

FACT SHEET FOR PARTNERSHIP FIELD VALIDATION TEST

Midwest Regional Carbon Sequestration Partnership (MRCSP)

NETL Cooperative Agreement DE-FC26-05NT42589

DOE/NETL Project Manager: Traci Rodosta,
Traci.Rodosta@NETL.DOE.GOV

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Terrestrial Sequestration Field Test: Reclaimed Minelands

Test Location: Various reclaimed mineland plots in West Virginia

Amount and Source of CO₂: Not applicable – this is a terrestrial field test to determine and validate rates of sequestration under different reclamation conditions.

Field Test Partners: West Virginia University

Summary of Field Test Site and Operations: Soil samples from five mine sites in Monongalia County, West Virginia were analyzed to assess soil carbon accumulation in mine sites reclaimed to grass and legumes. The Waynesburg coal seams for all five mine sites were contour mined beginning as early as 1982 and as late as 2007 using front end loaders. Mining operations ceased at different times for each of the sites (1990, 1998, 2000, 2005, and 2007). Overburden material placed on the disturbed land consisted of 70 to 80% sandstone with shale making up the remaining 20 to 30% of material. Three of the sites were backfilled with three inches of topsoil material, while the fourth site was backfilled with eight inches of topsoil. All sites used grass/legume mixes to reclaim the disturbed land

Research Objectives: Reclaimed mine sites planted to trees, grasses, or legumes provide opportunities for removing CO₂ from the atmosphere through carbon accumulation in soils and aboveground biomass. The overall objective of this project is to estimate the amount of soil carbon that may be stored in mine sites reclaimed to grass and/or legumes. Soil samples from multiple mine sites where mining activities ended at different times are being collected to assess the change in soil carbon over time (Table 1). Additionally, a mine site where reclamation activities just began is being used to assess the soil carbon content at the beginning of reclamation activities. This information, combined with soil samples collected from the same site over time, enhances estimates of the amount of CO₂ emissions that may be offset through the storage.

Table 1. Site Characteristics of the Chronosequence Identified in 2006

Site Name	Mylan Park	WVSK	Dent's Run ¹	New Hill	WV01
Mining Begins	1982	1996	1999	2003	2004
Mining Ends	1985	1998 ²	2000	2005	2006
Mine Soil Age in 2006	21	8 ²	6	1	0
Pre Mine Land use	----- Mixed Pasture and Forest -----				
Coal Seam	----- Waynesburg -----				
Method of Mining	----- Contour Mining, Front end loaders -----				
Overburden Type	----- 70-80% Sandstone, rest is shale -----				
Reclamation Method	----- Backfilled, 7.6 cm" topsoil, grass and legumes -----				

- (1) After soil sampling in 2006, the property owner stopped allowing access to the site.
 (2) After soil sampling in 2006, it was discovered that this site had been recontoured in 2003 and thus was actually only three years old.

A secondary objective of the project is to estimate the economic consequences of activities that are adopted to enhance carbon sequestration on all land uses considered for the Midwest Regional Carbon Sequestration Partnership (MRCSP) region. The tradeoffs between existing land management activities and those that enhance carbon sequestration were assessed. For reclaimed mine sites, the economic analysis entails estimating the difference in soil carbon accumulation rates in soils on sites reclaimed to grass/legumes and forest. Forests capture carbon in both aboveground (biomass) and belowground (soil) systems. The economic viability of using the carbon accumulation on reclaimed mine sites as a greenhouse gas mitigation activity was also assessed. Specifically, the soil carbon stocks and rates of change data collected on mine sites will serve as a baseline against which estimates of potential carbon accumulation in forests on reclaimed mine sites is compared. Results of these analyses may be used to provide information necessary for developing carbon trading schemes.

Summary of Modeling and MMV Efforts:

In 2006, samples were collected along a nested transect (Figure 1), which were located to encompass the maximum variability expected at each site. Carbon data from the nested transects in 2006 were used to characterize the spatial variability and to optimize a grid for soil sample collection on irregular field sites in 2007 and 2008. These grid sampling points were georeferenced so that the same points could be sampled in subsequent years.

Soil samples were collected at two depths, 0 to 6 and 6 to 12 cm (where possible) in late summer/early fall of 2006, 2007 and 2008 using a 12.5 cm diameter auger. Mine soils are shallow, so deeper depths were not feasible. The number of samples collected for each depth for each year for each mine site is provided in Table 2. A total of 1105 soil samples were collected from the five sites over three years. Table 3 lists the measurement techniques used in the field testing.

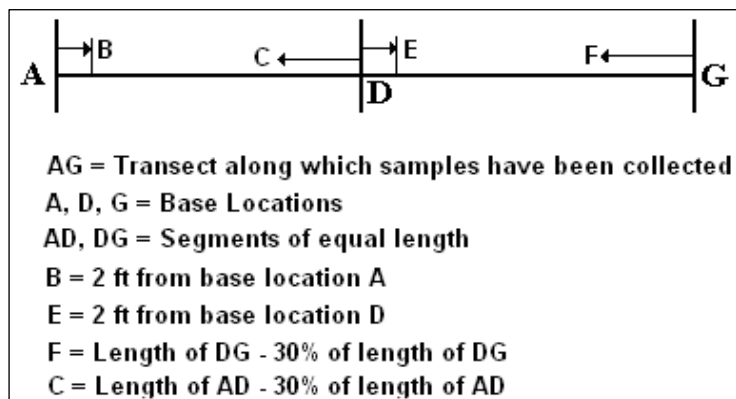


Figure 1. Schematic Representation of the Nested Transect Sampling Strategy Adapted in 2006 at All Five Reclaimed Mine Sites

Table 2. Total Number of Soil Samples Collected at Each Site, for Each Depth and Each Year from all Sampled Mine Sites

Year	Depth (cm)	Site					Total
		WV01 ⁽¹⁾	New Hill	WVSK	Dent's Run ⁽²⁾	Mylan Park	
2006	0-6	X	60	30	60	60	210
	6-12	X	60	30	55	56	201
2007	0-6	64	79	83	X	74	300
	6-12	10	12	13	X	12	47
2008	0-6	64	79	83	X	74	300
	6-12	10	12	13	X	12	47
Total		148	302	252	115	288	1,105

(1) Could not be sampled in 2006.

(2) After soil sampling in 2006, the property owner stopped allowing access to the site.

Table 3. Measurement Techniques Employed at Field Test Sites

Measurement Technique	Measurement Parameters	Application
Dry combustion – LECO	Total Organic Carbon (%) Total Nitrogen (%)	Measure soil carbon and nitrogen content
Dry combustion - Loss on Ignition	Total Organic Matter (%)	Measure soil organic matter that is then adjusted by the soil bulk density to estimate soil organic carbon content
Flow Injection Analysis	Extractable nitrate and ammonia	Measure soil nitrate and ammonia content to assess availability for biomass production

Accomplishments to Date:

Soil Organic Carbon (SOC) Estimation Activities

- Mine sites were selected that had known pre-mining land use, coal seam, overburden geology and mining and reclamation practices, and where the mine operator or landowner was known and permitted access to the sites.
- Performed an initial assessment on the number of samples required to generate statistically significant results.
- Collected a total of 1,105 soil samples from 0-6 and 6-12 cm depth intervals from five reclaimed mine sites that were reclaimed in different years.
- Measured total carbon (C) and nitrogen (N) concentrations for collected soil samples. The process involves estimation of the *minimum* number of samples necessary to characterize

and capture spatial variability of soil bulk density in these 'intensely heterogeneous' soils. The outcome was used to assess the importance of volume based relative to concentration (%) based SOC-sequestration rates in chronosequence-based SOC-sequestration studies such as this one.

- Completed bulk density measurements for the soil samples collected from the recently reclaimed mine site (WV01) and the Skousen (WVSK), Dent's Run, Mylan Park, and New Hill reclaimed mine sites.
- Selective dissolution techniques to separate recalcitrant and/or labile soil organic carbon (SOC) have been implemented on a subset of soil samples collected from the Mylan Park, WVSK, New Hill and WV01 (25 soil samples from each reclaimed mine site were analyzed).
- Investigated carbohydrate types and contents in these reclaimed mined lands in order to gain insights into soil quality and 'freshness'. Carbohydrates offer efficient building bridges between soil aggregates and in turn facilitate development of better soil structure.
- Implemented analyses using UV-Vis (ultraviolet-visible spectroscopic) and Fluorescence spectroscopic methods to understand degree of humification of SOC molecules in order to gain an insight into SOC sequestration potentials of reclaimed mine soils. In general, the greater the degree of humification, the greater the aromatic nature and degree of substitution, the greater the stabilization of SOC and, therefore, potential for SOC sequestration on reclaimed mine land.
- Implemented analyses using FT-IR (Fourier Transform Infrared) Spectroscopy to investigate the types of principal functional groups attached to the SOC molecules. This analysis is conducted because the presence of different groups holds the key to interaction of SOC with soil mineral matter (mineralogically stabilizes SOC pools) as well as biochemical recalcitrant nature of SOC. Treatments were compared with the control in order to ascertain the effects of removal of chemical moieties affected by the treatments as a key to understand SOC dynamics.

Economic Analysis Activities

- Obtained mining permit data documenting the area (acres) and date reclaimed mine sites in West Virginia satisfied Phase 1 (re-contouring), Phase 2 (vegetative cover established to control for soil erosion), and Phase 3 (vegetative cover density satisfies bond requirements). Entered WV mining permit records into a database to aid in calculating the probability of an operator completing reclamation within the 5 year time span.
- Participated in the 2007 Mined Land Reforestation Conference hosted by Appalachian Regional Reforestation Initiative (ARRI) in Abingdon, Virginia to enhance our knowledge of proper techniques for reforestation activities on reclaimed mine lands.
- Developed carbon sequestration rate estimates that result from forestry activities using the US DOE 1605(b) report and the Carbon On-Line Estimator (COLE). These were combined with economic parameters to estimate the minimum carbon price required to encourage forestry as a mine reclamation activity.
- Used the estimates of the potential costs savings from reclamation with the Forest Reclamation Approach (FRA) recommended by Appalachian Regional Reforestation Initiative (ARRI) to develop a map of the minimum carbon prices necessary to encourage reforestation in the MRCSP research region.

Dissemination of results

- Compiled data and presented preliminary results of different soil sample analysis and tools to evaluate carbon sequestration potential at different conferences. The presentations addressed a comparison of results from two mined sites, the mineral association and biological recalcitrance of SOC in reclaimed mine soils, the structural diversity of SOC in reclaimed mine soils, and the importance of bulk density to estimate carbon sequestration potential in reclaimed mine soils.
- Presented a selected paper at the Association of Resource and Environmental Economist Annual Meetings in Portland, OR. The presentation addressed the results of efforts to assess the increase in carbon that can be sequestered in the MRCSP Region through landowner adoption of reclamation practices that enhance forest productivity. The paper also assessed the economic consequences of adopting the Appalachian Regional Reforestation Initiative (ARRI) reclamation recommendations.
- Presented a selected paper on Carbon Sequestration in a Mine Soil Chronosequence: Temporal and Chemical Changes for the Northeastern Branch Crop, Soils, and Agronomy Conference in Portland, ME.

Summarize Target Sink Storage Opportunities and Benefits to the Region:

- The results of these analyses may be applied to most of the 576 thousand hectares of land permitted for mining activities in the MRCSP region where the predominant reclamation activity is grass/legumes (approximately 95% of reclaimed mineland is planted to grass/legume).
- It is expected that reclaimed mine land in the MRCSP region may store 11 – 22 million metric tons of carbon (40 – 81 million metric tons of carbon dioxide equivalents) over twenty years.
- The disturbed soil that results from mining activities may not absorb rainfall as well as undisturbed sites, resulting in increased soil erosion. Planting grass/legumes on reclaimed mine sites, in addition to storing soil carbon, also reduces soil erosion. This erosion reduction benefits nearby streams, lakes, and other waterways that may contain fish and other wildlife.
- Improved wildlife habitat: Reclaimed mine sites provided additional cover and food sources for wildlife that may not otherwise be available.
- As carbon markets become more fully developed, the stored carbon may be sold as a carbon dioxide offset, which will earn additional income for landowners. This is particularly critical in the Appalachian region where incomes are depressed.

Cost*:

Total Project Cost: \$26,320

DOE Share: \$20,033 (76%)

Non-Doe Share: \$6,287 (24%)

(*) Costs are for overall MRCSP Phase II project, reported in thousands.