Memorandum

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Subject: *Clark Fork River Reach A Design Approach*

Introduction

The purpose of this memorandum is to document the design approach that has evolved based on this Design Team (CDM Smith, Applied Geomorphology, Inc. and Geum Environmental Consulting, Inc.) collaboratively completing designs for several Phases of the remedial action along the Clark Fork River since 2010. The remedial action is being conducted by the Montana Department of Environmental Quality (DEQ) and the Natural Resource Damage Program (NRDP) of the Montana Department of Justice. This design approach memorandum is necessary for several reasons:

- Phase 5-6 followed a different design approach which led to fatal flaws in the design, resulting in increased project costs and a need to redesign the project. The Phase 5-6 experience exposed the need for more rigorous QA/QC protocols and peer review during the engineering design process.

- Multiple engineering firms are working on the Clark Fork River remediation and restoration, and documenting successful design methodologies and how design methodologies have evolved over the last several years can help the design team(s) avoid unnecessary learning curves, filter out inappropriate and inadequate methodologies, and ultimately save costs.

- As new engineering firms are hired to work on the Clark Fork River, this document can serve as a road map to help them develop Scopes of Work and assign appropriate resources to the project.

- Because project phases are connected, and all are part of the same river, a consistent design approach will result in a continuous project that consistently supports remedial action objectives and related restoration goals.

- The design process presented herein has been accepted by federal and state agencies involved in the work.

Pre-Design Activities

DEQ selects project Phases based on access, priority of the Phase based on the ROD and other agency coordination, and in priority order from upstream to downstream.

DEQ selects a design team which typically includes one or more engineering firms, a geomorphologist and a revegetation consultant. To help achieve continuity and consistency, the geomorphologist and revegetation consultant are common among several Phases and work as a team with different engineering firms.

The **Revegetation Consultant** assists DEQ to coordinate procurement of nursery grown plants with contracted growers approximately 2 years in advance of the design process to ensure that the necessary plant materials are available for each project phase. Either early design layouts or estimated project acreages are used to develop plant orders.

The **Revegetation Consultant** maintains an inventory of willow cutting collection sources to ensure that willows will be available for streambank construction in each project phase.

The **Engineer** develops a Sampling and Analysis Plan (SAP) for each phase to guide the determination of the extent of contamination. This plan is submitted to DEQ and EPA for approval.

Investigations

Test Pit Investigation:

The **Engineer** excavates test pits on a 125 ft. by 125 ft. grid based on the extent of the available RIPES boundary. The boundary may be extended during sampling to capture the extents of contamination (i.e. sampling continues beyond the RIPES boundary if contamination levels that meet the removal criteria are found). Additional test pits on point bars, old channels and unique features like old oxbows, islands, etc. are added to the investigation. The grid can be modified based on observations made during sampling and other available data.

The test pit investigation is conducted as described in the SAP. During the investigation, enough data is collected to determine the horizontal and vertical extent of contamination based on the removal criteria (see below for removal criteria used in Phases 3 and 4). The test pit locations are staked and existing ground elevations for each test pit are surveyed by the **DEQ** contracted **Surveyors**.

Contamination Analysis and Tailings Removal Criteria:

A worksheet is created that shows the northing/easting and depth of each pit and the depth of contamination based on the removal criteria. The criteria used in Phases 3 and 4 and described in the Phases 3 and 4 PDP are presented below.

Tailings/impacted soil will be removed under the following conditions:

1. Arsenic levels exceed the human health standard in the surface interval (620 ppm).

2. The sum of Contaminants of Concern (COCs) (As, Cd, Cu, Pb, Zn) exceeds 1,400 mg/kg (parts per million) and any of the following:

- The lowest contaminated interval of metals is deeper than 24 inches,
- The contamination lies within the Channel Migration Zone (CMZ, described below) regardless of depth,
- Arsenic exceeds the human health standard at the surface (620 ppm) and the sum of COCs exceeds 1,400 mg/kg at an interval shallower than 24 inches, or
- In areas where floodplain connectivity is desired, the removal surface is lower than the floodplain connectivity elevation.

3. Limited areas outside the CMZ where contaminated material is shallower than 24 inches but that are contiguous to removal areas for construction efficiency.

4. Areas of uncommon native vegetation may be preserved and contamination left in place.

Channel Migration Zone (CMZ) Delineation:

A 100-year CMZ is developed for each phase based on measured historic migration rates. The 90th percentile, 100-year migration distance is applied as an erosion buffer to each bankline; these values are listed in Table 2-6 of the Reach A Geomorphology and Hydrology Report (CDM Smith and AGI, 2013). Additional areas prone to avulsion (typically meander cores), are delineated and included in the CMZ to develop a meander corridor that shows demonstrable potential for sediment recruitment over the next century.

Determination of Overexcavation:

Each test pit is evaluated to determine if an additional 6 inches should be removed or feature lines should be added to the Bottom of Excavation (BOE) surface.

1. If the next depth interval result of the test is >1,000 ppm, assume there is a reasonable amount of variability that the test pit depth could be lowered 6 inches.

2. If the surrounding test pits are at a lower elevation. For example, the test pits around the test pit to be evaluated are 24 inches but the test pit being evacuated is 6-12 inches at 6,000 ppm and the lower one (12-18) is 1,000 ppm. The depth should be lowered to 18-inches. Also look at the XRF data to see what the readings were to get an idea if the concentration at the higher interval might be an anomaly.

3. If the test pit sample depth is 18-24 inches at 1,450 ppm and the next deeper sample is 300 ppm, the excavation depth could be terminated at 24 inches.

Other considerations that can modify the depth of contamination/BOE are:

1. Look at the existing topography and identify any old oxbows, channels, point bars and other distinct features. Evaluate the test pit depths within the features and surrounding the features. For example, there are two test pits in the bottom of the old oxbow at 48 inches, the surrounding test pits depths are 12 inches. We could assume that the contamination depth in the oxbow is 48 inches and the contamination depth in the banks of the old oxbow

are only 12 inches. By adding a feature line at the top of the bank and the bottom of the oxbow and assigning elevations that are 48 inches and 12 inches below existing ground, respectively, the interpolated depths will be a lot more representative of actual conditions than if the interpolation is performed between the 12-inch test pits and the 48-inch test pits. This procedure was done in Phase 2 – Work Area A, and the old channel was contaminated as expected but was in fact still contaminated somewhat deeper. So, lowering the test pits in the bottom of the old channel another 6 inches might be appropriate. XRF data can also be very helpful in the evaluation.

2. Evaluate the point bar test pits. We have seen that in Phases 1 and 2 the contamination was considerably deeper in the test pits within the point bars and higher than predicted on the adjacent floodplain side of the test pits. Adding feature lines around the point bars on the river and adjacent floodplain side and assigning the point bar test pit elevation to the depth of contamination within the point bar polygon will account for the deep pockets of contamination. We have also seen that contamination in the upstream end of point bars was deeper than in the downstream area of the point bars. This might be due to the migration pattern of the channel.

3. Add feature lines in the river and lower them to the depth of contamination elevation of the test pits next to the river. If this is not done and the points are interpolated across the river, the elevations seem to be skewed to the elevation of the opposite bank test pit. In the field it appears that contamination on one side of the river is independent from the opposite side.

Once the spreadsheet of BOE depths is reviewed internally, maps are prepared with the topography/aerial photography and test pit information. A draft contamination boundary is added to the maps based on the removal criteria described above (or specific for the phase being investigated).

Existing Conditions Hydrology/Hydraulics Investigation:

Hydrology:

The hydrology investigation is performed by the **Engineer.** The 2-year and 10-year peak annual flows need to be determined based on available data and compared to previous analyses. There is good information on these more frequent peak flows from the USGS gages at Galen and Deer Lodge and a short period of record for the Clark Fork just above the Little Blackfoot River. There is also gage information on some tributaries (Racetrack Creek, Lost Creek) as well as historic data on Cottonwood Creek. This information was analyzed in the *Geomorphology and Hydrology of Reach A* (CDM Smith and AGI, 2013). If tributaries entering the phases are being modeled, these flows need to be evaluated to determine if mainstem flows should be remain the same throughout the model or if the flows need to be adjusted. For example, in Phases 3 and 4, the flows were increased downstream from the confluence of the CFR with Lost Creek.

Existing Conditions HEC-RAS Model:

The HEC-RAS modeling is also performed by the **Engineer.** As part of the field investigations, river cross sections are identified in the field, surveyed and used to build the HEC-RAS models for the 2-year flow existing condition. Because the 2-year water elevation typically stays within the channel, the model uses the surveyed cross-sections to build the 2-year flow model and no additional LiDAR data is needed. Sections are surveyed to capture major changes in channel geometry including narrow sections and wide section and pools and riffles. Other features require additional sections such as bridges and junctions and split flows. Initially it was thought that a 200-spacing on sections would be adequate, but, given the typical complexity of the river, the average spacing on recent surveys has been about 100 feet. The surveyed section should include top of bank because the LiDAR mapping often does not map the banks with precision.

For Phases 15 and 16, the river bed was mapped using a boat equipped with sonar and GPS. This is a very efficient method of data collection but bank heights (if not well defined by LiDAR) will need to be surveyed separately. The river bottom surface can then be incorporated into the LiDAR mapping and cross sections can be cut efficiently without the need for spicing sections in.

The first run of the Existing Conditions 2-year model usually can be accomplished with just the surveyed cross sections and no LiDAR data is needed because banks tend to be higher than the 2-year flow. The model is then evaluated and, if additional data is needed, it is collected and added to the model. The model is reviewed internally and revised as needed. Then the model is expanded to include the entire floodplain by extending the cross-sections using the Existing Conditions surface (EG) created from LiDAR data and run for the 10-year recurrence flow. If there are infrastructure concerns, the model may also be expanded to calculate the 50-year or 100-year return floods. These conditions are reviewed for areas of high velocity, shear stress and supercritical flow that may be concerns in the design. To improve understanding of river function, the stream is broken into sub reaches of similar hydraulic conditions to evaluate average conditions through these sub reaches. Inundation maps are developed for 2-year and 10-year flows to document existing out of bank flows. A memorandum is prepared with discussion of results, appended model outputs, and maps showing cross section locations and inundation for the 2-year and 10-year flows.

Existing Conditions Geomorphology Investigation:

The geomorphic investigation is performed by the contracted **Geomorphologist.** The geomorphology of each phase is summarized for the Preliminary Design Plan (PDP) using existing data previously compiled in the report *Geomorphology and Hydrology of Reach A* (CDM Smith and AGI, 2013) supplemented with original field data collection and analysis. The field investigation includes an evaluation of geomorphic surfaces and geologic controls in the reach, the collection of a series of pebble counts in riffles to capture general bed substrate conditions, an erosion inventory, and an inventory of residual pool depths to support post-construction monitoring. Typical information summarized may include channel slope, meander patterns and radius of curvature, bank erosion rates and patterns, typical channel morphology derived from the HEC-RAS cross sections or model output, and any other aspects of geomorphology that may provide context or assist in the design. For example, historic planform changes such as cutoffs should be documented, and any areas of rapid channel evolution should be identified. The geomorphology summary typically includes the discussion of floodplain access under existing conditions based on HEC-RAS 2-year discharge modeling results.

Existing Conditions Vegetation Investigation:

The **Revegetation Consultant** completes the vegetation investigation. The purpose of the vegetation investigation is to document existing conditions in each project phase and identify unique vegetation communities. The vegetation investigation includes mapping vegetation communities and assigning specific attributes to each vegetation community. Vegetation community mapping is typically done after the test pit investigation has been completed by the **Engineer**. Vegetation communities are mapped to the extents of the test pit investigation, or further where appropriate. Vegetation mapping is done during the growing season in order to identify distinguishing plant species. Detailed methods on vegetation community mapping are currently being developed (Geum, 2016).

Vegetation communities are initially mapped in GIS using aerial photographs and LiDAR data. Mapped communities are then verified in the field. Vegetation community boundaries are then finalized in GIS based on field verified boundaries.

Two primary analyses are done using the vegetation community mapping including determining the average and range of depths of contamination in each vegetation community and determining the average and range of ground elevations relative to river hydrology in each vegetation community. The latter analysis evaluates vegetation community elevation relative to the 2-year return flow water surface elevation. These analyses are typically done during development of the Preliminary Design Plan when the Existing Conditions HEC-RAS Model, draft final grading surface, test pit investigation results, and Proposed Conditions HEC-RAS Model become available. This information is needed to complete the vegetation analysis.

To evaluate vegetation communities in relation to contamination depths, a surface is created using the soil pit data delivered by the **Engineer**, and statistics are generated in ArcGIS that provide a minimum, maximum and average contamination depth for each vegetation community.

To determine vegetation communities in relation to the 2-year water surface elevation (WSE), an existing ground surface created by the **Engineer** is used, if resolution is sufficient. If resolution has been degraded to make AutoCAD analysis feasible, an existing ground surface is created from LiDAR data provided by DEQ, in addition to ground survey data if it is available. The original LiDAR data (xyz format) is processed using tools in ArcGIS to create a terrain data set. This results in files that retain the original resolution of the xyz file. Next, a 2-year WSE surface is created using HEC-RAS cross sections provided by the **Engineer**. These cross section elevations are used to generate a raster within the channel margins, and then extrapolated out into the floodplain as points that are located based on topography. The 2-year WSE surface is developed using tin-interpolation which is then converted to a raster. The existing ground surface is then subtracted from the 2-year WSE surface, generating a surface displaying existing ground elevation relative to the 2-year WSE. This Relative Elevation Model (REM) is usually presented as a color ramp, and it is used in various steps of the revegetation design process.

Based on recent conversations, the vegetation community data will be used to determine the extent of woody vegetation in each project phase to be used as a target for replacing woody vegetation cover in the design process. Criteria for determining a replacement proportion are being developed.

Design

Design Team Meeting:

Typically, after the test pit, hydrology, hydraulics, geomorphology, and vegetation investigations are complete, a design team meeting is held to develop the proposed contamination removal boundary and evaluate the BOE surface. Each discipline brings their investigation results and this information is used to help establish the removal boundary extents. During the meeting, the team discusses any features like old channels, oxbows, or secondary channels that should be preserved or rebuilt. Potential restoration opportunities may also be identified and discussed. Any channel realignment or necessary structures should be discussed. At this time, areas are identified where floodplain connectivity can be increased through additional removals. Results of vegetation mapping are used to identify unique areas that may need to be preserved, or land uses that must continue post-remediation.

BOE Surface:

Once the Design Team agrees with the contamination removal boundary, the Draft BOE surface is built in AutoCAD. The Existing Ground Surface (EG) elevation at the contamination boundary and bank lines are added as feature lines to the surface and sloped at a 1:1 to the depth of contamination.

The Draft BOE is then compared to the EG that was created from the bare points provided by the LiDAR Company. We keep the EG in tiles or combination of tiles due to their smaller size and ease to work with. Algorithms could be used to reduce the file size, but it appears that a lot of the resolution is lost especially next to the river. We also add the bank feature lines created by the **Surveyor** to account for the movement of banks since the LiDAR points were taken.

The comparison/volume surface is then assigned colors for cut and fill to determine if any of the BOE surface is higher than the EG. Those areas are further evaluated to make sure no features were missed.

The approximate removal volume is also calculated for planning purposes. For example, the large volume of tailings removal led to the splitting of Phases 3 and 4 into Phase 3A, Phase 3B and a redefined Phase 4.

Once the Draft BOE is completed, an internal review is conducted to make sure that the test pit data is consistent with the BOE surface.

The design team(s) are currently having discussions about how to develop a consistent method for a bottom of tailings surface using AutoCAD and/or GIS that can be used to analyze average thickness of tailings in vegetation communities as part of the vegetation investigation, and to calculate a BOE that provides the most accurate estimate possible of material to be removed. Currently, the **Revegetation Consultant** develops a bottom of tailings surface by first creating a tin-interpolated volume surface using depth of tailings as the z-value. This "tailings thickness" surface is subtracted from the existing ground surface to estimate a bottom of tailings surface. There may be some advantages to combining these methods with AutoCAD methods described above.

Preliminary Landowner Plans:

After a proposed removal boundary has been developed, an initial meeting with landowners and members of the design team typically occurs to present the findings to the landowner, ask questions about existing land uses, and solicit input and information relative to design elements. Existing land uses within the removal boundary and the potential for borrow source development are typically important topics at these meetings. The **Revegetation Consultant's** role in these meetings is typically to describe the approach to revegetating the areas and gather information to group mapped vegetation communities into land use cover types (groupings of vegetation communities where similar revegetation treatments can be applied to meet the long-term land use goals for a given area).

Landowner plans are developed by the **Engineer** with input from other members of the design team and typically include: a site map, excavation extents and depth with test pit depths, land use with depth of vegetated backfill and microtopography, proposed new fence locations, potential borrow source investigation areas, and anticipated areas of inundation at a 2-year flood event, and conceptual revegetation by land use cover type. For each cover type, initial revegetation treatment criteria are provided in addition to examples of where floodplain features might be located, planting locations, and floodplain woody debris placement areas. Floodplain elevations, revegetation treatments and potential plant species are often the issues that land owners are most interested in as they will affect the ultimate appearance of the site and future land uses. In some cases, the need to reclaim land for agricultural purposes may be an over-riding criteria that arises from discussions with a landowner, and this can be an important driver for design.

Field Visit – Preliminary Bank Treatments:

A field visit is conducted with the Design Team to determine the preliminary bank treatments and specifically locate point bars, lateral bars, secondary channels and any other features that could influence the hydraulics of the channel. Toe conditions are also evaluated if possible as part of the initial investigation. Toe conditions are evaluated in terms of the potential to preserve the native bank toe in any bank treatment. This assessment can be facilitated by having field maps that show historic bankline migration rates. Resource grade GPS coordinates are taken in the field.

A map with the preliminary bank treatments is prepared and reviewed by the Design Team. After additional evaluation with the Proposed Conditions HEC-RAS model, this map is included in the PDP.

Draft Final Grading Surface (FG)/Proposed Conditions HEC-RAS Model:

With the information collected during the site visit on bank treatments, secondary channels and any other features (bridges-culvert) and the HEC-RAS Existing Condition 2-year WSE, the bank feature lines are modified to the expected 2-year WSE at each cross section. The bank feature lines are interpolated at a constant slope from one cross section to the next. Point bars, lateral bars, any secondary channels, and oxbows are added to the Draft FG surface. Feature lines are added at the point bars at the location identified in the field and graded to slopes around 20:1 or shallower, if possible. Lateral bars are also added to the surface. These lines form the basis of the Draft FG. Avulsion paths are determined by the **Geomorphologist** and added to the surface. The **Revegetation Consultant** provides criteria and conceptual locations for wetlands, oxbow features, swales, preservation areas, and areas where a specific land use will occur. The outside bank elevations are raised by 6-inches throughout the avulsion paths, and the elevations transition for approximately 100 to 150 feet upstream or downstream of the avulsion path to tie into 2-year flow bank elevations.

Avulsion paths are determined by the **Geomorphologist**, by comparing avulsion route slopes to existing channel slopes. Where that ratio (Sa/Sc) exceeds 5.0, avulsion risk is considered high and these paths are treated as a defined avulsion path. Ratios of 3-5 are considered moderate and are assessed more site-specifically in terms of overall slope values and implications of a cutoff. For example, if a cutoff would abandon an irrigation diversion, the moderate risk path may be included as a risk in the grading plan.

The surveyed cross sections are modified in the HEC-RAS model to the 2-year WSE (except at the upstream ends of the avulsion paths where they are 6-inches higher) and point bars and lateral bars are added to those cross sections where they will be constructed. The model is run to determine if any of the existing conditions 2-year WSE change once these features are added. Typically, we have seen that the upstream and downstream cross section elevations of the 2-year flow near point bars/lateral bars changes slightly. The same is true for any added secondary channels or oxbows that are activated at flows less than 2-year WSE. The bank elevations are adjusted in the proposed model until the bank elevations and the 2-year WSE are the same or within ~0.1 ft. This procedure will have to be repeated if any of the features are modified that could impact the hydraulics of the system.

Once the proposed conditions HEC-RAS model is finalized and reviewed internally, the bank feature lines in the draft FG surface are revised to reflect any changes in the model's water elevations. The bank feature lines are then offset by 10 feet and raised at a 2 percent slope (sloping towards the channel). Depending on the topography and tie-in elevations, the floodplain is graded at 0.3 to 0.5 percent towards the outside design boundary. Any special features are designed and added to the surface.

Special attention is paid to grading within the avulsion paths. The risk of high flows activating these pathways is reduced by constructing higher ground over the meander tab. In addition to the 2 percent slope mentioned previously, for the upstream end of avulsion paths there is a further raise in finished grade within the next 20-50 feet, a distance which depends on the length of the avulsion path. This ground is raised by another 0.3 feet. This high point on the avulsion path is typically one foot higher (bank height raise 0.5 ft. + 10 ft. offset raise 0.2 ft. + meander tab raise of 0.3 ft.) than the 2-year WSE at the upstream end of the avulsion path. The downgradient slope of the avulsion path should not exceed 3 percent if possible. The **Geomorphologist** is involved closely in this process to make sure the velocities across the downgradient slopes are not too high at the 10-year flow to avoid erosion of the larger grain sizes of the Type A material (a mixture of alluvium and vegetated backfill material that has recently been specified for some higher risk avulsion paths) during out of bank events. The avulsion path slopes, expected velocities, and particle size that is expected to move are documented in a table. It might take a few iterations to arrive at a solution and on tight meander bends not all criteria can be satisfied.

The outside boundary of the FG is added to the model and sloped towards the floodplain at a 4:1 slope. The surface is then cleaned up and reviewed by the Design Team. Any comments/revisions are addressed by modifying the surface before the surface is used to cut cross sections for the Proposed Conditions model.

The runs of the 2-year flow and 10-year flow (and higher flows if required) model are reviewed for areas of high shear stress or velocity, supercritical flow conditions, changes in split flows, and any other potential for increases risk of instabilities in the channel and floodplain. Comparisons are made with the existing conditions. Any issues are addressed and the model is revised until the floodplain meets the requirements of the Design Team, clients, and landowners. An inundation map for the proposed conditions 2-year flow and 10-year flow models are prepared and the areas of inundation are calculated for each design flow. This information is presented in a memorandum summarizing model development, presenting the modeling results, appending model output, and showing cross sections and inundation surface. Model outputs and drawings are also appended to the PDP.

The models are then provided to another **Engineer** for review. Comments are addressed and documented as part of the QA procedures. Each comment is discussed and the resolution action is documented.

Additional analysis is performed to calculate incipient motion of different substrate particle sizes that will move under the 10-year flow. This is used to determine if bank toes need to be replaced or are sufficient as is. The bank toe material is intended to be stable at the 10-year flow. Additional analysis is also performed to identify the critical d_{50} for sections with high shear stress in support of a general discussion in the PDP report on channel stability. The design team has discussed the potential value of having this analysis complete prior to bank treatment lay-out so the information can be used to select appropriate bank treatments.

Once modeling and preliminary floodplain grading are complete, the **Revegetation Consultant** begins to refine revegetation treatments in coordination with other members of the Design Team. The main revegetation-related items refined at this stage include: streambank treatments, floodplain treatment grading (swales and wetlands), microtopography (discussed below), vegetative backfill depths (discussed under Borrow Areas Investigation/Design), and planting locations. Planting locations are typically identified fairly early as they influence floodplain treatments and fencing locations.

Using the Draft FG and BOE, preliminary floodplain fill volumes (alluvium and vegetated backfill) are calculated to determine borrow area needs.

Borrow Areas Investigation/Design:

Borrow Area locations are identified and evaluated based on discussions with the DEQ, the NRDP, and landowners. The preliminary investigation is conducted to verify if the materials meet the design criteria for alluvium and vegetative backfill, general fill, etc. If they do, additional test pit data is collected and a borrow area design is prepared for each of the identified locations. Typically, 12-inches of topsoil are stripped from the borrow areas and stockpiled for reclamation purposes. Preliminary volumes are calculated and additional needs are identified. The **Revegetation Consultant** evaluates the potential to use material below the top 12 inches as vegetative borrow. Soil properties such as texture, organic matter (OM), and salinity/sodicity metrics are considered.

If needed, a compost recommendation is developed with the objective of achieving 1.5% OM in the soil. Vegetative borrow material suitability criteria are provided in the Phases 2, 3 & 4 borrow investigation reports. Results of the borrow investigations are delivered to DEQ and NRDP as Data Summary Reports.

Estimated volumes of compost, vegetative borrow, and alluvium are needed for planning purposes. Alluvium is used for floodplain reconstruction, and construction of on-site and other non-public roads. Volumes for these items are calculated and used to produce the engineer's estimate. Cost information is generally not included in the PDP, but is provided to DEQ separately from the final design bid package.

Microtopography, Wood and Brush Placement:

Using the Draft FG, initial locations for microtopography and wood placement in the floodplain are developed and provided by the **Revegetation Consultant** as a shapefile. This information is presented in the landowner plans, in the PDP and used to determine microtopography/brush placement areas and wood needs. Microtopography includes both floodplain roughness (1/2 foot variations in topography) and woody material placement. Woody material can be placed at either a normal density or high density. High density wood is placed in high risk areas such as avulsion paths. Generally, floodplain roughness is implemented in all areas within the remediation boundary except for areas designed for agricultural land use (i.e., hay production). Woody material is prioritized for use along streambanks, within avulsion paths, and within planting units. In all phase except Phase 1, there has not been enough woody material available to place it in all designated areas. Re-prioritization of woody material placement has been required during construction when woody debris is lacking. Criteria for re-prioritization has been phase specific and dependent on the amount of material left.

Draft Final Bank Treatments:

The Design Team finalizes bank treatments including integrating the treatment transitions with floodplain grading.

Dewatering Plan:

During the test pit investigation, depth to groundwater elevations are collected and used to create a groundwater surface for the season during which the investigation was conducted. Additional piezometer information may be available to estimate the depth to groundwater during different times of the year.

This groundwater surface is compared to the BOE surface and areas are identified that would require dewatering. Based on the estimated depth of contamination, dewatering trench/well point locations and sediment pond locations are identified. These locations are compared to the location of the internal haul roads, if known, to minimize potential conflicts. In addition, any conflict between the bank treatment construction/structures/etc. and dewatering trench/sediment ponds are identified. If necessary, trenches/well points/sediment ponds are moved to reduce any conflicts.

Work Areas and Haul Roads:

Work areas are delineated and named. The delineations of the work areas are assigned with the input of the construction team to make sure the work flow makes sense and that they are close to 10 acres. The locations of temporary bridges and culverts are also identified and internal haul roads are designed and included in the Haul Road Plans. Primary haul roads normally outside the removal boundary are also planned and shown on the drawings.

Clearing Areas:

Woody vegetation clearing areas are identified using aerial photography (or layers provided by the **Revegetation Consultant**). The surface areas are calculated for the engineer's estimate. These areas are added to the site plan to show where the clearing should take place.

Fencing Types and Locations:

Locations and types of fencing area also evaluated and integrated into the design at this time. Fence locations are based on existing fence locations and types, where wildlife protection fence is needed, where construction protection fence is needed, planting locations, property boundaries, etc. This is often an iterative process involving the landowners. The **Revegetation Consultant** typically provides the fencing lay-out (for wildlife protection fence) via shapefile. Once the fence locations are reviewed by the Design Team and the landowners, they are added to the Site Plan and presented in the PDP. This item is always subject to change as the design proceeds. A memo is in the works that will outline vegetation protection measure criteria and specific recommendations for Phases 1 through 9.

Details:

All details are reviewed by the construction oversight team and the Design Team to incorporate design changes or improvements noted during construction. This has been a very valuable process and many improvements to design aspects or new treatments have been developed. These items are also addressed in the special provisions and specifications.

Preliminary Design Plan (PDP) and Draft Design Drawings:

Most of the information described above is reviewed by the Design Team and presented in the PDP for review by DEQ and NRDP. The PDP includes sections with results of the investigations on vegetation (**Revegetation Consultant**), geomorphology (**Geomorphologist**), Hydrology and Bank Toe Material (**Engineer**). It may be preferable to submit these investigations as stand-alone documents as is done for the tailings/impacted soils investigation and the borrow area investigations. Results of the existing conditions and proposed conditions hydraulic models are discussed in the PDP and appended to the document. An outline of a recent PDP report is attached to this memorandum. Draft Design Drawings are also presented with the PDP and contain all the major elements of the design but do not include subgrade surfaces, swale elevations and other items specific to the site. The report and drawings are the main elements of the PDP and result from a collaborative effort among members of the design team who are involved in development of the surfaces and plans as they are prepared. This iterative approach reduces the amount of review necessary to complete the PDP before delivery to the client.

Before delivery to the client, the draft PDP is reviewed by the Technical Review Committee (TRC). The TRC consists of personnel involved in the design as well as other design experts not involved in developing the design. The TRC members produce comments which are reviewed in the TRC meeting and resolved. The TRC chairman documents the meeting and the responses to comments and ensures that all comments are addressed. After this internal review, the draft PDP is reviewed by DEQ, NRDP and the Environmental Protection Agency (EPA) and then modified as needed for further review by the Design Review Team (DRT), a group of interested parties including local government, state and federal agencies.

Draft and Final Bid Packages

The following Items are generally produced for the first time after the PDP for submittal with the draft Bid Package:

Subgrade Surface:

The draft FG is used to create the draft SG (subgrade surface) which is typically 0.5 feet (vegetated backfill) below the FG surface except next to the banks, point bars, wetlands, and some areas of specific land uses (i.e., hayfields). The draft final bank treatments are used to create feature lines that reflect the type of material designated in the details for each of the treatments. Geum provides a shapefile with the vegetative backfill depths. In areas where oxbow or secondary channels will be re-built, grading is often more detailed and developed closely with Geum to ensure that the surfaces reflect pre-remediation surfaces to support successful revegetation.

Once the surface is reviewed, a volume surface (SG vs FG) is created and colors assigned for each vegetative backfill depth. This surface is used to check the vegetative backfill depths. Any discrepancies are evaluated and corrected before the volume calculations for vegetative backfill are finalized. Keep in mind that some treatments might change during the final-walk though and might have to be adjusted.

The avulsion paths and CMZ shapefiles provided by the **Geomorphologist** are added to the drawings and areas where general fill can be placed are identified to ensure that materials balance with the available borrow area materials. As part of the CMZ shapefile submittal, areas of the originally defined CMZ that are not contaminated are clipped out of the total CMZ area, so that the modified CMZ contains only those areas that are contaminated. Areas where Type A material is needed are also identified and volumes are calculated.

Non-impacted Material:

In addition to the vegetative backfill analysis, a volume surface (BOE vs SG) is created to determine the volume of non-impacted material and alluvium/general fill. Non-impacted material is material that does not exceed the contaminant levels of tailings/impacted soil but needs to be removed to allow construction of the final grade with sufficient provision for vegetative backfill. This sometimes occurs where the FG is lower than the EG. The volume surface (BOE vs SG) is also used to determine where the non-impacted material is located, if any, and its depths. Some areas are too small to extract the material while others provide significant volume. We have noticed that only a fraction of the initially identified non-impacted material can be used - any areas with less than 0.2 feet tend not to be feasible to remove and use. Adjustment to the quantities are made. The suitable non-impacted material is subtracted from the general fill needs.

Figures are created with depth ranges of non-impacted material and presented to the Design Team for review during the next design submittal.

Final Grading Review and Refinement:

The FG surface is then provided to another **Engineer** for review. Comments are addressed and documented as part of the QA procedures. Each comment is discussed and the resolution action is documented.

The **Revegetation Consultant** reviews the FG surface in ArcGIS to ensure that design criteria are still being met for floodplain features. This review is based on the 2-year WSE provided by the **Engineer**. The **Revegetation Consultant** does not review the HEC-RAS model itself. The **revegetation consultant** provides written comments to the Engineer describing their findings.

A final step usually conducted after the FG has been reviewed by the landowners and client is to assign elevations to wetlands and swales based on design criteria that are specific to each Phase, mainly due to varying groundwater influences. The revegetation consultant provides swale and wetland locations in a shapefile format. The Design Team reviews the final FG and any comments/revisions are addressed.

Continued Landowner Meetings:

Landowner involvement continues through the design process, so that the final FG and other design elements are acceptable to the landowner.

Final Field Review

After development of the draft Final Plans, the Design Team conducts a final walk through to evaluate bank treatments and other design issues that may warrant a field check.

Draft Bid Package:

With the additional elements developed since the PDP, a draft Bid Package is prepared that includes Design Drawings, Special Provisions, and Technical Specifications. The **Revegetation Consultant** provides updated drawings, details and specification language for fencing, haul road and staging area reclamation, floodplain roughness and wood placement, and other revegetation-related items. All members of the Design Team review the final plan set and special provisions for content and clarity, and a final Technical Review Committee meeting is held at which remaining issues with the design are resolved.

DEQ and NRDP review and comment on the draft Bid Package. Once DEQ/NRDP comments are addressed and incorporated into the package, the package is submitted to EPA for approval.

Final Bid Package:

Any final comments from EPA, DEQ, NRDP, and the Design Team are addressed in the bid package. The engineer’s estimate is finalized with bid items and volumes from the final surfaces and final design package before it goes out to bid.

Revegetation Plan Development and Implementation:

A preliminary revegetation plan is included in the PDP; however, the detailed, final revegetation plan is not prepared until a few months prior to construction completion in a phase. The final revegetation plan includes planting locations, seeding locations, seedbed prep locations, and installation of vegetation protection measures (other than fence installation, which is typically done by the general contractor. The revegetation plan includes plant installation quantities, species mixes and container sizes. Planting polygons are created in ArcGIS using the FG surface. A Tier II Solicitation is issued to select a vegetation contractor to implement the revegetation plan. Revegetation is implemented as construction is completed in portions of a project area.

Monitoring

Monitoring Plan Development:

A vegetation and geomorphology Sampling and Analysis Plan is developed for each project phase, based on the *Clark Fork River Operable Unit Reach A Geomorphology and Vegetation Monitoring Plan* (DEQ, 2015). This sampling plan is developed near project completion so final surfaces and remediation/restoration treatments can be used as a spatial basis for the plan. Monitoring schedules, protocols and adaptive management strategies are described in detail in those plans. Information gathered during monitoring cycles and annual Qualitative Rapid Assessments (QRA) is used to identify maintenance actions and refine future designs.

References:

CDM Smith CDM Smith and AGI, 2013. Geomorphology and Hydrology of Reach A, Clark Fork River Operable Unit Milltown Reservoir/Clark Fork River Superfund Site, Powell, Deer Lodge, and Granite Counties. Prepared for the Montana Department of Environmental Quality. September.

Department of Environmental Quality, 2015. Clark Fork River Operable Unit Reach A Geomorphology and Vegetation Monitoring Plan.

ATTACHMENT: Table of Contents for Preliminary Design Report