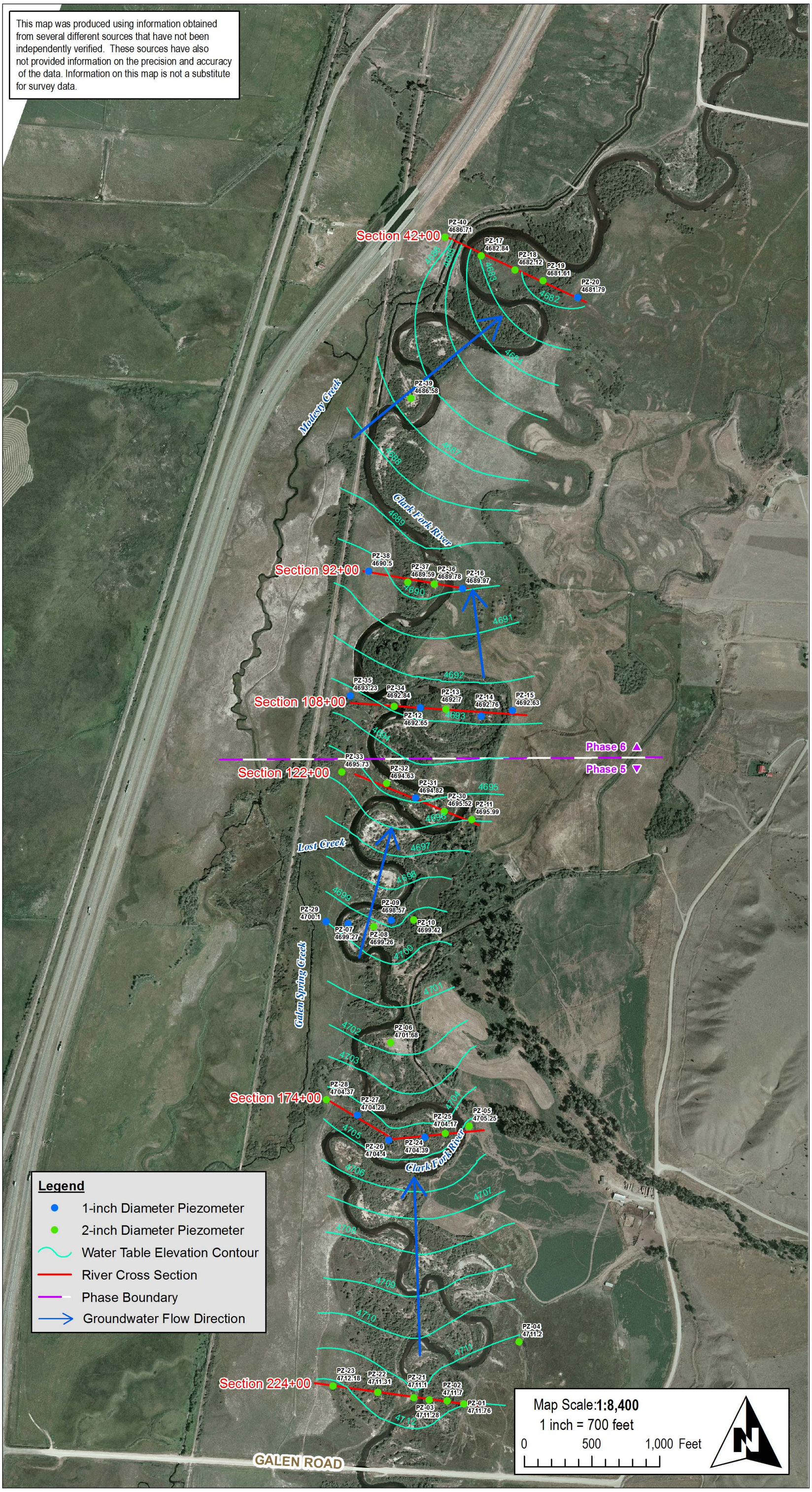
Section 42+00
PZ-40 4686.56
PZ-17 4682.92
PZ-18 4682.25
PZ-19 4681.84
PZ-20 4682.55
PZ-39 4686.64
Modesty Creek
Clark Fork River
Section 92+00
PZ-38 4690.46
PZ-36 4689.98
PZ-16 4690.43
PZ-37 4689.73
Section 108+00
PZ-35 4693.27
PZ-34 4692.99
PZ-13 4693.65
PZ-15 4694.94
PZ-12 4694.26
PZ-14 4694.16
Phase 6
Phase 5
Section 122+00
PZ-33 4695.48
PZ-32 4694.8
PZ-31 4695.01
PZ-30 4695.72
PZ-11 4696.41
PZ-07 4699.35
PZ-29 4699.8
PZ-08 4699.35
PZ-09 4698.73
PZ-10 4699.75
Galen Spring Creek
PZ-06 4701.87
PZ-28 Piezometer Damaged
Section 174+00
PZ-27 4704.43
PZ-24 4704.55
PZ-05 4705.25
PZ-26 4704.52
PZ-25 4704.33
Clark Fork River
PZ-04 4711.88
Section 224+00
PZ-23 4712.31
PZ-22 4711.47
PZ-21 4711.24
PZ-02 4711.98
PZ-03 4711.44
PZ-01 4712.17
GALEN ROAD

Legend

- 1-inch Diameter Piezometer
- 2-inch Diameter Piezometer
- Water Table Elevation Contour
- River Cross Section
- Phase Boundary
- Groundwater Flow Direction

Map Scale: 1:8,400
1 inch = 700 feet
0 500 1,000 Feet

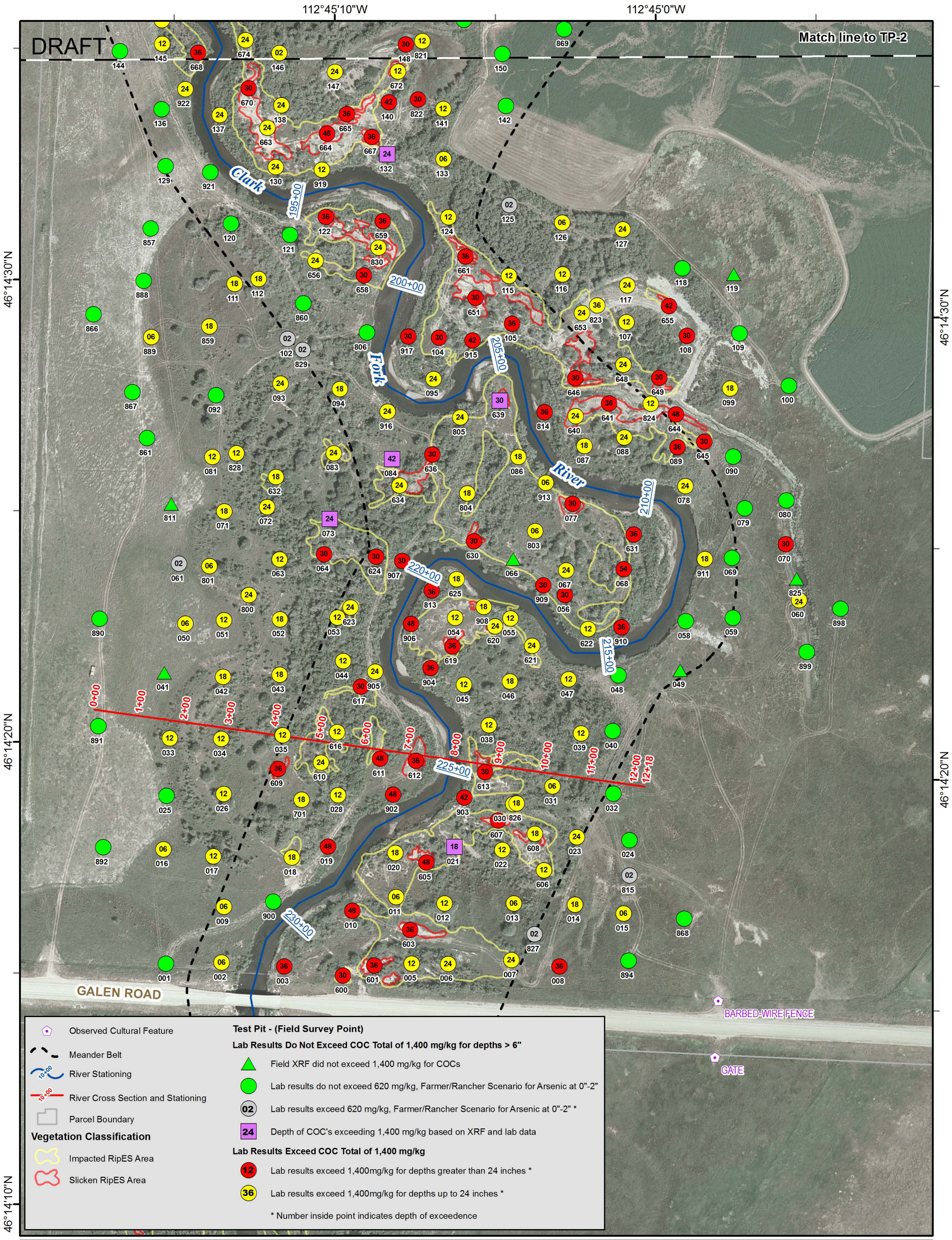
TerraGraphics Environmental Engineering, Inc. www.TerraGraphics.com	File: Montana\CFROU\MXD's\WTE_0618_20130114	Map Projection: NAD83 Montana State Plane	Project Name: Clark Fork River Operable Unit Phases 5 & 6 Part 1, Floodplain Investigation	Water Table Map August 1, 2012
	Print Date: May 13, 2013	Project Manager: M. Culpo		
	Project Number: 10074-3 MDEQ - CFR Investigation - TO #26	Cartographer: B. Bailey		



TerraGraphics Environmental Engineering, Inc. www.TerraGraphics.com	File: Montana\CFROU\MXD's\WTE_0829_20130114	Map Projection: NAD83 Montana State Plane	Project Name: Clark Fork River Operable Unit Phases 5 & 6 Part 1, Floodplain Investigation	**Water Table Map August 29, 2012**
	Print Date: May 13, 2013	Project Manager: M. Culpo		
	Project Number: 10074-3 MDEQ - CFR Investigation - TO #26	Cartographer: B. Bailey		

Appendix C

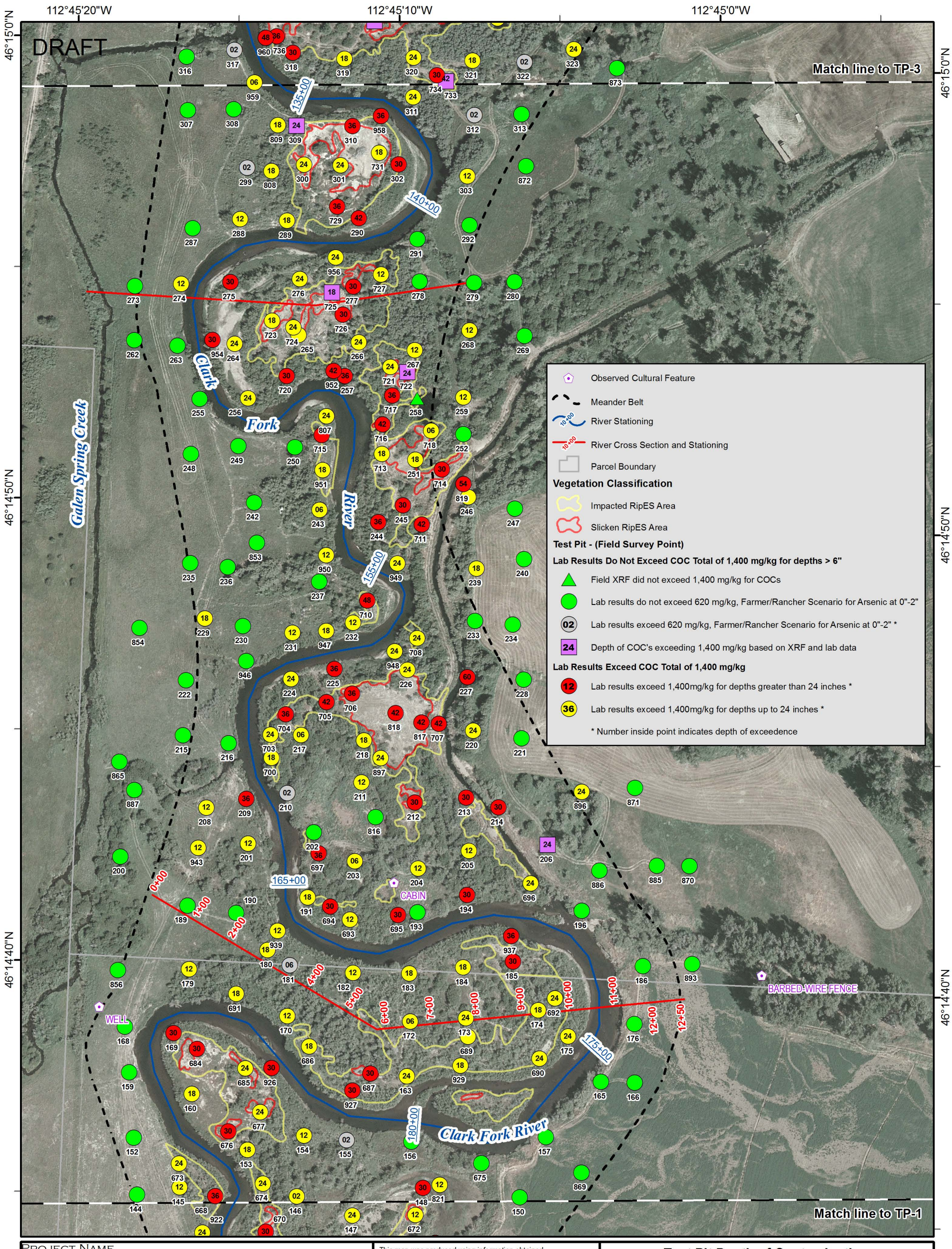
Revised Test Pit Depth of Contamination Maps



PROJECT NAME Clark Fork River Operable Unit Phases 5 & 6 Part 1, Floodplain Investigation	This map was produced using information obtained from several different sources that have not been independently verified. These sources have also not provided information on the precision and accuracy of the data. Information on this map is not a substitute for survey data.	Test Pit Depth of Contamination Results Map TP-1 (2011 Aerial Image) DRAFT

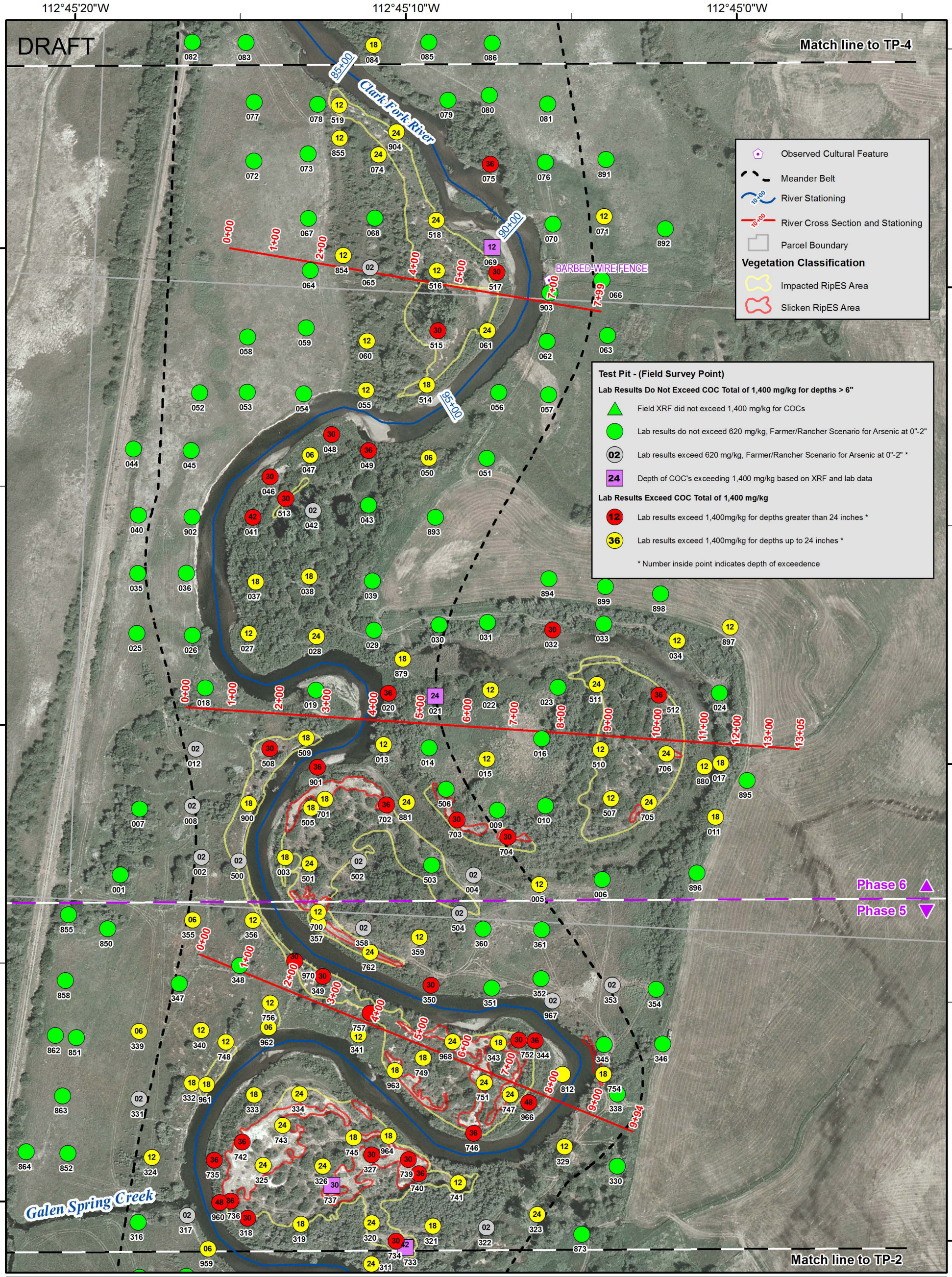
TerraGraphics Environmental Engineering, Inc.
www.TerraGraphics.com

FILE: Montana\CFROU\MXD\TP1_20130723	Map Projection: NAD83 UTM12N	Map Scale: 1:2,400 1 inch = 200 feet 0 50 100 200 Feet
PRINT DATE: July 23, 2013	PROJECT MANAGER: M. Culpo / J. Mickey	
PROJECT NUMBER: 10074-3 MDEQ - CFR Investigation - TO #26	CARTOGRAPHER: J. Mierzwinski / B. Bailey	



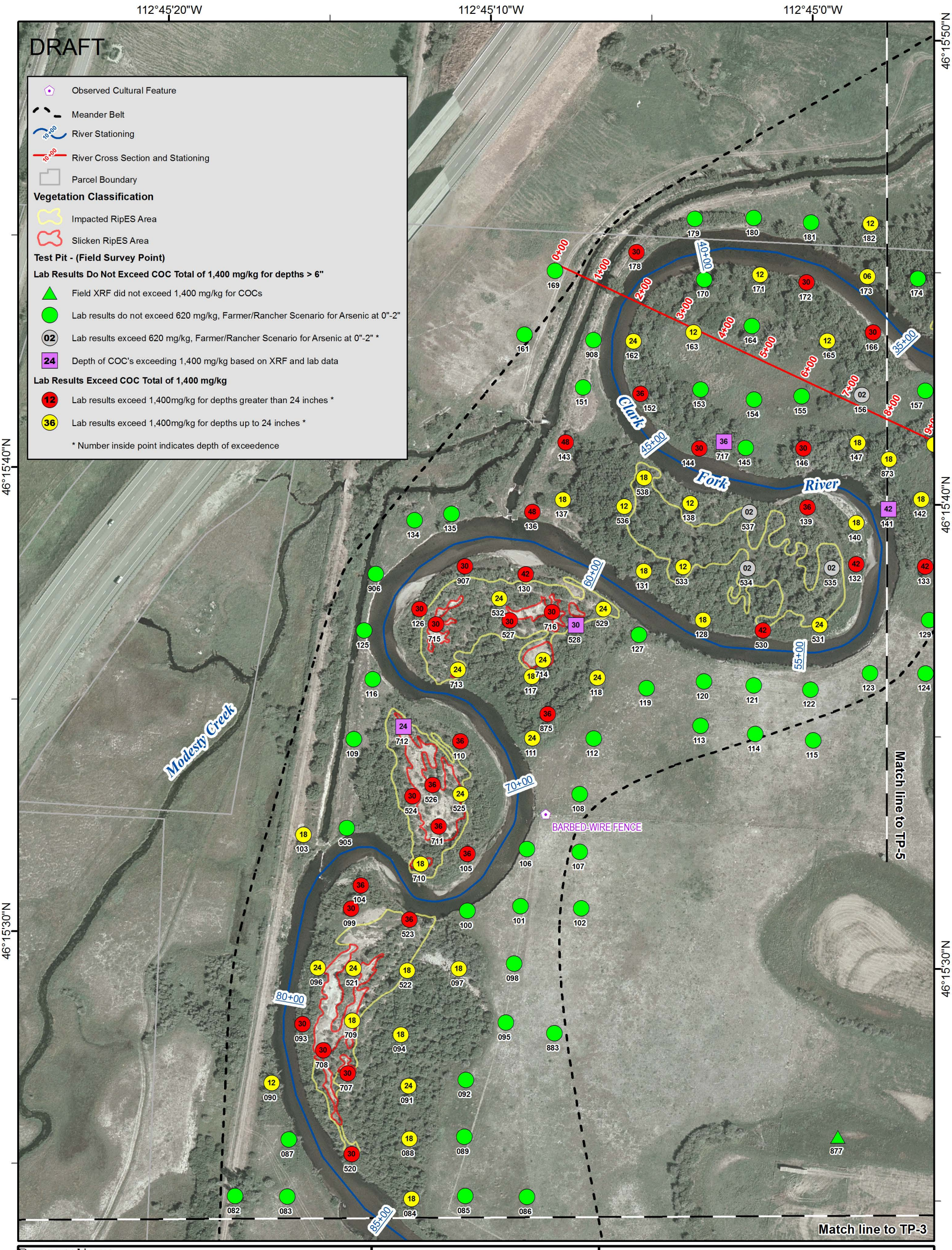
PROJECT NAME **Clark Fork River Operable Unit Phases 5 & 6 Part 1, Floodplain Investigation**	This map was produced using information obtained from several different sources that have not been independently verified. These sources have also not provided information on the precision and accuracy of the data. Information on this map is not a substitute for survey data.	**Test Pit Depth of Contamination Results Map TP-2 (2011 Aerial Image)** DRAFT

TerraGraphics Environmental Engineering, Inc. www.TerraGraphics.com	FILE Montana\CFROU_Phase5\MXD\TP2_20130723	Map Projection: NAD83 UTM12N	Map Scale: **1:2,400** 1 inch = 200 feet 0 50 100 200 Feet
	PRINT DATE July 23, 2013	PROJECT MANAGER M. Culpo / J. Mickey	
	PROJECT NUMBER 10074-3 MDEQ - CFR Investigation - TO #26	CARTOGRAPHER J. Mierzwinski / B. Bailey	



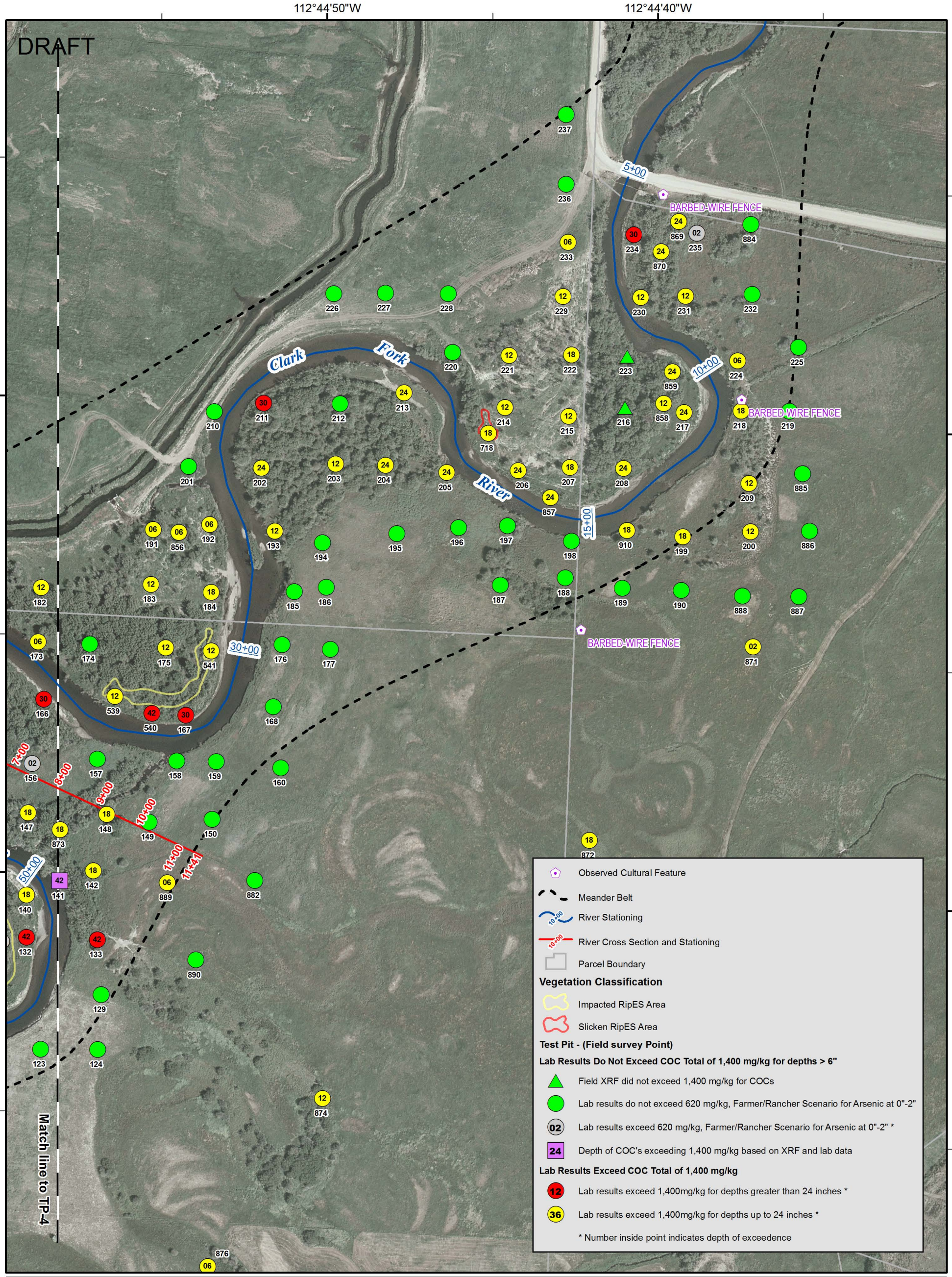
PROJECT NAME Clark Fork River Operable Unit Phases 5 & 6 Part 1, Floodplain Investigation	This map was produced using information obtained from several different sources that have not been independently verified. These sources have also not provided information on the precision and accuracy of the data. Information on this map is not a substitute for survey data.	Test Pit Depth of Contamination Results Map TP-3 (2011 Aerial Image) DRAFT

TerraGraphics Environmental Engineering, Inc. www.TerraGraphics.com	FILE Montana\CFROU\MXD\TP3_20130723	Map Projection: NAD83 UTM12N	Map Scale: 1:2,400 1 inch = 200 feet 0 50 100 200 Feet
	PRINT DATE July 23, 2013	PROJECT MANAGER M. Culpo / J. Mickey	
	PROJECT NUMBER 10074-3 MDEQ - CFR Investigation - TO #26	CARTOGRAPHER J. Mierzwinski / B. Bailey	



Project Name		Test Pit Depth of Contamination Results Map TP-4 (2011 Aerial Image) DRAFT
Clark Fork River Operable Unit Phases 5 & 6 Part 1, Floodplain Investigation	This map was produced using information obtained from several different sources that have not been independently verified. These sources have also not provided information on the precision and accuracy of the data. Information on this map is not a substitute for survey data.	

TerraGraphics Environmental Engineering, Inc. www.TerraGraphics.com	File: Montana\CFROU\MXD\TP4_20130723	Map Projection: NAD83 UTM12N	Map Scale: 1:2,400 1 inch = 200 feet 0 50 100 200 Feet
	Print Date: July 23, 2013	Project Manager: M. Culpo / J. Mickey	
	Project Number: 10074-3 MDEQ - CFR Investigation - TO #26	Cartographer: J. Mierzwinski / B. Bailey	



PROJECT NAME Clark Fork River Operable Unit Phases 5 & 6 Part 1, Floodplain Investigation	This map was produced using information obtained from several different sources that have not been independently verified. These sources have also not provided information on the precision and accuracy of the data. Information on this map is not a substitute for survey data.	Test Pit Depth of Contamination Results Map TP-5 (2011 Aerial Image) DRAFT

TerraGraphics Environmental Engineering, Inc.
www.TerraGraphics.com

FILE: Montana\CFROU\MXD\\TP5_20130723	Map Projection: NAD83 UTM12N	Map Scale: 1:2,400 1 inch = 200 feet 0 50 100 200 Feet
PRINT DATE: July 23, 2013	PROJECT MANAGER: M. Culpo / J. Mickey	
PROJECT NUMBER: 10074-3 MDEQ - CFR Investigation - TO #26	CARTOGRAPHER: J. Mierzwinski / B. Bailey	

Appendix D

Eroding Banks Data

Bend Stations	Eroding Bank Id	Migration Distance 1947-2011 (ft)	Long Term Rate (ft/yr)	Migration Distance 2006-2011 (ft)	Short Term Rate (ft/yr)	Floodplain Contamination	Relative Stability Concern (High, Med, Low)	Toe Material Type	Vegetation Type (Upland or Riparian)	Riparian Density	Riparian Rootzone connection to Baseflow	Comments
231+00 to 229+00	8-1L	26	0.4	0	0.0	Contaminated	High	Cobble, Sand	U	H	N	Outside bend below bridge; long term movement; Willows at stable points of scallops w/ roots to baseflow.
227+00 to 223+00	8-1R	0	0.0	3	0.5	Contaminated	Low					Outside limb of new bend
	8-2R	0	0.0	3	0.5	Contaminated	Low	Sand, Fine sand	R	H	Y	Small scallop, Willows at stable points of scallops w/ roots to baseflow.
	8-3R							Sand, Cobble	U	H	N	
	8-4R	37	0.6	12	2.0	Contaminated	High	Silt, Clay Sill	U	H	N	o/s bend
220+00 to 218+00	8-3L	36	0.6	0	0.0	Contaminated	High	Silt, Clay Sill	U	M	N	o/s bend; high historic rates, Roots in bank below tailings
217+00 to 218+00	8-6R	26	0.4	10	1.7	Contaminated	High					o/s bend
215+00 to 210+00	9-1R	44	0.7	0	0.0	Mixed	High	Silt, Sand, Cobble	U	L	N	o/s bend; high historic rates, Sparse grasses and weeds
210+00 to 207+00	9-1L	9	0.1	0	0.0	Contaminated	Low	Silt, Cobble	R	H	Y	Low rates
206+00 to 207+00	9-2L	14	0.2	4	0.7	Contaminated	Low	Clay Sill, Cobble	U	M	N	Low rates
207+00 to 208+00	9-2R	0	0.0	0	0.0	Contaminated	Low					
205+00 to 204+00	9-3R	27	0.4	22	3.7	Contaminated	High	Silt, Cobble, Clay Sill	R	M	N	Very rapid, Looks like very erosive soils at toe
203+00 to 204+00	9-3L	29	0.5	10	1.7	Contaminated	High	Sand, Sill	R	M	N	o/s bend; high historic rates
201+00 to 202+00	9-4L	29	0.5	14	2.3	Contaminated	High	Cobble, Sand, Clay Sill	U	M	N	d/s limb translating; high historic rates
195+00 to 198+00	9-4R	40	0.6	6	1.0	Contaminated	High	Clay Sill, Cobble	R	H	N	o/s bend; high historic rates, Roots in bank below tailings
191+00 to 192+00	9-5L	33	0.5	8	1.3	Contaminated	High					
189+00 to 190+00	9-5R	0	0.0	0	0.0	Contaminated	Low					
175+00 to 172+00	9-7R					Clean	Low	Clay, Silt, Gravel, Cobble	U	M	N	Very tall bank
165+00 to 166+00	9-8L	9	1.5	3	0.5	Contaminated	Low					
157+00 to 155+00	10-1R	51	0.8	0	0.0	Contaminated	High	Cobble, Sand	R	H	N	High historic rates towards ditch
157+00 to 158+00	10-2L	25	0.4	0	0.0	Contmainted	Low					
152+00 to 153+00	10-3L	28	0.5	8	1.3	Contmainted	Moderate					
143+00 to 137+00	10-2R	16	0.3	6	1.0	Mixed	Moderate	Gravel, Cobble, Sand, Clay Sill	U	M	N	o/s bend, Sparse roots in bank below tailings
146+00 to 143+00	10-5L	53	0.9	3	0.5	Mixed	High	Cobble, Clay Sill, A boulder	U	M	N	o/s bend; high historic rates
128+00 to 132+00	10-6L	36	0.6	0	0.0	Contaminated	Moderate	Clay Sill, Cobble, Gravel	U	M	N	o/s bend, Sparse roots in bank below tailings
123+00 to 118+00	10-3R	38	0.6	16	2.7	Mixed	Moderate	Clay Sill, Gravel	U	L	N	o/s bend; only contaminated on upstream limb
114+00 to 109+00	10-7L	39	0.6	0	0.0	Contaminated	High	Gravel, Cobble, Clay Sill	U	L	N	o/s bend; high historic rates
105+00 to 98+00	11-1L	23	0.4	3	0.5	Clean	Low	Cobble	U	M	N	Weeds
94+00 to 90+00	11-1R					Clean	Low	Cobble, Gravel	U	L	N	Pasture grass
74+00 to 70+00	11-2R					Clean	Low	Clay Sill, Cobble, Gravel	U	L	N	Pasture grass
67+00 to 63+00	11-3R					Clean	Low	Cobble, Clay Sill	U	L	N	
56+00 to 50+00	12-1R					Clean	Low	Cobble, Clay Sill	R	M	Y	
14+00 to 9+00	12-2R	31	0.5	13	2.2	Contaminated	High	Cobble, Clay Sill	U	H	Y	o/s bend; high historic rates, Grassbergs slumped and moderately stable
8+00 to 10+00	12-3R	29	0.5	0	0.0	Contaminated	Low	Cobble, Clay Sill	R	M	N	low rates
	average		**0.5**		**0.9**							
	max		**1.5**		**3.7**							

Appendix E

Preliminary Design Plans

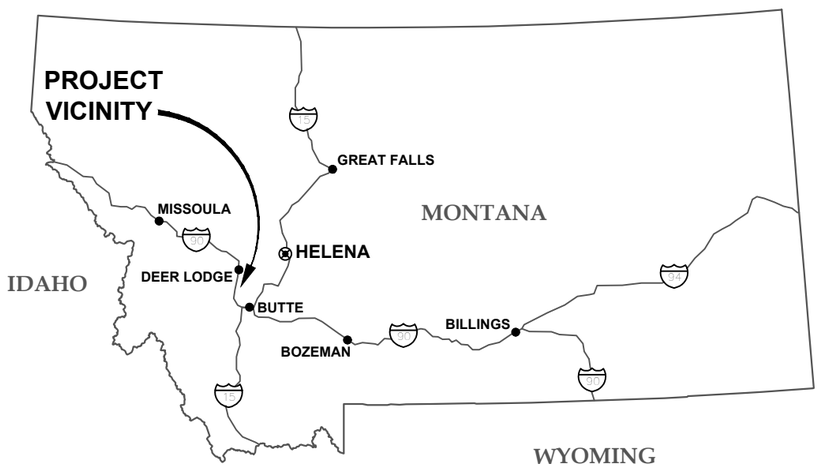
PRELIMINARY DRAWINGS

MILLTOWN RESERVOIR/CLARK FORK RIVER NPL SITE

CLARK FORK RIVER OPERABLE UNIT

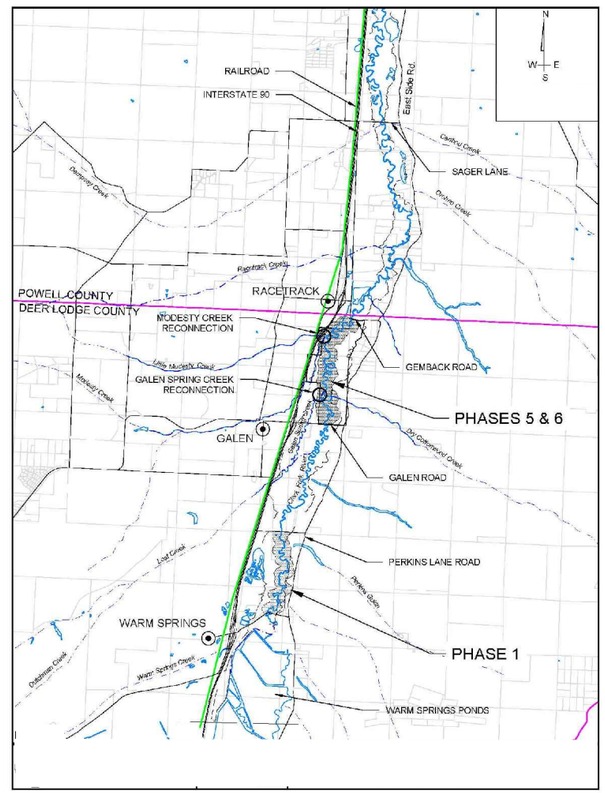
REACH A, PHASES 5 & 6 REMEDIAL ACTION

DEER LODGE COUNTY, MONTANA



VICINITY MAP

NO SCALE



LOCATION MAP

NO SCALE

SHEET INDEX

SHEET INDEX #	SHEET TITLE
CS	COVER SHEET
G1	PLAN SET INFORMATION
C1 - C4	EXISTING CONDITIONS
C5 - C8	DEWATERING PLAN
C9 - C12	EXCAVATION PLAN
C13 - C16	PROPOSED GRADING AND STREAMBANK TREATMENT LOCATION PLAN
C17 - C20	REVEGETATION COVER TYPES
D1	DETAILS

MONTANA
MWCB

OWNER

Remediation Division
Montana Department of Environmental Quality
1100 NORTH LAST CHANCE GULCH, HELENA, MONTANA 59601
TELEPHONE: (406) 841-5000

ENGINEER

TerraGraphics Environmental Engineering, Inc.
15 W 6th Ave, Power Block West 3rd Flr, HELENA, MONTANA 59601
TELEPHONE: (406) 441-5441
FAX: (406) 441-5443

GEUM ENVIRONMENTAL CONSULTING, INC

PRELIMINARY DESIGN PLANS
NOT FOR CONSTRUCTION

TerraGraphics Environmental Engineering, Inc.

DRAWN: G. HOGGATT	COORDINATE SYSTEM: MSP, NAD 83, INT FT	CLARK FORK RIVER OPERABLE UNIT REACH A, PHASES 5 & 6 REMEDIAL ACTION	COVER SHEET
ENGINEER: M. CULPO	SCALE: AS SHOWN		
CHECKED: S. FIROR	APPROVED:	DEER LODGE, MONTANA	
REVISED:	DATE:		

SHEET INDEX:	CS
PROJECT NO.:	12007
DATE:	7/25/2013
SHEET:	1 OF 23

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GENERAL NOTES

1. LOCATIONS AND ELEVATIONS ARE MONTANA STATE PLANE (MSP), NAD 83, NAVD 88, INTERNATIONAL FT.
2. THE OWNER'S SURVEYOR WILL PROVIDE BENCHMARKS AND HORIZONTAL CONTROL FOR THE SITE.
3. LOCATIONS OF EXISTING SITE FEATURES ARE APPROXIMATE. CONTRACTOR SHALL FIELD VERIFY THE EXACT LOCATION OF FEATURES AND ALL EXISTING UTILITIES BEFORE COMMENCING WORK. UNDERGROUND UTILITIES SHALL BE LOCATED AND MARKED PRIOR TO EXCAVATION. CALL THE ONE-CALL UTILITY LOCATE SERVICE AT 1-800-424-5555 AT LEAST FIVE (5) WORKING DAYS PRIOR TO STARTING CONSTRUCTION.
4. CONTRACTOR SHALL BE RESPONSIBLE FOR THE PROTECTION OF ALL EXISTING MONUMENTS AND ANY OTHER SURVEY MARKERS DURING CONSTRUCTION. ALL SUCH MONUMENTS OR MARKERS DESTROYED DURING CONSTRUCTION SHALL BE REPLACED AT CONTRACTOR'S EXPENSE.
5. A COPY OF THESE DRAWINGS MUST BE ON THE JOB SITE WHENEVER CONSTRUCTION IS IN PROGRESS.

ABBREVIATIONS

ALIGN	ALIGNMENT	EXTG	EXISTING	OC	ON-CENTER
ALT	ALTERNATE	FT	FEET	REQ'D	REQUIRED
APPROX	APPROXIMATE	H	HIGH	ROW	RIGHT-OF-WAY
ARCO	ATLANTIC RICHFIELD COMPANY	H:V	HORIZONTAL:VERTICAL	RR	RAILROAD
BMP	BEST MANAGEMENT PRACTICE	INV	INVERT	SCH	SCHEDULE
BNSF	BURLINGTON NORTHERN SANTA FE	IRR	IRRIGATION	SED.	SEDIMENTATION
		LF	LINEAL FOOT	SD	STORM DRAIN PIPE
DEQ	DEPARTMENT OF ENVIRONMENTAL QUALITY	MAX	MAXIMUM	TYP	TYPICAL
		MIN	MINIMUM	W	WIDE
DIA	DIAMETER	MSP	MONTANA STATE PLANE	WMA	WASTE MANAGEMENT AREA
E	EASTING	MT	MONTANA	YD	YARD
ELEV.	ELEVATION	N	NORTHING		
		NTS	NOT TO SCALE		

LEGEND

EXISTING		PROPOSED
	CREEK/DRAINAGEWAY	
	EXISTING FLOODPLAIN FLOW PATH	
-P/L-	PROPERTY LINE	
- IRR -	IRRIGATION DITCH	
-UT-	UNDERGROUND TELEPHONE	
FO FO	FIBER OPTIC LINE	
	EDGE OF GRAVEL ROAD	
X X	FARM FENCE	
	RIPARIAN (ELECTRIC) FENCE	
	REMOVAL LIMITS	
	SILT OR CONSTRUCTION FENCE	
	DEWATERING TRENCH	
	SEDIMENTATION POND	
	SUMP AND DISCHARGE LINE	
	EXISTING BRIDGE	
	ACCESS CULVERT	
	SWALE	
4520	MAJOR CONTOUR	4520
4519	MINOR CONTOUR	4519
	TOP OF RIVER BANK	
	ACCESS ROUTE	
	VEHICLE TRACKING CONTROL	
2 2 18 42	TEST PIT WITH DEPTH OF CONTAMINATION	
	TEST PIT WITH NO CONTAMINATION	
CP-GALEN N: 741664.922 E: 1145270.372 Z: 4721.60 RR SPIKE	SURVEY CONTROL POINT	

1 / D3 — DETAIL NUMBER / SHEET WHERE SHOWN

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TerraGraphics Environmental Engineering, Inc.

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ENGINEER: M. CULPO	SCALE:		
CHECKED: S. FIROR	APPROVED:	DEER LODGE, MONTANA	
REVISED:	DATE:		

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PROJECT NO.:	12007
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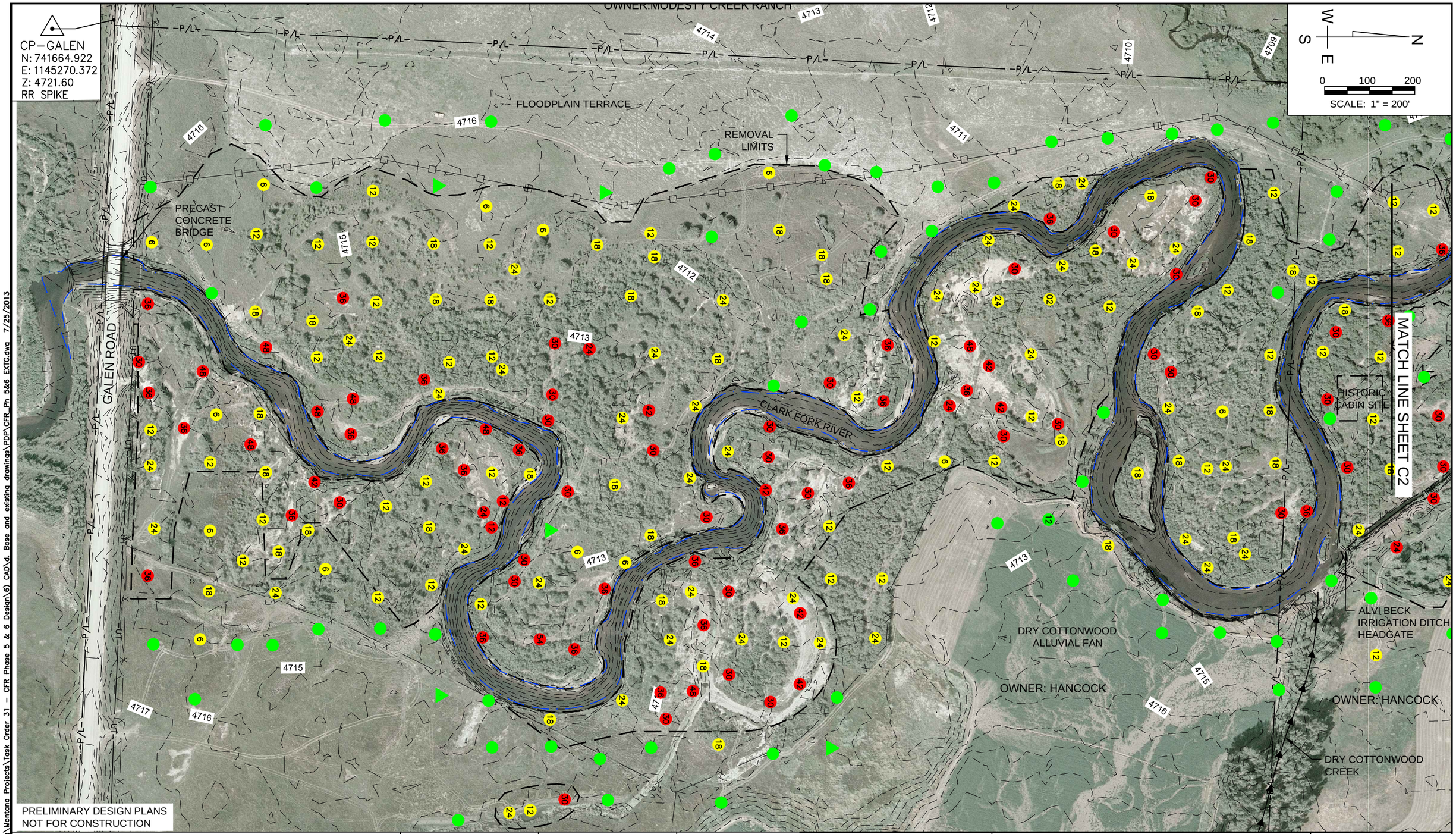
SHEET:	2 OF 23



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TerraGraphics Environmental Engineering, Inc.

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ENGINEER: M. CULPO	SCALE: AS SHOWN		
CHECKED: S. FIROR	APPROVED:	DEER LODGE, MONTANA	
DATE:	DATE:		

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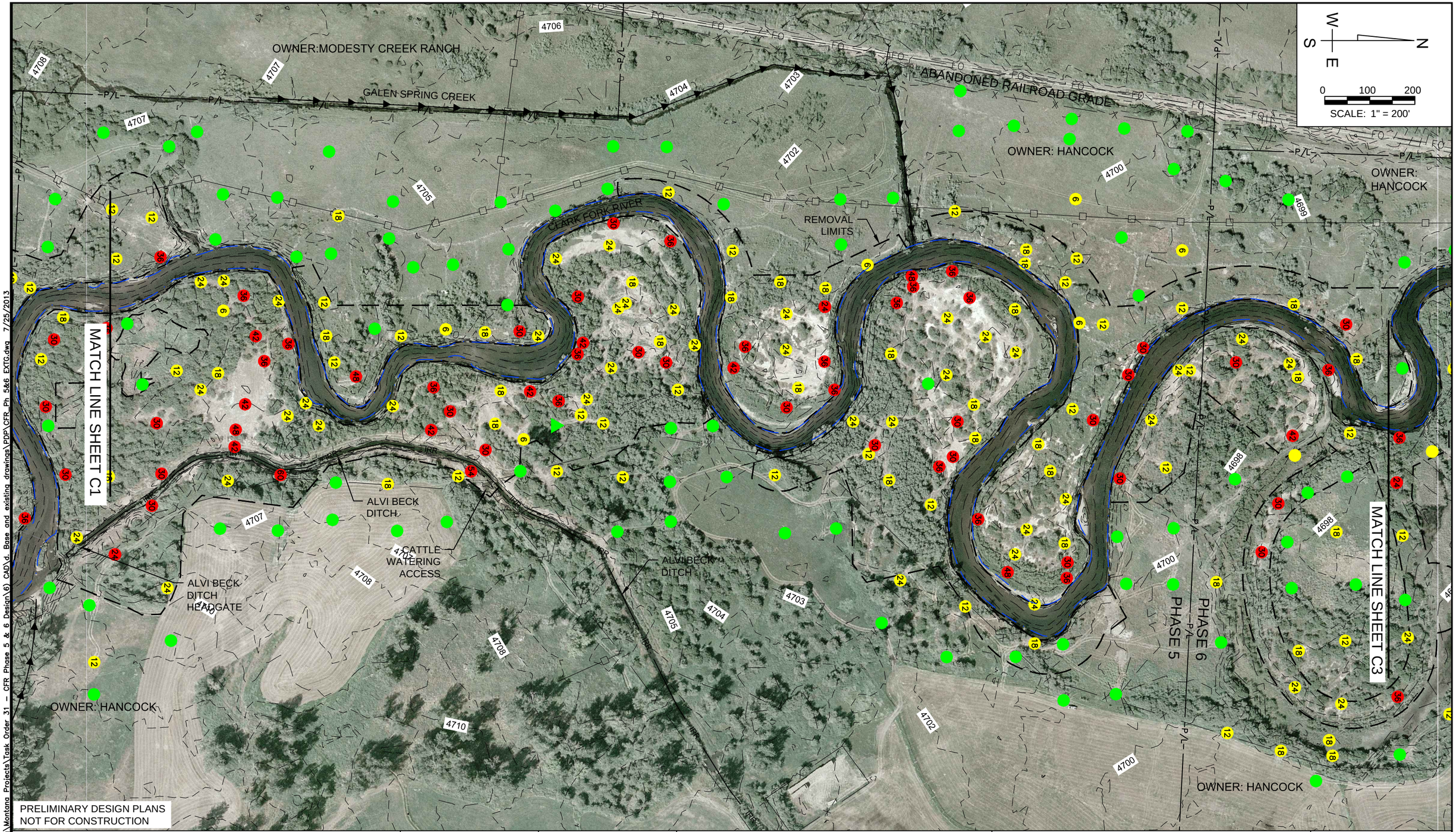

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TerraGraphics Environmental Engineering, Inc.

DRAWN: G. HOGGATT	COORDINATE SYSTEM: MSP, NAD 83, INT FT	CLARK FORK RIVER OPERABLE UNIT REACH A, PHASES 5 & 6 REMEDIAL ACTION	EXISTING CONDITIONS
ENGINEER: M. CULPO	SCALE: AS SHOWN		
CHECKED: S. FIROR	APPROVED:	DEER LODGE, MONTANA	
DATE:	DATE:		

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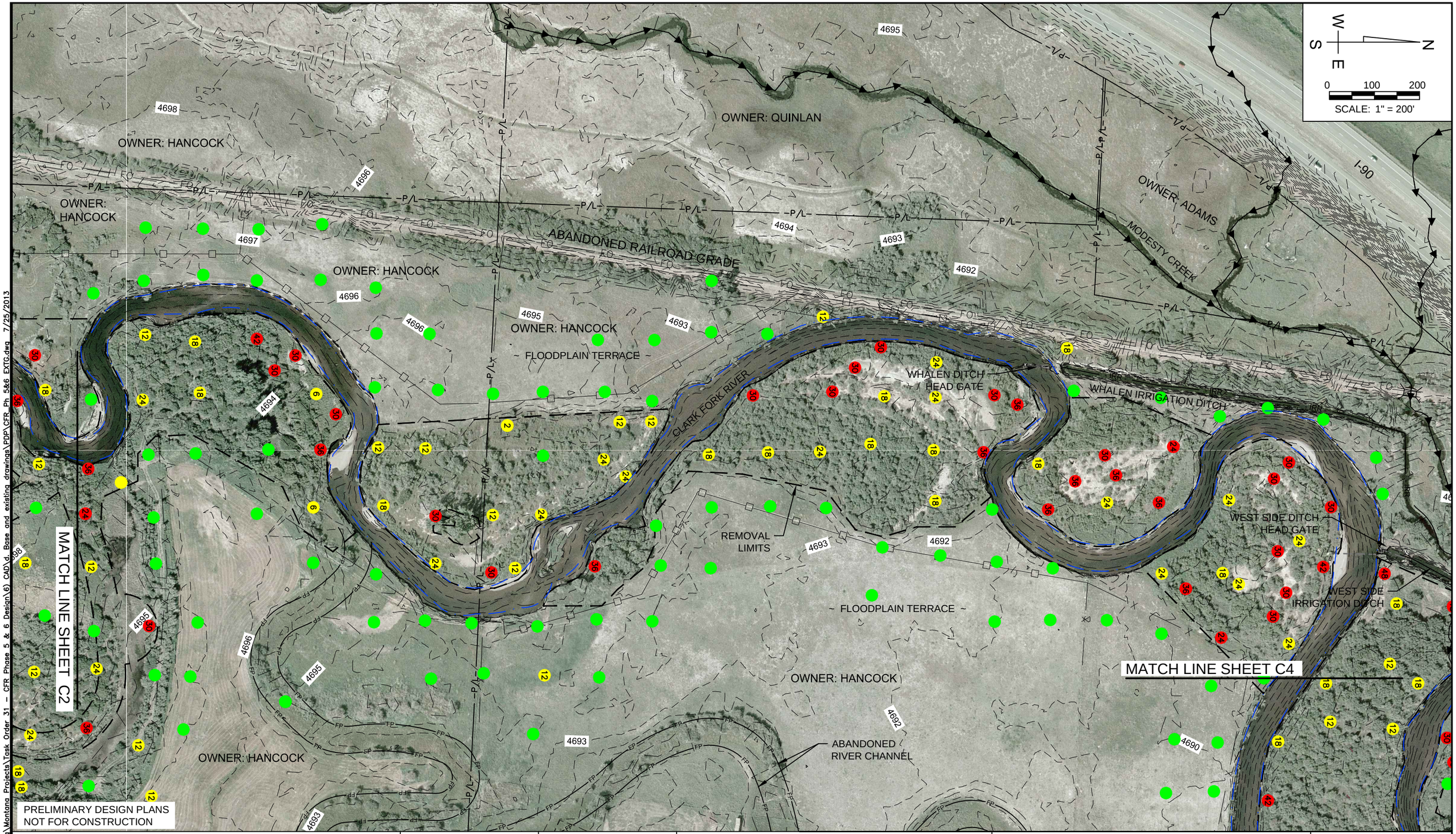
SHEET:	4 OF 23



PRELIMINARY DESIGN PLANS
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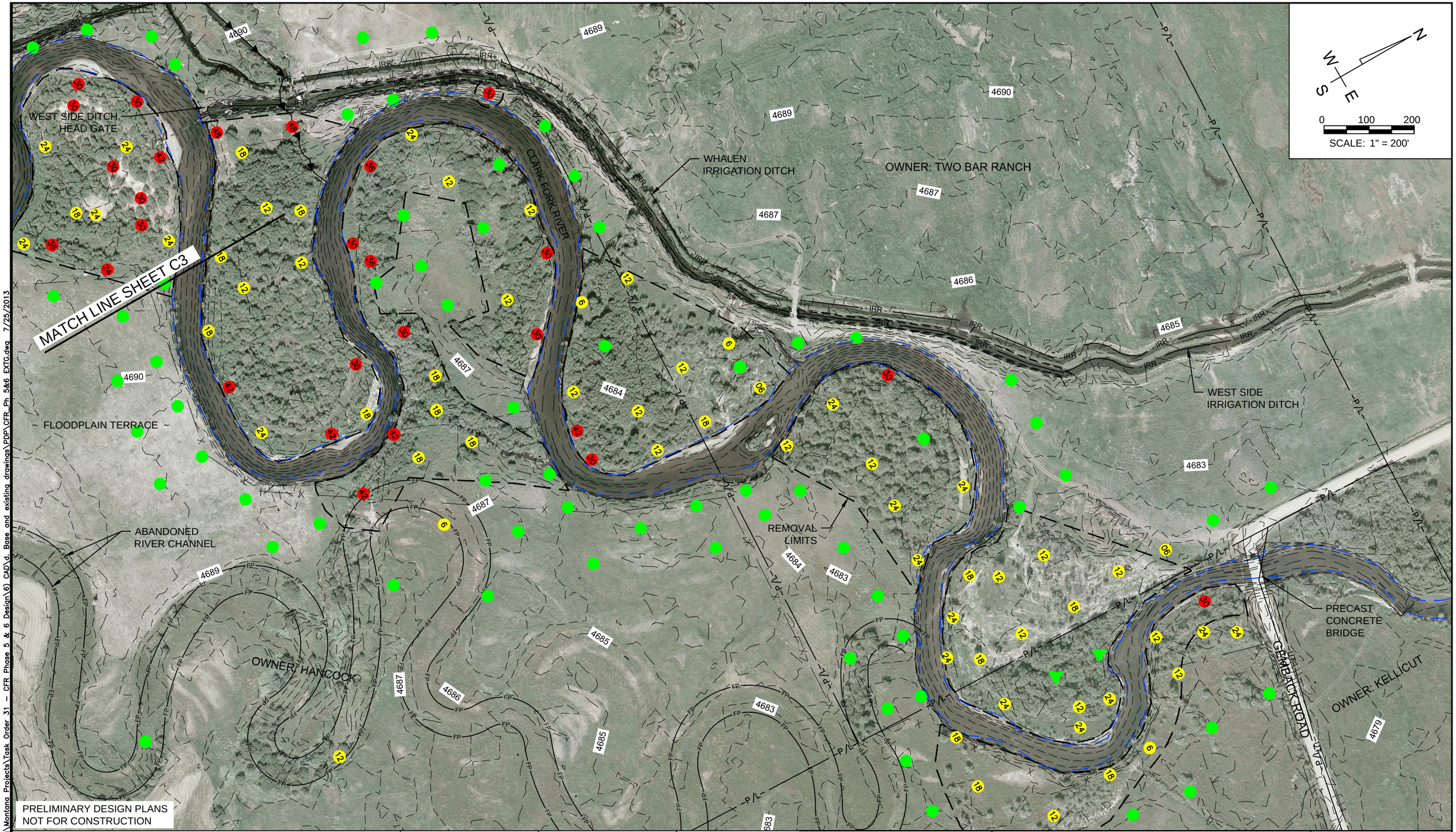
ENGINEER: M. CULPO	SCALE: AS SHOWN		PROJECT NO.: 12007
CHECKED: S. FIROR	APPROVED:	DEER LODGE, MONTANA	DATE: 7/25/2013
DATE:	DATE:		SHEET: 5 OF 23

EXISTING CONDITIONS



PRELIMINARY DESIGN PLANS
NOT FOR CONSTRUCTION

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TerraGraphics
Environmental Engineering, Inc.

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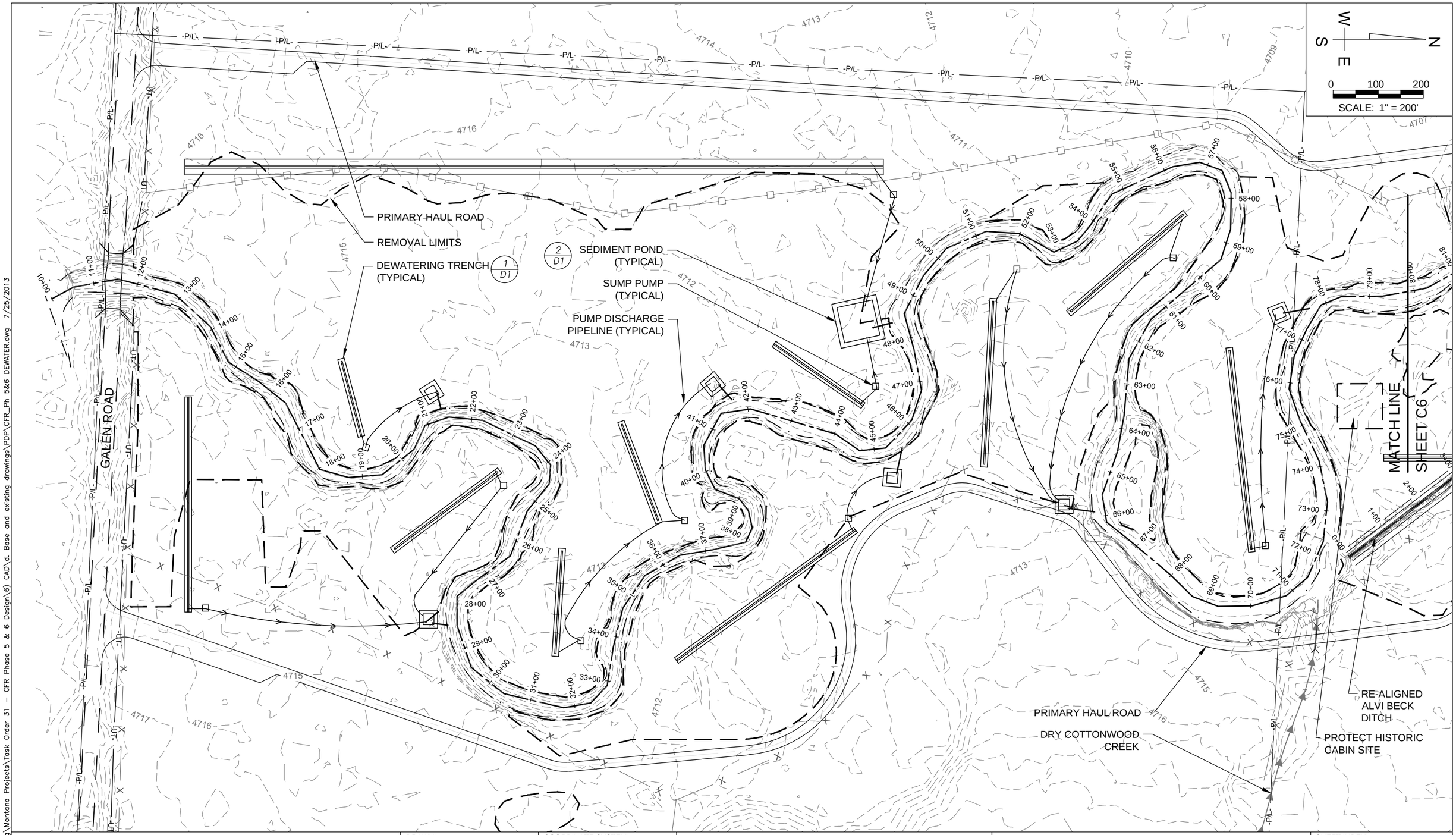
ENGINEER: M. CULPO	SCALE: AS SHOWN		PROJECT NO.: 12007
CHECKED: S. FIROR	APPROVED:	DEER LODGE, MONTANA	DATE: 7/25/2013
DATE:	DATE:		SHEET: 6 OF 23

EXISTING CONDITIONS



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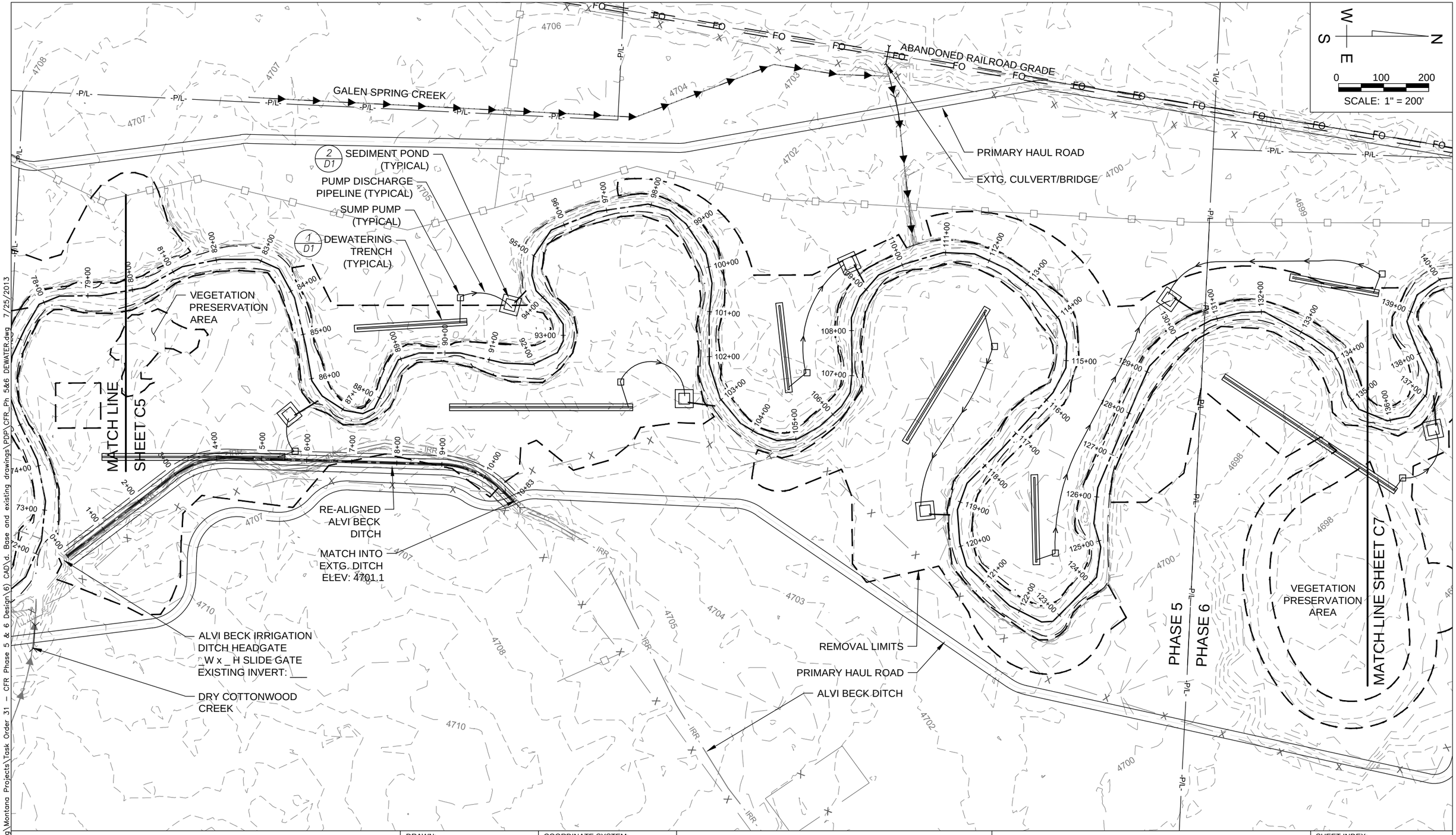
TerraGraphics Environmental Engineering, Inc.

DRAWN: G. HOGGATT	COORDINATE SYSTEM: MSP, NAD 83, INT FT	CLARK FORK RIVER OPERABLE UNIT REACH A, PHASES 5 & 6 REMEDIAL ACTION	SHEET INDEX: C5
ENGINEER: M. CULPO	SCALE: AS SHOWN		PROJECT NO.: 12007
CHECKED: S. FIROR	APPROVED:	DEER LODGE, MONTANA	DATE: 7/25/2013
DATE:	DATE:		SHEET: 7 OF 23

DEWATERING PLAN



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	ENGINEER: M. CULPO	SCALE: AS SHOWN			PROJECT NO.: 12007
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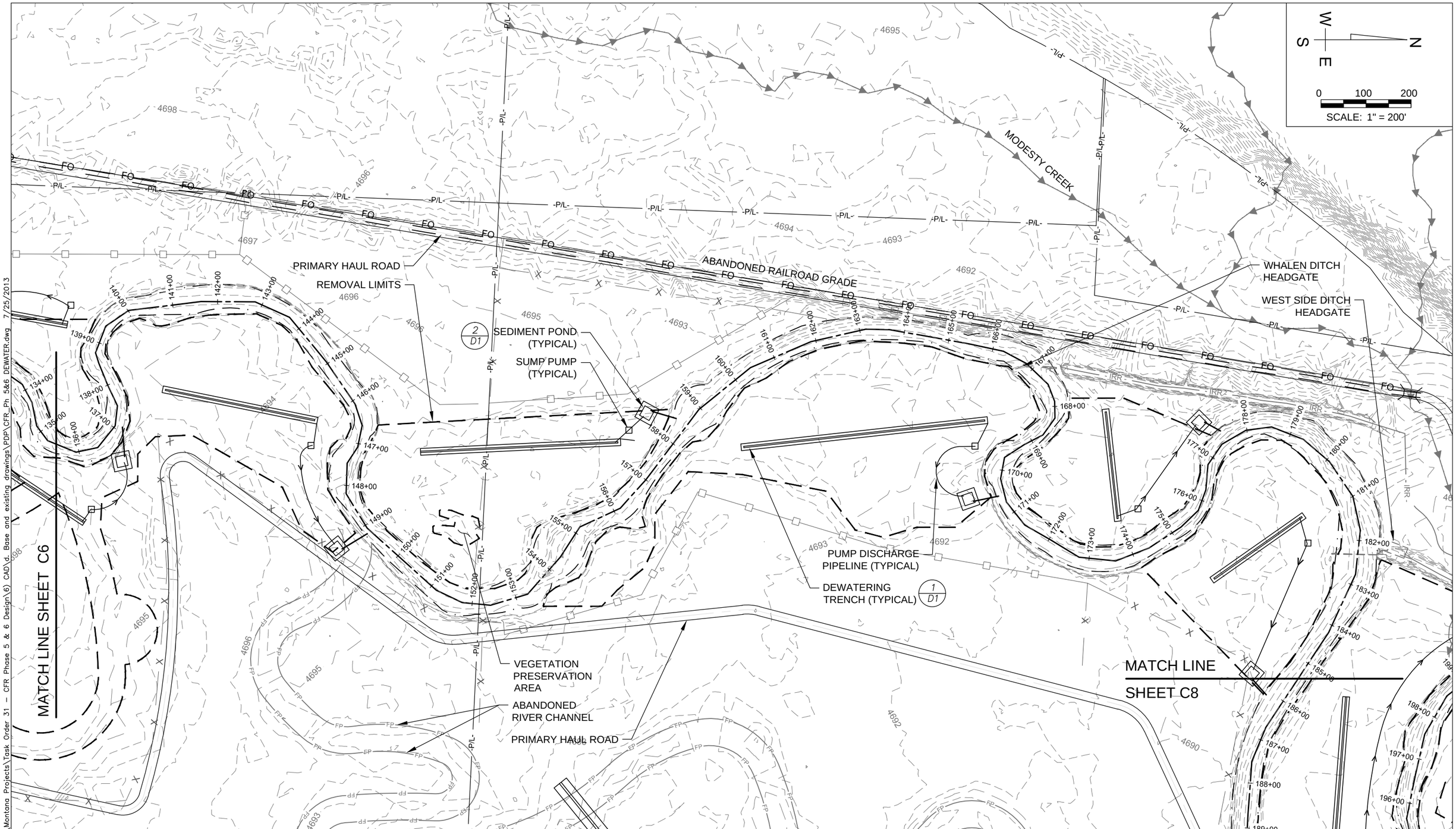

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Environmental Engineering, Inc.

DRAWN: G. HOGGATT	COORDINATE SYSTEM: MSP, NAD 83, INT FT	CLARK FORK RIVER OPERABLE UNIT REACH A, PHASES 5 & 6 REMEDIAL ACTION	DEWATERING PLAN
ENGINEER: M. CULPO	SCALE: AS SHOWN		
CHECKED: S. FIROR	APPROVED:	DEER LODGE, MONTANA	
DATE:	DATE:		

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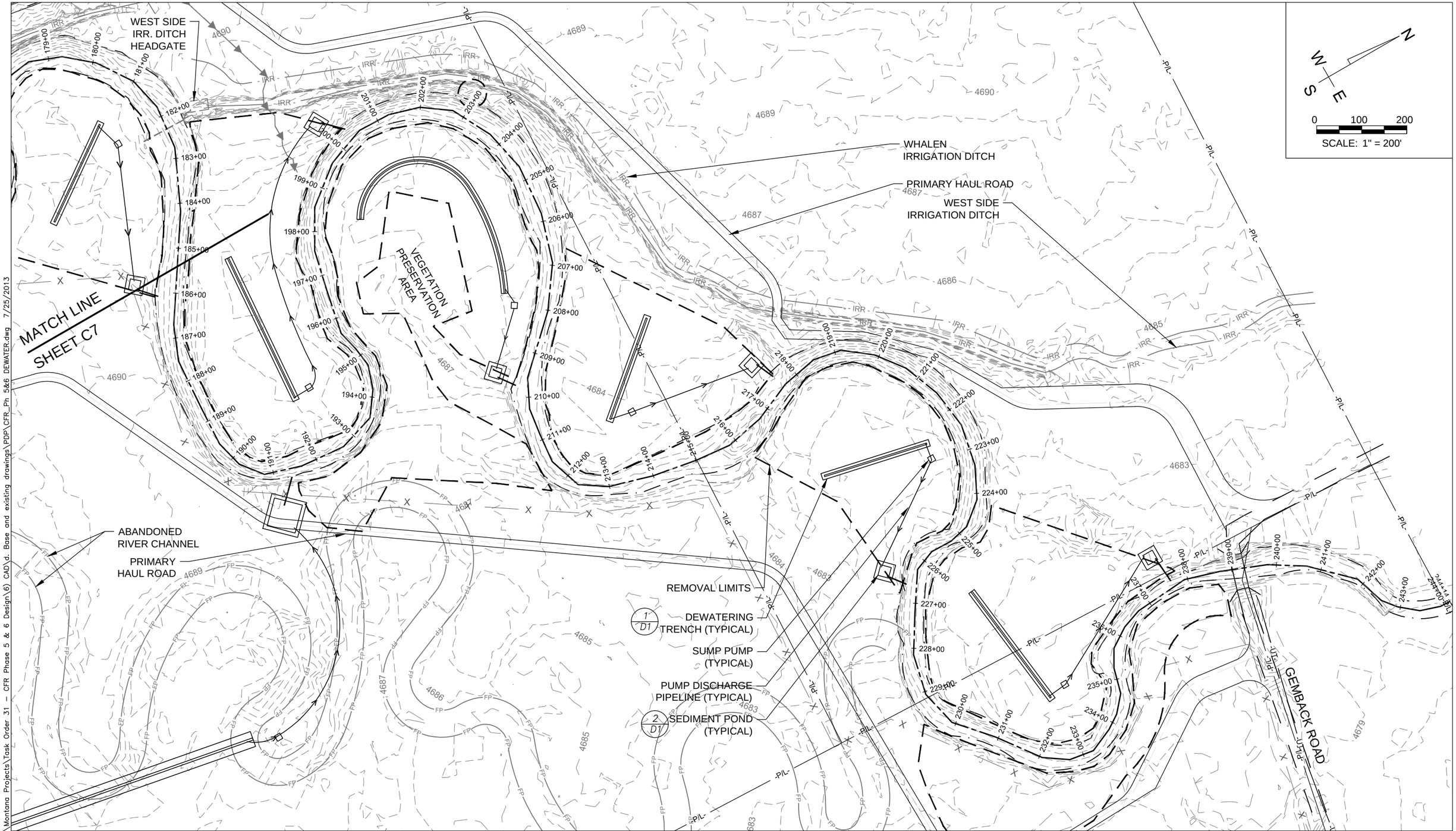

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Environmental Engineering, Inc.

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ENGINEER: M. CULPO	SCALE: AS SHOWN		
CHECKED: S. FIROR	APPROVED:	DEER LODGE, MONTANA	
DATE:	DATE:		

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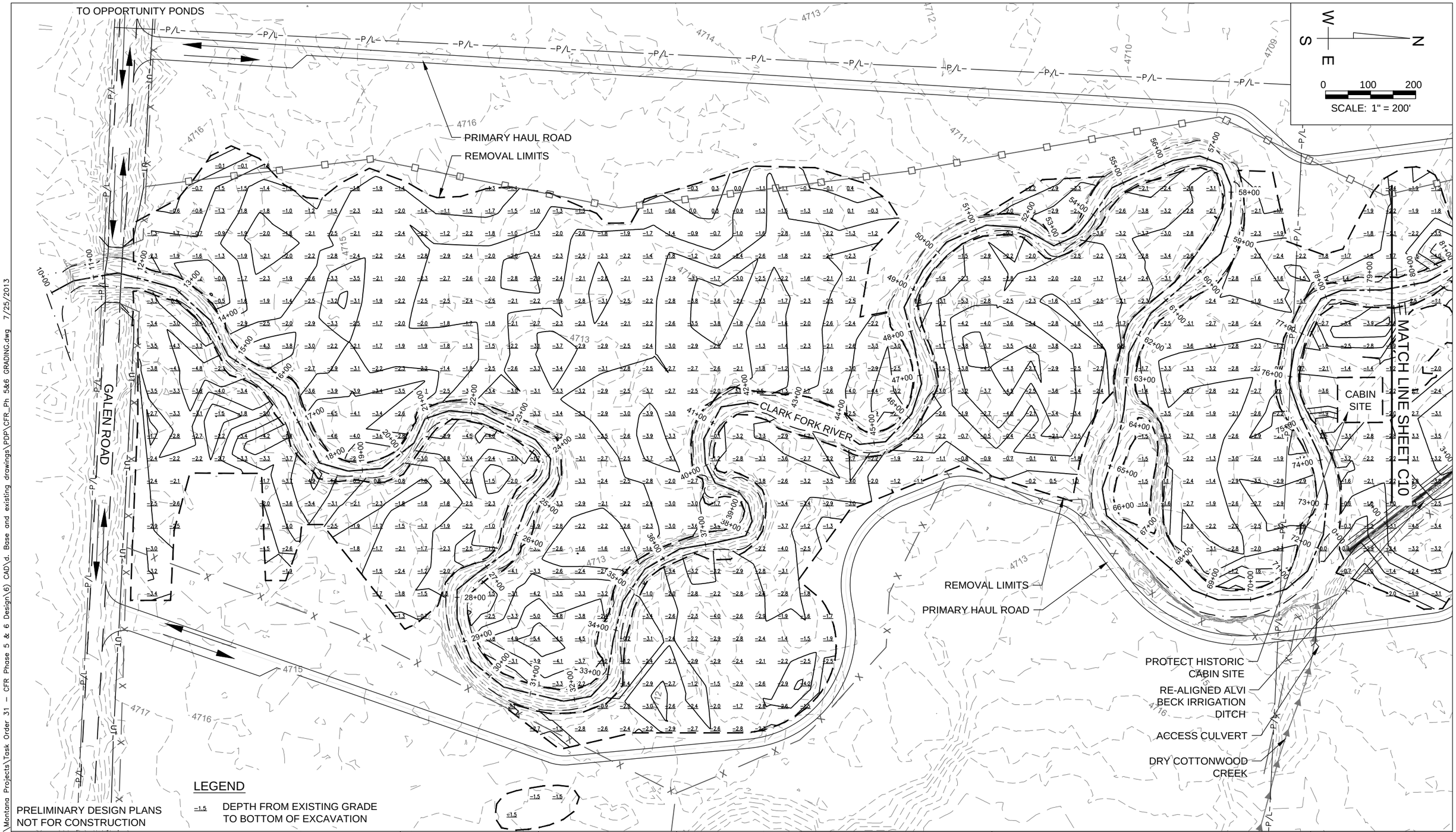

PRELIMINARY DESIGN PLANS
NOT FOR CONSTRUCTION

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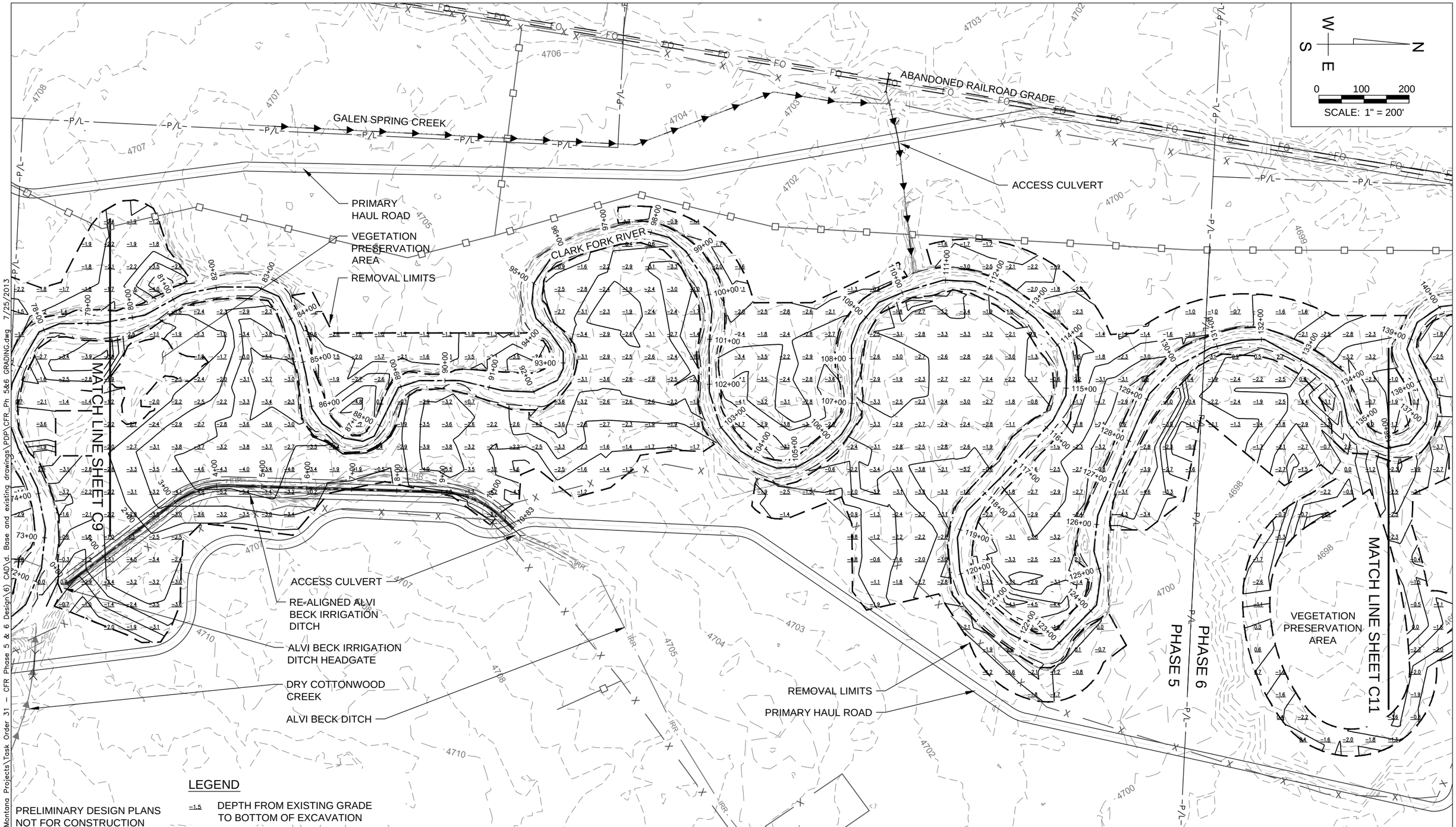
ENGINEER: M. CULPO	SCALE: AS SHOWN		PROJECT NO.: 12007
CHECKED: S. FIROR	APPROVED:	DEER LODGE, MONTANA	DATE: 7/25/2013
DATE:	DATE:		SHEET: 11 OF 23

EXCAVATION PLAN



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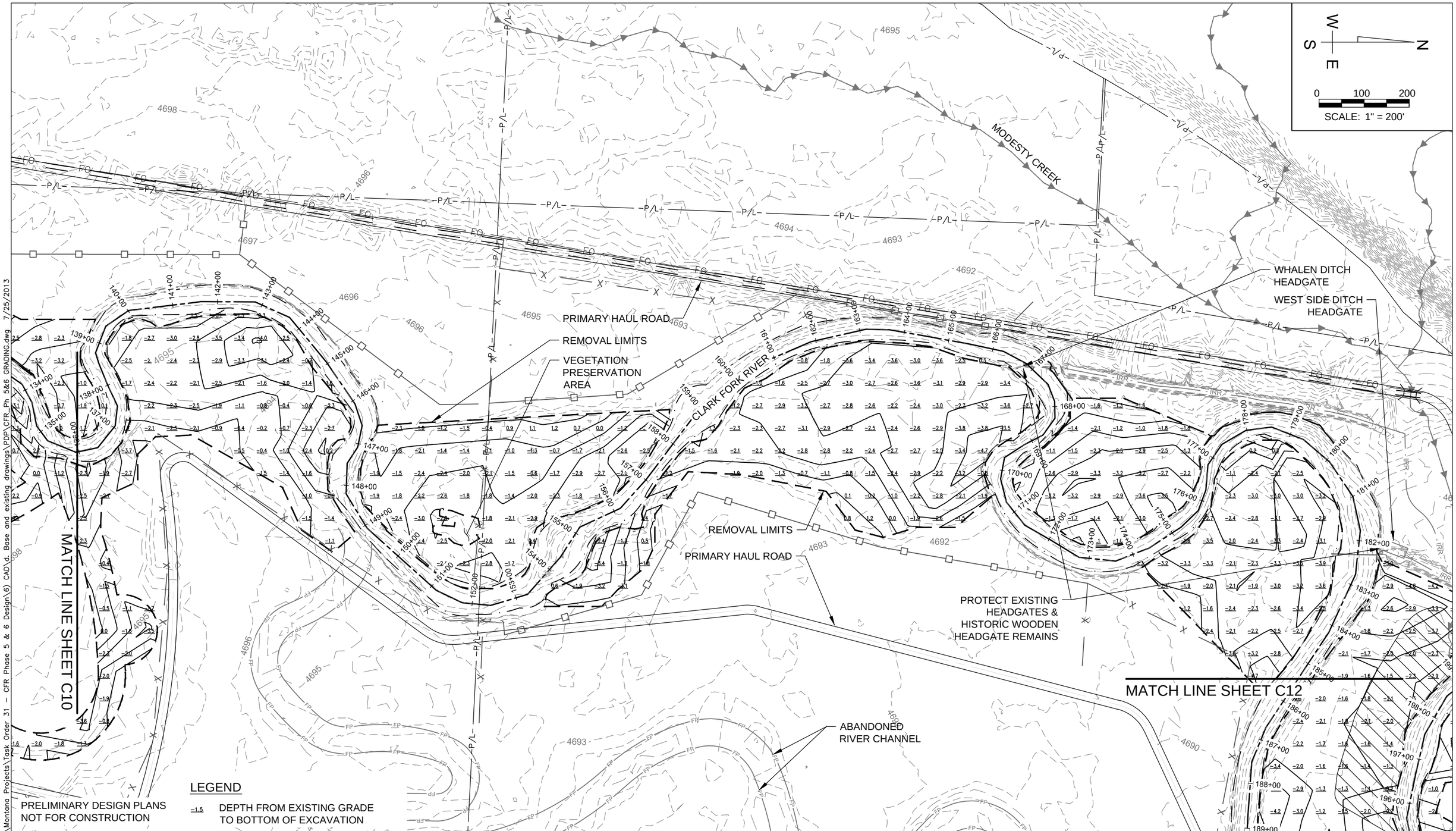
TerraGraphics Environmental Engineering, Inc.

DRAWN: G. HOGGATT	COORDINATE SYSTEM: MSP, NAD 83, INT FT	CLARK FORK RIVER OPERABLE UNIT REACH A, PHASES 5 & 6 REMEDIAL ACTION	SHEET INDEX: C10
ENGINEER: M. CULPO	SCALE: AS SHOWN		PROJECT NO.: 12007
CHECKED: S. FIROR	APPROVED:	DEER LODGE, MONTANA	DATE: 7/25/2013
DATE:	DATE:		SHEET: 12 OF 23

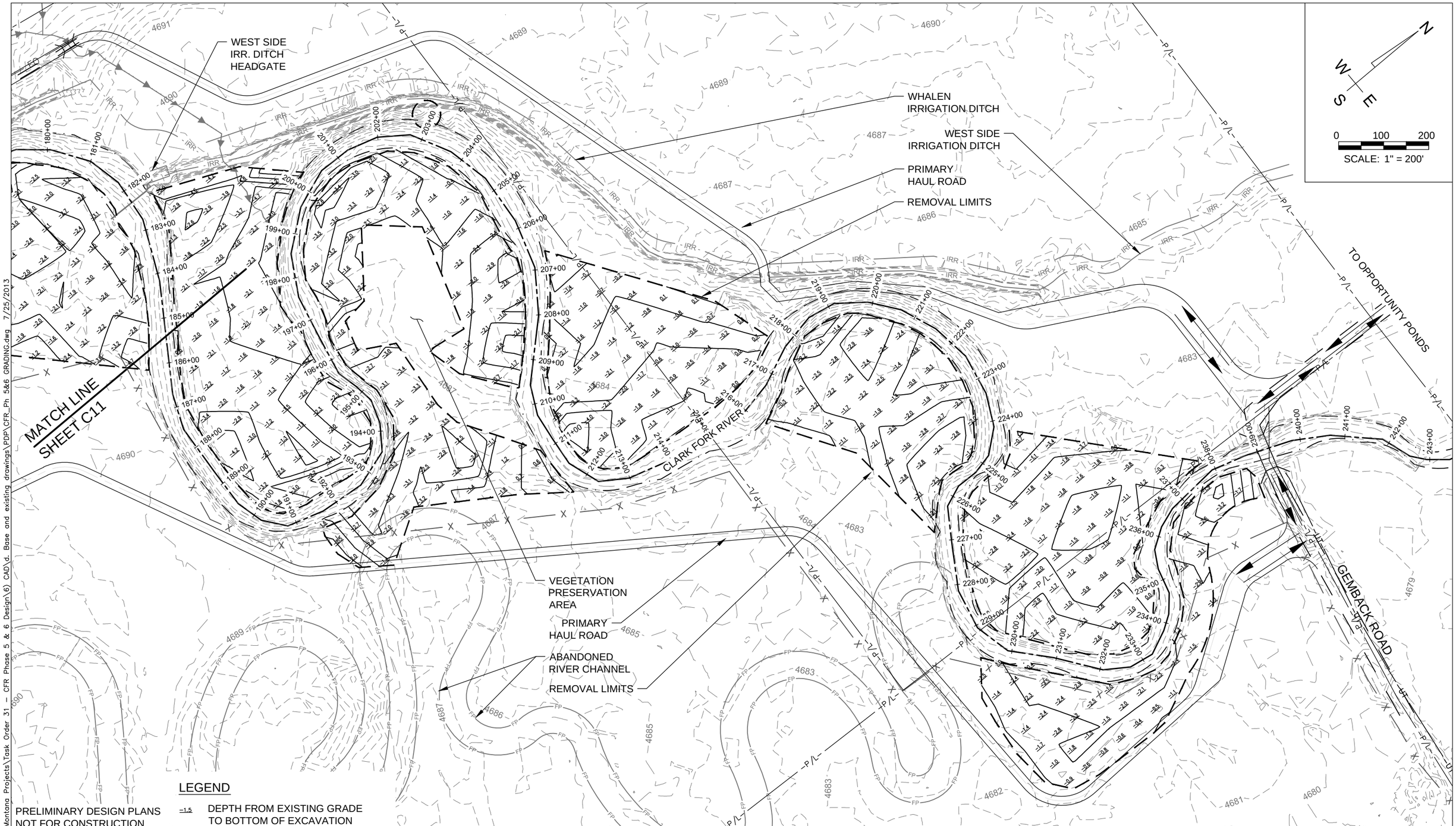
EXCAVATION PLAN



TerraGraphics Environmental Engineering, Inc.

DRAWN: G. HOGGATT	COORDINATE SYSTEM: MSP, NAD 83, INT FT	CLARK FORK RIVER OPERABLE UNIT REACH A, PHASES 5 & 6 REMEDIAL ACTION	EXCAVATION PLAN
ENGINEER: M. CULPO	SCALE: AS SHOWN		
CHECKED: S. FIROR	APPROVED:	DEER LODGE, MONTANA	
DATE:	DATE:		

SHEET INDEX:	C11
PROJECT NO.:	12007
DATE:	7/25/2013
SHEET:	13 OF 23



LEGEND

–1.5 DEPTH FROM EXISTING GRADE TO BOTTOM OF EXCAVATION

PRELIMINARY DESIGN PLANS
NOT FOR CONSTRUCTION

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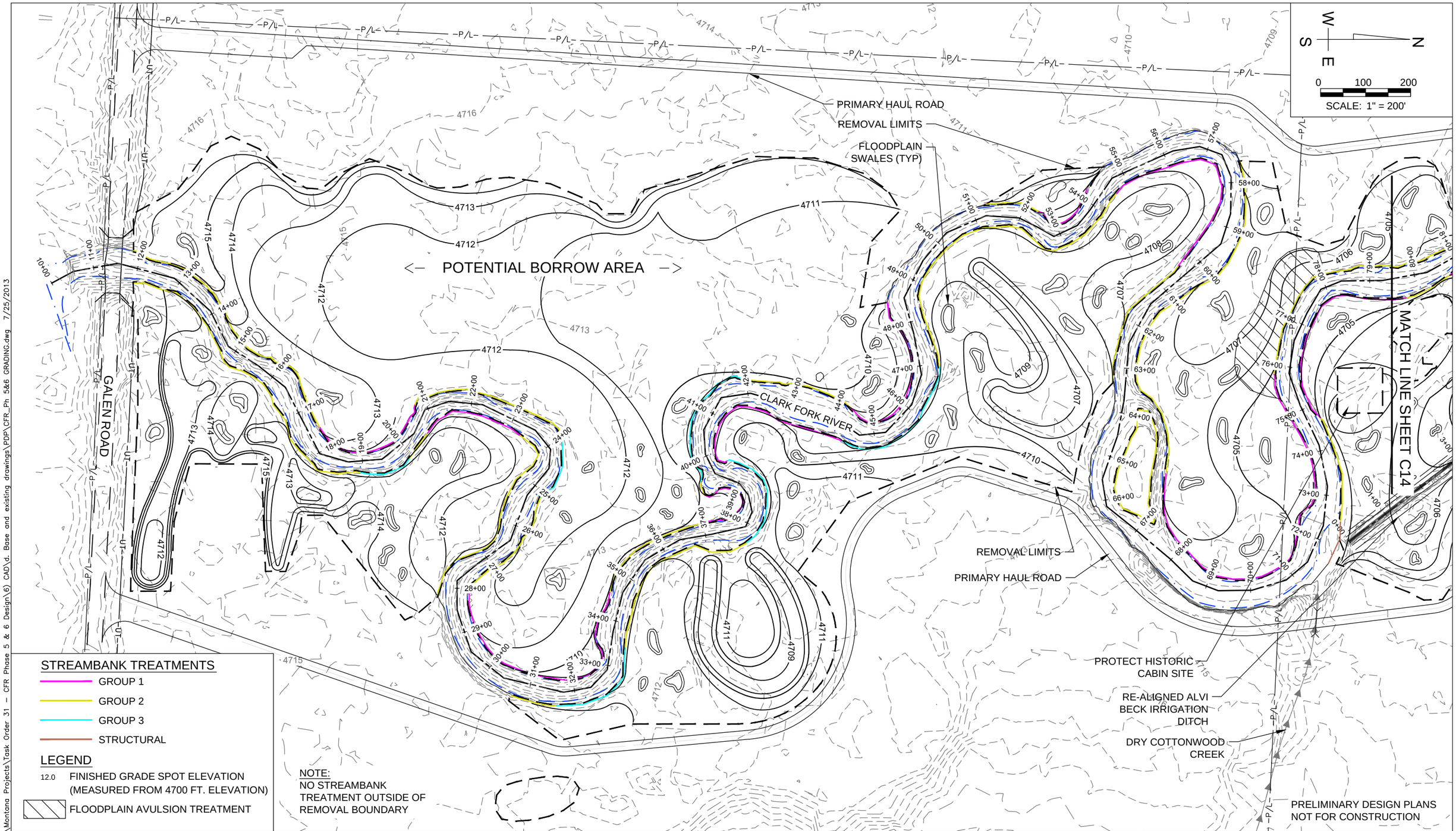
DRAWN: G. HOGGATT	COORDINATE SYSTEM: MSP, NAD 83, INT FT	CLARK FORK RIVER OPERABLE UNIT REACH A, PHASES 5 & 6 REMEDIAL ACTION	EXCAVATION PLAN
ENGINEER: M. CULPO	SCALE: AS SHOWN		
CHECKED: S. FIROR	APPROVED:	DEER LODGE, MONTANA	
DATE:	DATE:		

SHEET INDEX:	C12
PROJECT NO.:	12007
DATE:	7/25/2013
SHEET:	14 OF 23



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TerraGraphics Environmental Engineering, Inc.

DRAWN: G. HOGGATT	COORDINATE SYSTEM: MSP, NAD 83, INT FT	CLARK FORK RIVER OPERABLE UNIT REACH A, PHASES 5 & 6 REMEDIAL ACTION	GRADING AND STREAMBANK TREATMENT LOCATION PLAN
ENGINEER: M. CULPO	SCALE: AS SHOWN		
CHECKED: S. FIROR	APPROVED:	DEER LODGE, MONTANA	
DATE:	DATE:		

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PROJECT NO.:	12007
DATE:	7/25/2013
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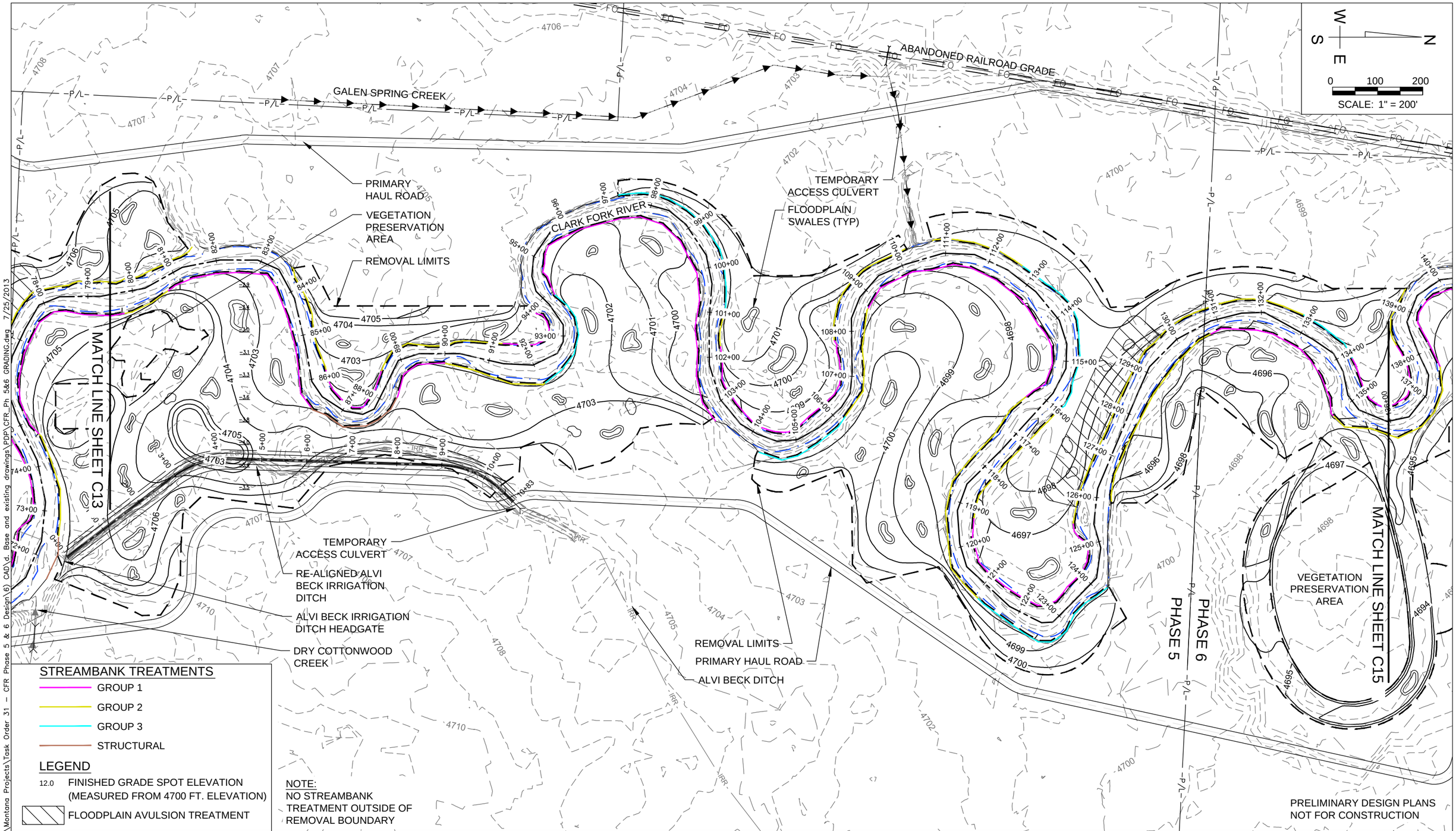

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TerraGraphics Environmental Engineering, Inc.

DRAWN: G. HOGGATT	COORDINATE SYSTEM: MSP, NAD 83, INT FT	CLARK FORK RIVER OPERABLE UNIT REACH A, PHASES 5 & 6 REMEDIAL ACTION	GRADING AND STREAMBANK TREATMENT LOCATION PLAN
ENGINEER: M. CULPO	SCALE: AS SHOWN		
CHECKED: S. FIROR	APPROVED:	DEER LODGE, MONTANA	
DATE:	DATE:		

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PROJECT NO.:	12007
DATE:	7/25/2013
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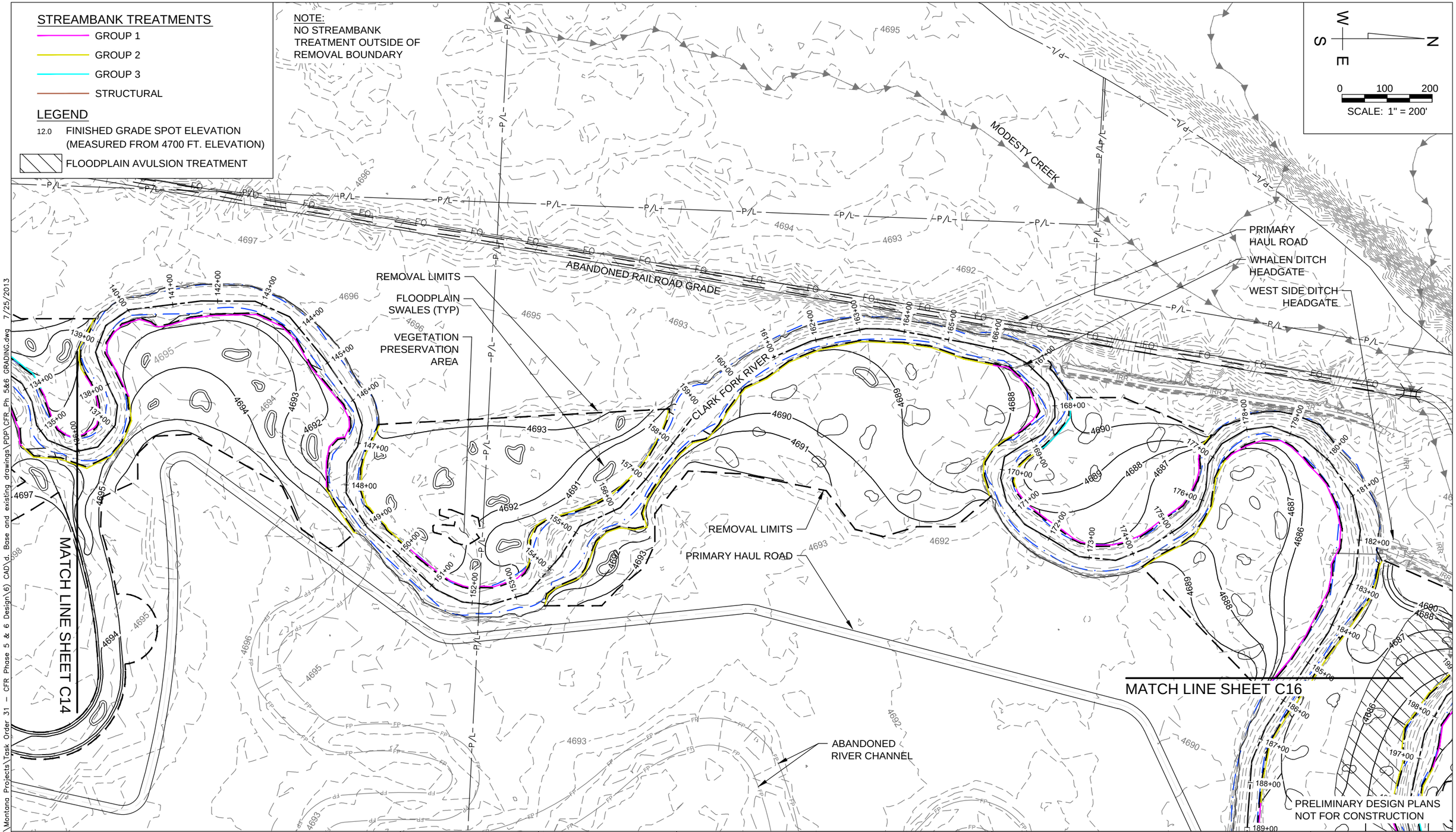

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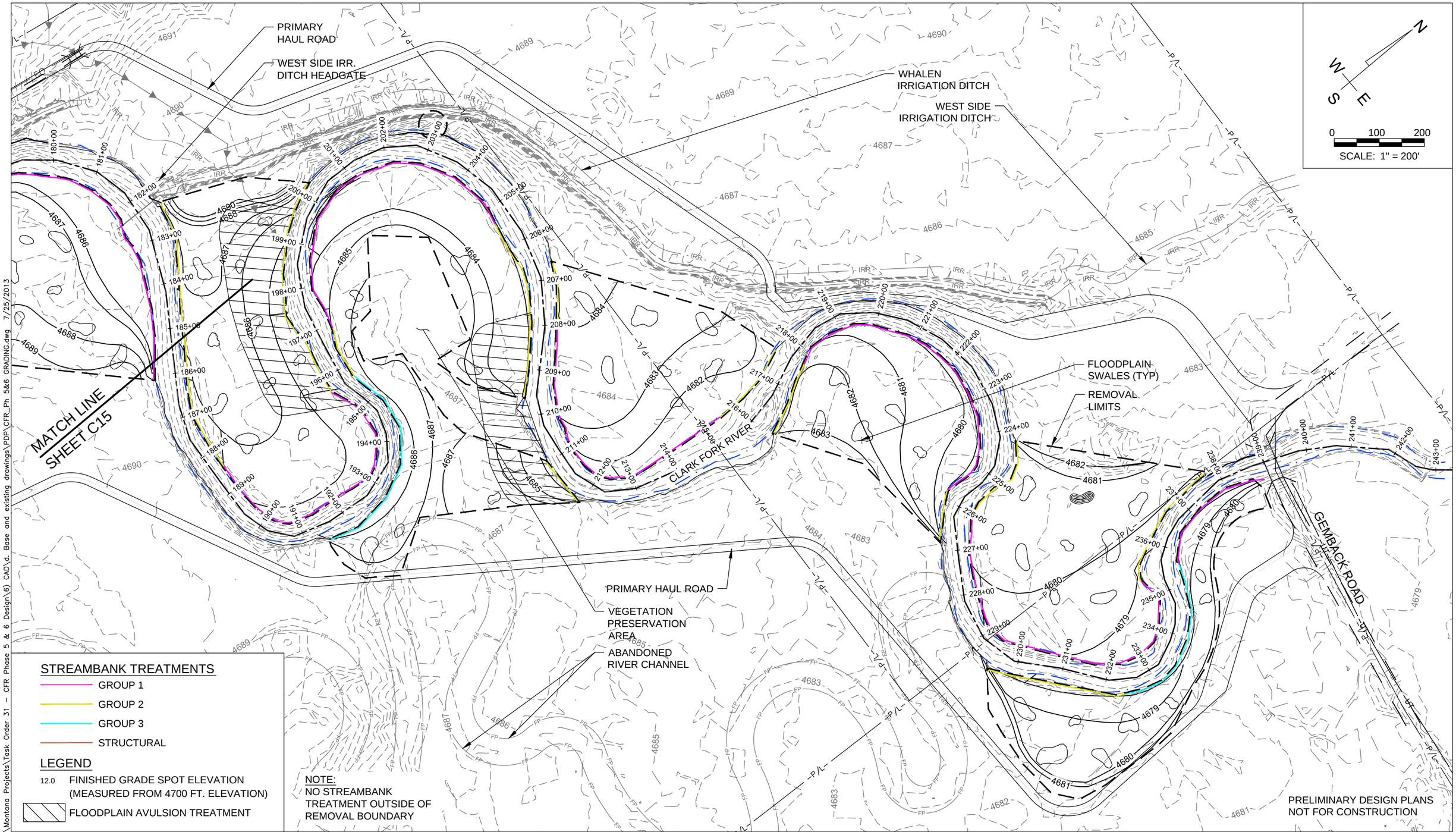
TerraGraphics Environmental Engineering, Inc.

DRAWN: G. HOGGATT	COORDINATE SYSTEM: MSP, NAD 83, INT FT	CLARK FORK RIVER OPERABLE UNIT REACH A, PHASES 5 & 6 REMEDIAL ACTION	SHEET INDEX: C15
ENGINEER: M. CULPO	SCALE: AS SHOWN		PROJECT NO.: 12007
CHECKED: S. FIROR	APPROVED:	DEER LODGE, MONTANA	DATE: 7/25/2013
DATE:	DATE:		SHEET: 17 OF 23

GRADING AND STREAMBANK TREATMENT LOCATION PLAN



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TerraGraphics Environmental Engineering, Inc.

DRAWN: G. HOGGATT	COORDINATE SYSTEM: MSP, NAD 83, INT FT	CLARK FORK RIVER OPERABLE UNIT REACH A, PHASES 5 & 6 REMEDIAL ACTION	SHEET INDEX: C16
ENGINEER: M. CULPO	SCALE: AS SHOWN		PROJECT NO.: 12007
CHECKED: S. FIROR	APPROVED:	DEER LODGE, MONTANA	DATE: 7/25/2013
DATE:	DATE:		SHEET: 18 OF 23

GRADING AND STREAMBANK TREATMENT LOCATION PLAN

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TerraGraphics
Environmental Engineering, Inc.

DRAWN: G. HOGGATT	COORDINATE SYSTEM: MSP, NAD 83, INT FT	CLARK FORK RIVER OPERABLE UNIT REACH A, PHASES 5 & 6 REMEDIAL ACTION	REVEGETATION COVER TYPES
ENGINEER: M. CULPO	SCALE: AS SHOWN		
CHECKED: S. FIROR	APPROVED:	DEER LODGE, MONTANA	
DATE:	DATE:		

SHEET INDEX:	C17
PROJECT NO.:	12007
DATE:	7/25/2013
SHEET:	19 OF 23

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TerraGraphics
Environmental Engineering, Inc.

DRAWN: G. HOGGATT	COORDINATE SYSTEM: MSP, NAD 83, INT FT	CLARK FORK RIVER OPERABLE UNIT REACH A, PHASES 5 & 6 REMEDIAL ACTION	REVEGETATION COVER TYPES
ENGINEER: M. CULPO	SCALE: AS SHOWN		
CHECKED: S. FIROR	APPROVED:	DEER LODGE, MONTANA	
DATE:	DATE:		

SHEET INDEX:	C18
PROJECT NO.:	12007
DATE:	7/25/2013
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ENGINEER: M. CULPO	SCALE: AS SHOWN		
CHECKED: S. FIROR	APPROVED:	DEER LODGE, MONTANA	
DATE:	DATE:		

SHEET INDEX:	C19
PROJECT NO.:	12007
DATE:	7/25/2013
SHEET:	21 OF 23

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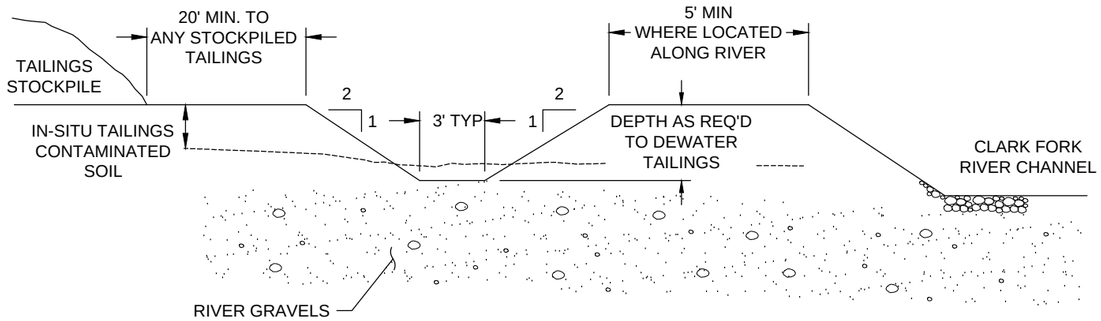
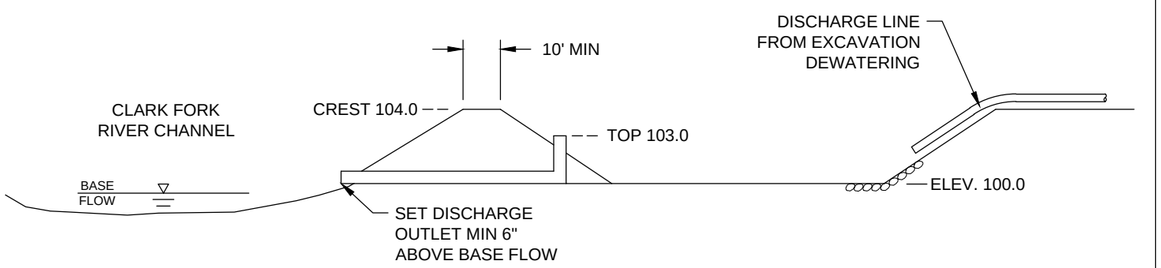
DRAWN: G. HOGGATT	COORDINATE SYSTEM: MSP, NAD 83, INT FT	CLARK FORK RIVER OPERABLE UNIT REACH A, PHASES 5 & 6 REMEDIAL ACTION	REVEGETATION COVER TYPES
ENGINEER: M. CULPO	SCALE: AS SHOWN		
CHECKED: S. FIROR	APPROVED:	DEER LODGE, MONTANA	
DATE:	DATE:		

SHEET INDEX:	C20
PROJECT NO.:	12007
DATE:	7/25/2013
SHEET:	22 OF 23

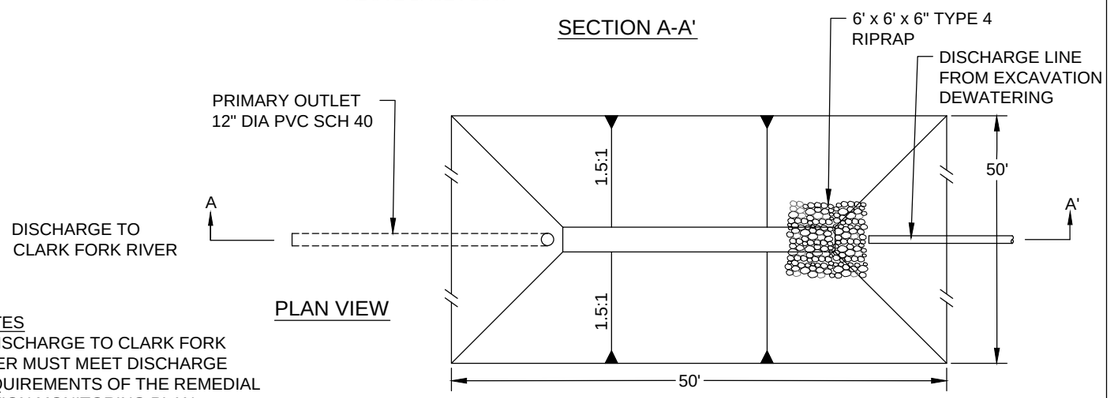
NOTES
1. SEE DEWATERING PLANS FOR APPROXIMATE HORIZONTAL LOCATIONS.
2. ANY CHANGES TO SIZE, CONFIGURATION OR LOCATION SHALL BE APPROVED BY PROJECT ENGINEER.
3. HAUL TAILINGS CONTAMINATED SOILS TO OPPORTUNITY POND REPOSITORY.
4. EXCAVATED FLOODPLAIN MATERIAL BELOW TAILINGS CONTAMINATED SOILS SHALL BE USED AS FLOODPLAIN BACKFILL.



1 — DEWATERING TRENCH SECTION - TYPICAL
NTS



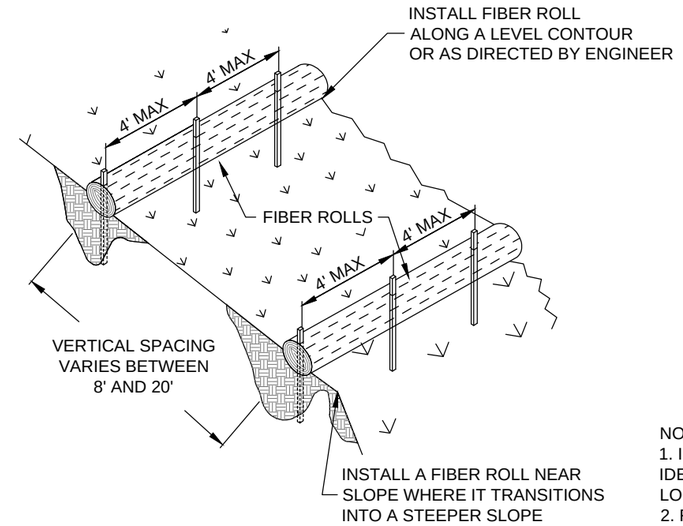
SECTION A-A'

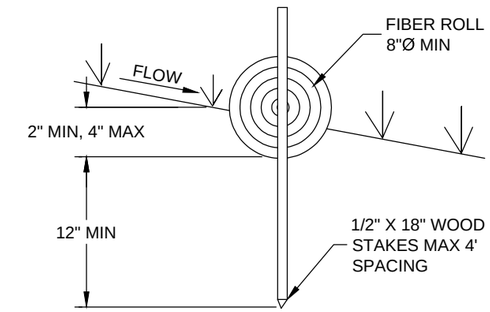


PLAN VIEW

NOTES
1. DISCHARGE TO CLARK FORK RIVER MUST MEET DISCHARGE REQUIREMENTS OF THE REMEDIAL ACTION MONITORING PLAN.
2. MIN. BASIN SIZE 50' x 50' x 4' DEEP OR AS REQUIRED TO MEET DISCHARGE REQUIREMENTS.

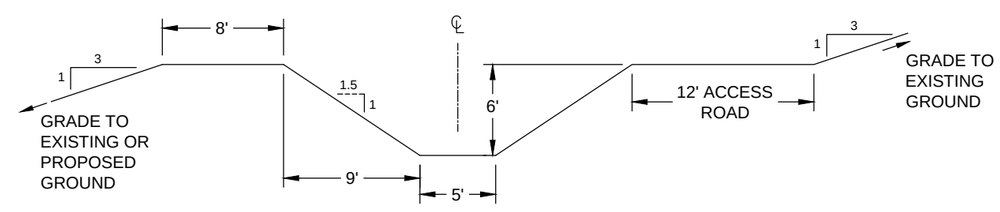
2 — SEDIMENTATION/INFILTRATION BASIN TYPICAL
NTS





NOTES:
1. INSTALL IN LOCATIONS AS SHOWN ON DRAWINGS, AS IDENTIFIED IN SITE-SPECIFIC EROSION CONTROL PLAN AND AT LOCATIONS REQUESTED BY ENGINEER.
2. REMOVE FIBER ROLL ONLY WHEN APPROVED BY ENGINEER.
3. REMOVE AND RESET FIBER ROLL AS NECESSARY TO PREVENT SEDIMENT RUNOFF FROM THE SITE DURING EXCAVATION AND BACKFILLING OR AS REQUESTED BY ENGINEER.

3 — FIBER ROLL DETAILS
NTS



4 — ALVI BECK IRRIGATION DITCH SECTION
SCALE ~ 1" = 10'

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TerraGraphics Environmental Engineering, Inc.	DRAWN: G. HOGGATT	COORDINATE SYSTEM: MSP, NAD 83, INT FT	CLARK FORK RIVER OPERABLE UNIT REACH A, PHASES 5 & 6 REMEDIAL ACTION	DETAILS	SHEET INDEX: D1
	ENGINEER: M. CULPO	SCALE: AS SHOWN			PROJECT NO.: 12007
	CHECKED: S. FIROR	APPROVED:	DEER LODGE, MONTANA		DATE: 7/25/2013
	DATE:	DATE:			SHEET: 23 OF 23