MAKING AND BUILDING A FLUVIAL GEOMORPHIC RECLAMATION DESIGN AT AN ACTIVE DRAGLINE MINE USING THE GEOFLUV™ DESIGN METHOD[1]

David Measles,[2] and Nicholas Bugosh

Abstract. A surface coal mine in southwest Wyoming designed and regraded 100 acres in 2006 using the ***Natural Regrade*** software with the GeoFluv™ design approach. Most of the spoil grading was done with a walking dragline. Final contours were completed with dozers. The GeoFluv™ -design software allows the user to design a stable reclaimed land surface using geomorphic input data. The challenges involved in implementing the GeoFluv™ design method included learning the differences between GeoFluv™ design and conventional surface modeling methods, designing surface contours and drainage longitudinal profiles that conform to the limits in the permitted post-reclamation contours, gaining buy-in from mine management and operations personnel, adapting the GeoFluv™ design to the Caterpillar CAES GPS equipment grading systems. The GeoFluv™ design was successfully implemented. The dragline and dozers stayed on schedule and the completed land surface had more topographic variation than normally achieved by conventional design. Future projects may include a 600-acres reclamation area with stream channels that are perpendicular to the highwall.

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[2] David Measles, Senior Mining Engineer, Bridger Coal Company, 932 Nine Mile Road, Point of Rocks, WY 82942. Nicholas Bugosh, GeoFluv Technical Director, Carlson Software, Rocky Mountain Region / Carlson Software, 19 Old Town Square, Suite 238, Fort Collins, CO 80524.

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Introduction

Bridger Coal Company is a captive mine fueling the Jim Bridger Power Plant in Southwest Wyoming. A total of 3,284 acres have been reclaimed at Bridger Coal since 1974 when the mine started full production. Most of the areas reclaimed to date are located between the initial box cut and an advancing dragline pit. Two small pits have been closed and reclaimed with the remaining mine still open, continuous and almost seventeen miles in length. In 2006 the mine took the initiative to try a new approach to existing reclamation design and implemented a new design on 100 acres using Carlson Software GeoFluv™ modeling method. The area was reclaimed and approved by the Wyoming State Department of Environmental Quality Land Quality Division (DEQ LQD) in late 2006.

Objectives

The objectives in reclaiming this area were: 1) alter the approved Post Mining Topography (PMT) plan within the variation allowed by the mine permit and design a GeoFluv™ ***Natural Regrade*** surface to replace it, 2) provide great topographic diversity to enhance plant and wildlife opportunities. Create stable natural-acting maintenance free surfaces or surfaces that behave more like native surfaces in flood events and support more diverse plant communities, 3) reduce the mass balance volume of material moved from the permitted approved PMT, lowering construction cost and, 4) work with management, dragline and dozer operators and to help them understand the concepts of fluvial geomorphology landform design and assist in the building of the new GeoFluv™ surface from the computer design, (fluvial means formed by flowing water, geo means earth, morphology means science or study of form, hence literally the science of landforms made by flowing water). The GeoFluvTM design is a particular design approach based on fluvial geomorphic principles that helps the user design a site-specific landform that will be stable against erosion given the local earth materials, climate, and vegetation. GeoFluvTM is not a generic name for using fluvial geomorphic elements, but refers to a specific patent-pending landform design algorithm. It is important to convey to the team that the designs must be made and constructed according to the GeoFluvTM method to assure optimum landform performance in the field.

Methods and Results

The reclamation area was chosen for the close proximity to existing walking dragline working in a nearby pit (Fig. 1). The dragline was cycling through the current pit and had time available for reclamation while waiting on drilling and blasting and coal removal before moving back to start a new cut. The window of opportunity to use the 79 yard bucket machine was one month. The original approved Post Mining Topography (PMT) was designed to displace and grade approximately 1.5 million cubic yards of spoil for 80 graded acres. The original PMT design was to suppose to be graded by dozers only. The updated design needed to accommodate a dragline walking pad through the entire area with and enter and exit strategy. Dozers were only used as support for the dragline.

Computer design constraints consisted of staying within plus or minus one contour interval (10 feet plus and 10 feet minus, total 20 feet) of the approved PMT. Original stream profile vertical elevations were constrained to be exactly as the approved stream elevations on major drainages. Bridger's permit drainages need approved profiles for every watershed over 80 acres.

These drainages are designed and permitted and must be built to within plus or minus 1 vertical foot of design elevation. One drainage in the area met these criteria and as such had to be duplicated using GeoFluv™ methodology. This approved drainage was designated the 'main" drainage in the GeoFluv™ design. As a result the new design had to be identical to the approved drainage in vertical accuracy. This was accomplished by changing elevation and slope percentages in GeoFluv™ software until an exact match was found. All smaller tributary drainages could then be designed to the Permit PMT limits of plus or minus 10 feet vertical elevation accuracy (these smaller drainages were not included in the original approved PMT). With the new design it was found that earthwork could be reduced. As design work was completed, a dragline pad had to be incorporated into the design to facilitate moving the massive machine through the area. This was done by using a dragline range diagram design on the modeled GeoFluv™ surface. Part of the pad was left for future dragline access into the area. Part of the pad was regraded into the new designed surface as the dragline was exiting the area.

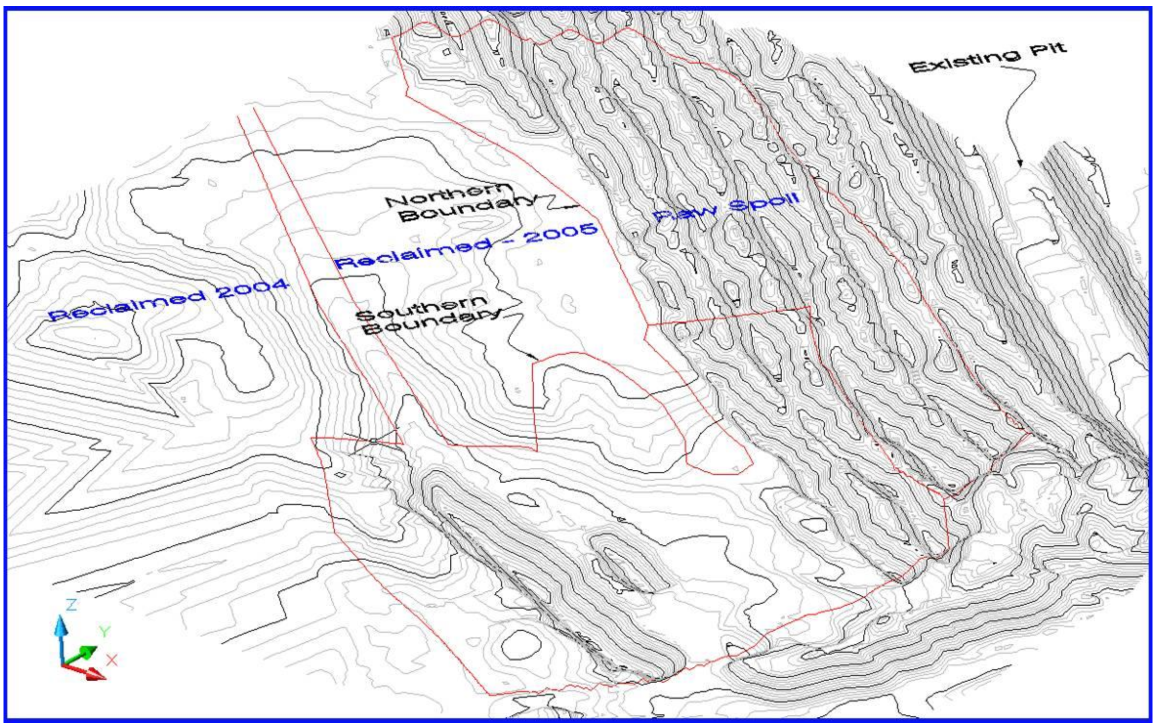

Figure 1. Spring 2006 topography, boundaries and previously reclaimed areas.

The entire design was finished just prior to the dragline walking into the area. It was found that the original 80 acres could be expanded to 100 acres for the same 1.5 million yards using the GeoFluv™ Model. Since the dragline time was available the decision was made to keep it in the area for the entire month and try to get the extra 20 acres for the same amount of equipment time. The dragline exited the area on schedule and achieved the goal of more acres for the same amount of yards. The adjacent area reclaimed in 2005 is compared to the GeoFluv design area reclaimed in 2006 (Table 1). Target cubic yards in both areas (1,711,278 – 1,700,000) reflect the original design approved in Bridger's permit.

Table 1. Comparison of Projects –GeoFluv VS Traditional approach

Method Used	Traditional	Geofluv
Year	2005	2006
Area	**R57-3-4**	**R58-3-3**
Target Yards	1,711,278	* 1,700,000
Actual Yards	1,727,996	1,537,441
Difference	(16,718)	162,559
Days Scheduled	28	31
Actual Days	42	31
Difference	14	0

* Designed using approved PMT and traditional reclamation.

Discussion

As the project proceeded it was found that the equipment operators were very receptive to the new idea of smaller features and pre-built stream channel sinuosity as well as ridge and valley concepts. However, some dozer operators thought that the slopes should be long and smooth from the ridge line across the face. It was not anticipated that groundmen (dozer operators that build pad for the draglines) were trained to build perfectly flat surfaces for the dragline to walk on. As a result the first ridge was flattened perfectly to facilitate a dragline even though the dragline would not walk on the slope again. A new rule was made that there would be no more tracking of dozers along the ridge line. All dozers were to track up and down the ridge parallel to the sub ridge and sub drainage lines on the plan.

Dragline operators were instructed on drainage and ridge locations and where the bulk of material was to be placed. For grade control Bridger draglines use onboard Aquila GPS computer systems. Typically only cross-section data is displayed on the onboard cab monitor, limiting the amount of detail shown at any given time. Because of this the dragline moved only the bulk of spoil but did not cut sub ridges or sub valleys.

Dozers were used to add support to the dragline. Most Bridger Coal dozers have onboard caterpillar CAES GPS computer grading systems. These GPS systems were loaded with design surfaces that included all GeoFluv^{TM} ridge, sub ridge, valleys, sub valleys and drainages. This provided a way for the modeled detail work to be built.

Different GeoFluv^{TM} models were designed with material mass balance being the number one priority. Spoil volume moved had to be minimized with the total volume being less than what would be incurred using the approved PMT in the same area. No spoil chemistry problems were discovered in the regraded spoil; therefore, special placement of spoil was not a concern. The design would have been closely scrutinized and possible abandoned if a reduction in mass balance could not be achieved with the GeoFluv^{TM} model.

The original PMT design was broad in scope with little topographical relief and undefined drainages (Fig. 2) while the new design worked well with the existing spoil configuration (Fig. 3) for drainage placement.

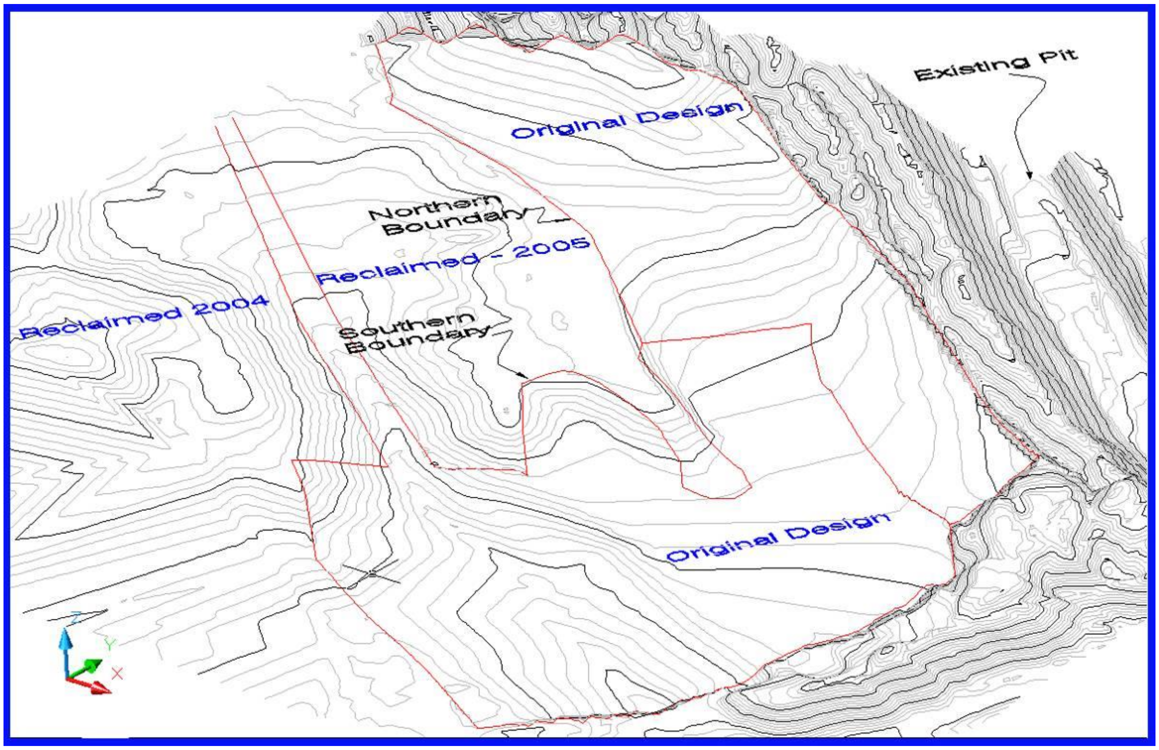

Figure 2. Original approved post mining design.

Experimentation with different drainages was the key in minimizing dirt work. Each time a drainage profile line was drawn and added to the surface model the earthwork was calculated against the existing topography. Moving drainage locations made the biggest difference in minimizing the volume of spoil needed to be moved. In this process it was found that putting a ridge line in the spoil, near the middle the project area, and draining each side to a different main drainage was a big advantage to saving earthwork. A northern and southern work area was established. This was accomplished by splitting the design into two separate GeoFluv™ areas each with separate boundary and calculations (Fig. 3). Drainage density was monitored with each drainage addition and movement to keep within design criteria. Tributaries were added to achieve the proper density and ridge lines were adjusted to help minimize earthwork. Ridge lines were raised in areas of cut and lowering in fill areas as much as possible to keep spoil movement to a minimum. Adjusting ridge lines, moving drainages and having updated hydrologic data instantly to evaluate the changes made the design process very easy. The design surface model could not be completed in the time allowed without GeoFluv™ simply because of the time it would take to re-evaluate all of the hydrologic consequences of the above mentioned actions.

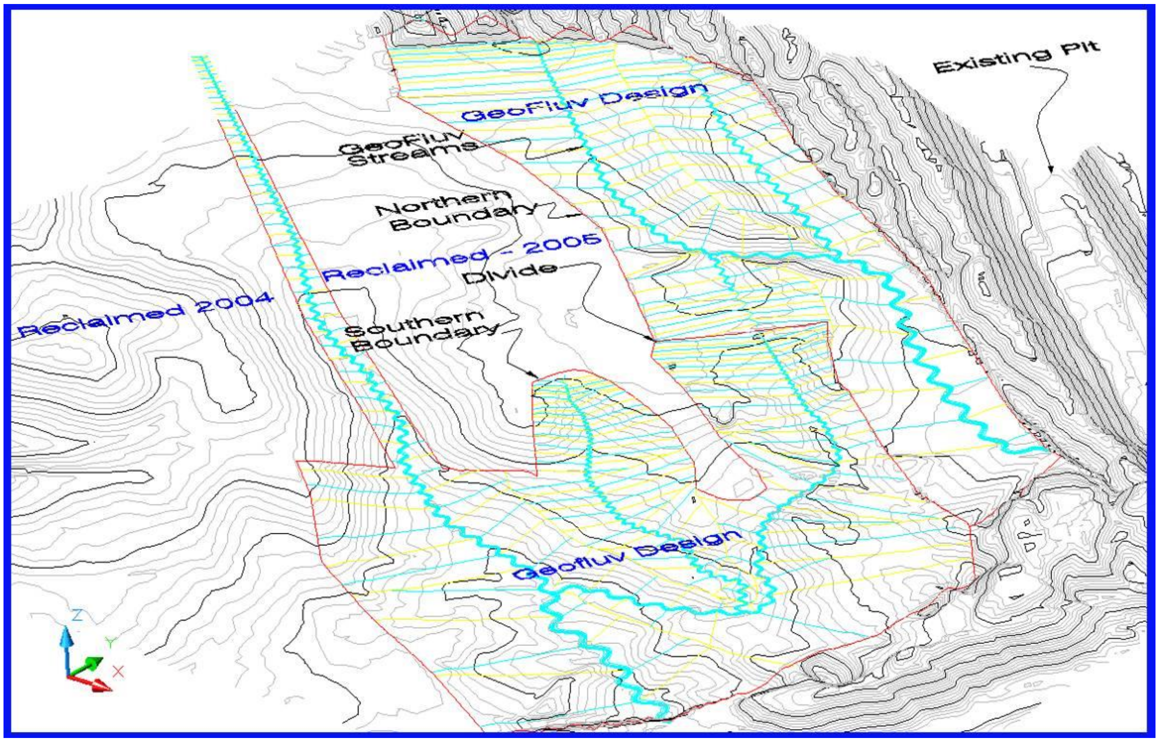

Figure 3. GeoFluv design, boundaries, streams and ridges.

The addition of north and east facing slopes created more catch basins for snow. This along with complex slopes promotes more plant and animal diversity. The addition of sub-ridges and sub-valleys (Fig. 3 – straight yellow and cyan lines) makes the surface more stable in larger flood events as runoff is more dispersed than it would be on the relatively flat surface. The new surface designed from Natural Regrade software produced a saving in earthwork of about 150,000 yards over the same 100 acre tract designed with traditional reclamation techniques (Table 1). The approved PMT Surface was compared to the GeoFluv Surface and a presentation was made to management for consent to move on with the project. Equipment moved into the area (Fig. 4) and started moving spoil. Two months later the project was completed on schedule while the dragline left the area (Fig. 5). It should be noted that if operators had been more familiar with the concept of how to construct the GeoFluv^{TM} design that more attention to detail would probably occurred in the allotted time frame and the construction would have more ridge and drainage detail. For a first time approach all went well with management, operators and engineers. More attention to detail in both design and implementation should be evident in future projects as mine personnel become familiar with the Natural Regrade concept. Vegetation, sediment yield and control, flood events and wildlife impact will be monitored in the future of the area as it is on all reclaimed land at Bridger Coal. Any adverse impacts will be mitigated.

Figure 4. Original Spoil (Spring 2006).

Figure 5. Finished Grading (Fall 2006)

Bridger Coal is currently designing a Geofluv™ surface for approximately 600 acres of pit closure in the center area of the mine and will see a reduction in spoil placement by several million cubic yards when compared to the currently permitted PMT surface. Geofluv™ gives the designer the ability to concentrate on mass balance without devoting all design attention to proper hydrologic conditions. Lowering reclamation construction costs using GeoFluv™ is dependent on the design engineer's attention to earth movement detail such as haul distance and mass balance. Cost reduction is dependent on several factors such as placement of drainages, placement of boundaries and proximity and chemical suitability of backfill material. The designer can use other methods such as adjusting head water elevations manually, putting sub-drainages in areas where fill needs to be minimized and pulling down ridge lines to minimize fill or make extra cut material available possibly closer to fill locations. Estimation of cost reduction is dependent on all the above factors and so should be evaluated for each specific site. Most mine sites with traditional reclamation design or typical "bread loaf" PMT should see a reduction in spoil placement by using the above mentioned methods.