Assessment of Stream Resources at Regulated Coal Mining and Remining Sites in Ohio

Final report prepared by Ohio State University, Dept. of Civil and Environmental, and Geodetic Engineering in cooperation with the ODNR, Division of Mineral Resources Management

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In Memory of Cheryl Socotch

During the course of this study one of the key team members and project manager for this study who was actively involved in all phases of this study passed away(Figure 5-3). Her drive and expertise helped bring this study to fruition, and the authors of this report dedicate it in her memory.

EXECUTIVE SUMMARY

The Ohio State University Department of Civil, Environmental, and Geodetic Engineering(OSU) with assistance from the Ohio Department of Natural Resources (ODNR), Division of Mineral Resources Management (DMRM) completed a field study that evaluated and characterized the long-term effects that mining and reclamation practices have had on stream resources 5 to 30 years following reclamation. The focus of the study was on reconstructed streams in the primary headwater areas of selected sub watersheds.

This joint field study also evaluated and documented the effectiveness of reclaiming previously disturbed areas through remining with respect to improvement in water quality, mitigation of hazards from past mining, and reconnecting streams which is important to watershed restoration. The joint OSU and DMRM workgroup selected five sites within Ohio's coal region with different lithology, age, and types of reconstruction for examination utilizing Ohio Environmental Protection Agency's (OEPA) Field Evaluation Manual for Ohio's Primary Headwater Habitat Streams.

The study discusses the physical, biological, and chemical characteristics of reconstructed streams and determined the classification of the reconstructed streams based on OEPA's stream classification system. In addition water quality results were compared to the USEPA's Coal Mining Technical Based limits(NPDES). Comparisons were made between streams reconstructed utilizing natural channel design and the less contemporary trapezoidal construction techniques. The study also showcases more recent reconstruction practices being employed by Ohio Coal Miners as well as the state of the regulatory framework in Ohio that governs stream

impacts and reconstruction. Over time, streams that were reconstructed using both trapezoidal type of reconstruction on steeper slopes and natural channel design on more moderate channel grades do recover and reach quasi equilibrium following reconstruction when land use and appropriate reconstruction practices are employed, and a sufficient amount of time has passed. In addition all reconstructed channels sampled met NPDES water quality standards. The downstream and adjacent three of the five biological sites located downstream or adjacent to the reconstructed stream segments exhibit Class III bio diversity characteristics, while two exhibited Class II bio diversity characteristics. A number of recommendations were also presented for consideration by the regulatory authorities. This study represents a small sampling of streams affected by mining, and is a good first step, however additional studies in this area is recommended.

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1 INTRODUCTION

1.1 Background

Since the passage of modern coal mining laws over 38 years ago in Ohio, mining through headwater streams has become very prevalent and has played an important role in obtaining valuable coal reserves. The reconstruction and restoration of streams at these mine sites however, has not been well documented in the state. In recent years coal mine permitting has become increasingly more complicated, especially considering the regulatory reviews needed to meet federal and state water quality standards pursuant to the 1972 Clean Water Act(CWA) and state laws as follows:

- the 401 section of the CWA ensures that discharges are consistent with regional water quality certifications issued by the Ohio Environmental Protection Agency (OEPA) to avoid, minimize, or mitigate impacts to water resources.
- the 402 section of the CWA establishes pollutant monitoring and reporting requirements through the National Pollution Discharge Elimination System (NPDES). The discharge permits establishes effluent limits set by the OEPA for sediment ponds on mine sites.
- the 404 section of the CWA requires all discharges of fill or dredged material affecting the bottom elevation of a jurisdictional water of the United States(US) to obtain a permit from the US Army Corps of Engineers (USACE).
- and the Ohio Revised Code 1513 mining permit from the DMRM.

Studying the impact of mining and subsequent reconstruction of headwater streams in various parts of the state over the past five to 30 years can serve as valuable background information for regulators involved in permitting activities and the general public who have questions or concerns about mining.

It is also important for the DMRM to effectively administer the mining permitting and reclamation programs and provide for an effective permitting system which facilitates mining of coal reserves and restores impacted streams to productive ecological systems.

The study is a collaborative project with DMRM staff from both an administrative and technical perspective. DMRM staff were involved in site selection along with input from OSU researchers. DMRM staff was the lead entity for background water quality sampling and provides oversight for the project. OSU also sought out background data from previous studies, reports, or guidelines from ODNR, OSU, OEPA, and coal companies.

1.2 Purpose

The goal of the study is to evaluate and characterize the long - term effects mining and reclamation practices have had on stream resources five to 30 years following reclamation of these sites and make recommendations for improvements to mining and reclamation program areas. The stream resources targeted for this study are located in the primary headwater areas with drainage areas less than one square mile. The study evaluated the physical, biological, chemical, and geomorphic characteristics of reconstructed streams and natural streams located in the same watershed. The results and data will be useful to Ohio's mining program to assess how

effective the regulations and mining practices have been over a long period of time and recommend any programmatic changes.

1.3 Scope of Work

The primary scope of the study is to assess the current fluvial-geomorphic post-mining conditions of streams and their recovery with respect to stream habitat, stability, channel or flow patterns, and vegetation in comparison to target values. Biological resources in the general area of the reconstructed streams were also assessed in comparison to target values. In addition chemical water quality in comparison to target values and floodplain soil tests were also conducted. These reconstructed streams ranged in type from ephemeral to intermittent streams.

This report discusses the listed elements at the following five sites: Central Ohio Coal Co. (COCCO) permit C-0209, B&N Coal Co. permits D-0958 and D-0807, Wills Creek Energy permit D-19, and Valley Mining permit C-1305 (Figures 1-1 and 1-2):

- Current fluvial-geomorphic conditions in comparison to approved stream reconstruction plans or actual reconstruction dimensions;
- Post-mining stream recovery (e.g. stream habitat, stability, channel or flow patterns, and vegetation) in comparison to stream evolution models;
- Biological resources in comparison to OEPA stream classification system;
- Chemical water quality in comparison to USEPA Technical Based Limits of Coal Mining(NPDES); and
- Stream cross sections and bankfull width compared to calculated flows.

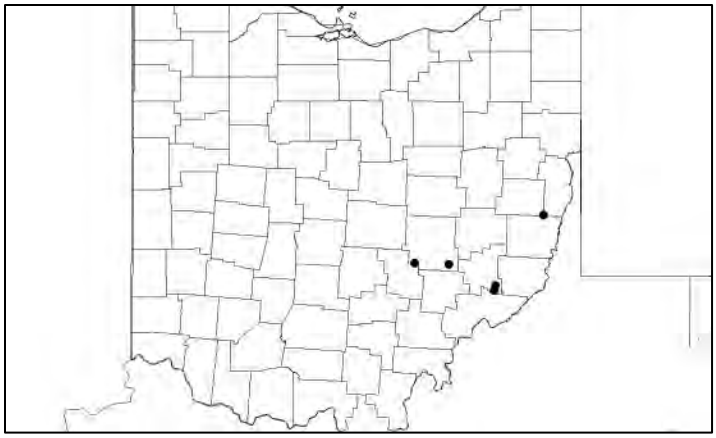

Figure 1-1. Permit Locations

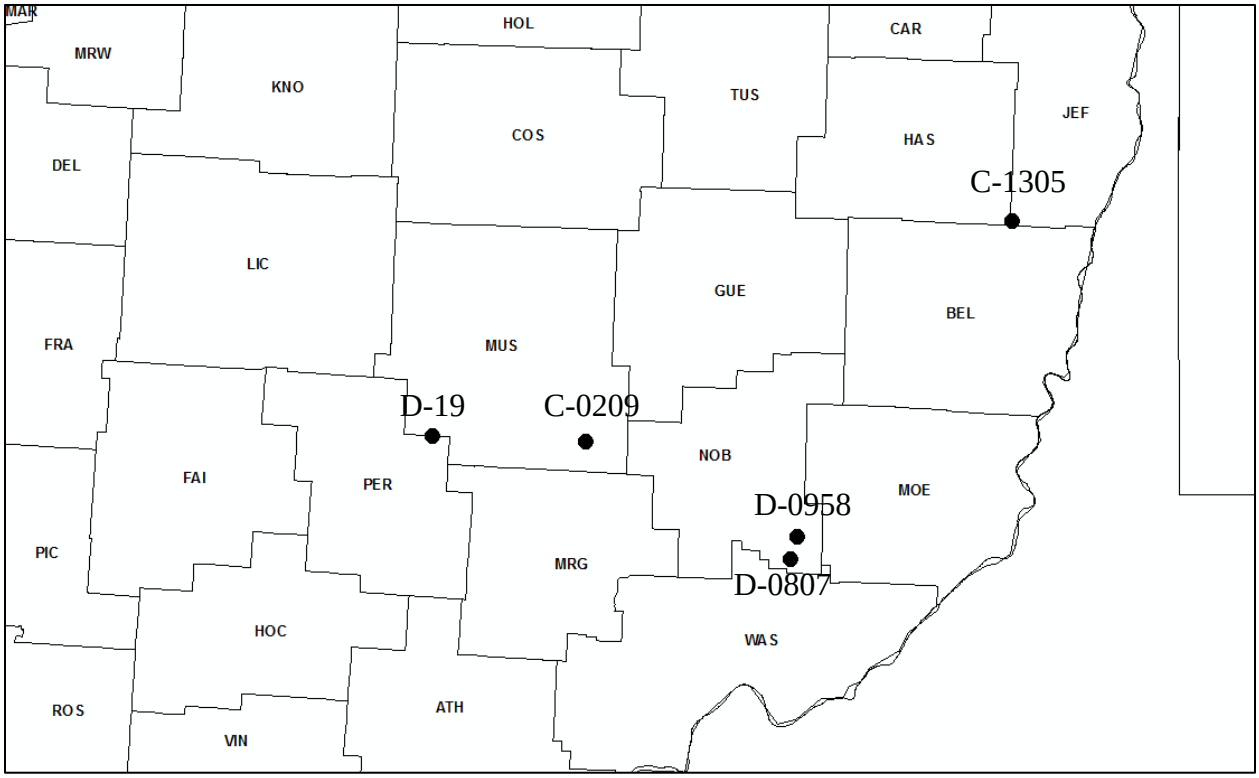

Figure 1-2. Zoomed in Permit Locations

2 STREAM EVALUATION APPROACH

The streams were evaluated using the OEPA, Division of Surface Water's Field Evaluation Manual for Ohio's Primary Headwater Streams version 2.3, 2009, hereinafter referred to as the " Manual" (Appendix A). OEPA is a national leader in the development of stream assessment tools. This manual was developed as a tool to provide standardized assessment for primary habitat streams. It describes methods OEPA has developed to better assess the actual and expected biological conditions in the waterway and an acceptable methodology to classify primary headwater habitat streams. The lowest level of field effort is a relatively rapid habitat evaluation procedure known as the Headwater Macro Invertebrate Field Evaluation Index (HMFEI). Two levels of biological assessment, one at an order level of taxonomic identification, and second to a genius species, provide flexibility in reaching a final assessment on the aquatic life use designation. For the purposes of this report the taxa group was used to calculate the total HMFEI score.

The evaluation of stream conditions was carried out following the protocols described in the Manual. It provides a standardized assessment for primary headwater habitat (PHWH) in the state of Ohio, which allows impacts to be evaluated with similar natural system standards. The Manual uses both physical and biological indicators to assess overall stream ecological integrity based on established indices of habitat quality such as Qualitative Habitat Evaluation Index (QHEI), (HMFEI), and Headwater Habitat Evaluation Index(HHEI). The HHEI is a rapid assessment to determine the potential of aquatic life use based entirely on physical

measurements. HHEI assigns a score to physical habitat features that have been found to be statistically important determinants of biological community structure in PHWH streams (Figure 2-1). There is an increased confidence when the HHEI is accompanied with a biological evaluation of the stream. Where possible, a combination of the HHEI rapid assessment method and the HMFEI scoring system was used in this study to determine the stream's classification. The Manual describes the OEPA's stream classification system and the PHWH scoring system utilized in this study. In summary there are three types of Primary Headwater Streams in Ohio: 1) Class III- PHWH Stream (cool-cold water adapted native fauna), 2) Class II – PHWH Stream (warm water adapted native fauna), and 3) Class I – PHWH Stream (ephemeral stream, normally dry channel).

The primary physical habitat distinction between a Class I and Class II – PHWH stream is the presence of flowing water or isolated pools for extended periods of time in Class II-PHWH stream channels during the summer months. The primary biological distinction is that Class I- PHWH streams either have no species or aquatic life present, or if present, the biological community is of relatively poor diversity. Using methodologies similar to those employed to develop the QHEI; a HHEI was constructed by OEPA. The HHEI can be used to score physical habitat features that have been found to be statistically important determinants of biological community structure in PHWH streams with drainage area less than one square mile.

Statistical analysis of a large number of physical habitat measurements showed that three habitat variables; 1) channel substrate composition, 2) bankfull width, and 3) maximum pool depth, are sufficient to statistically distinguish Class I, II, and III- PHWH stream using the HHEI scoring system. The HHEI rapid assessment tool is most predictive when "modified" channels are separated from "natural" channels that have little or no evidence of channel modification.

Thus indirectly, the final HHEI scoring process incorporates many more aspects of the geomorphology and hydrology of small stream channels (i.e. entrenchment, degree of sinuosity, etc.) than the limited set of three variables that require quantitative measurement.

The Manual describes the relationship between hydrology and potential PHWH stream class as follows: Perennial flow (continuous, permanent = either Class III or Class II PHWH stream; Interstitial flow (interrupted) = either Class III or Class II; Intermittent flow (temporary, summer – dry) = Class II; and Ephemeral flow = Class I[1].

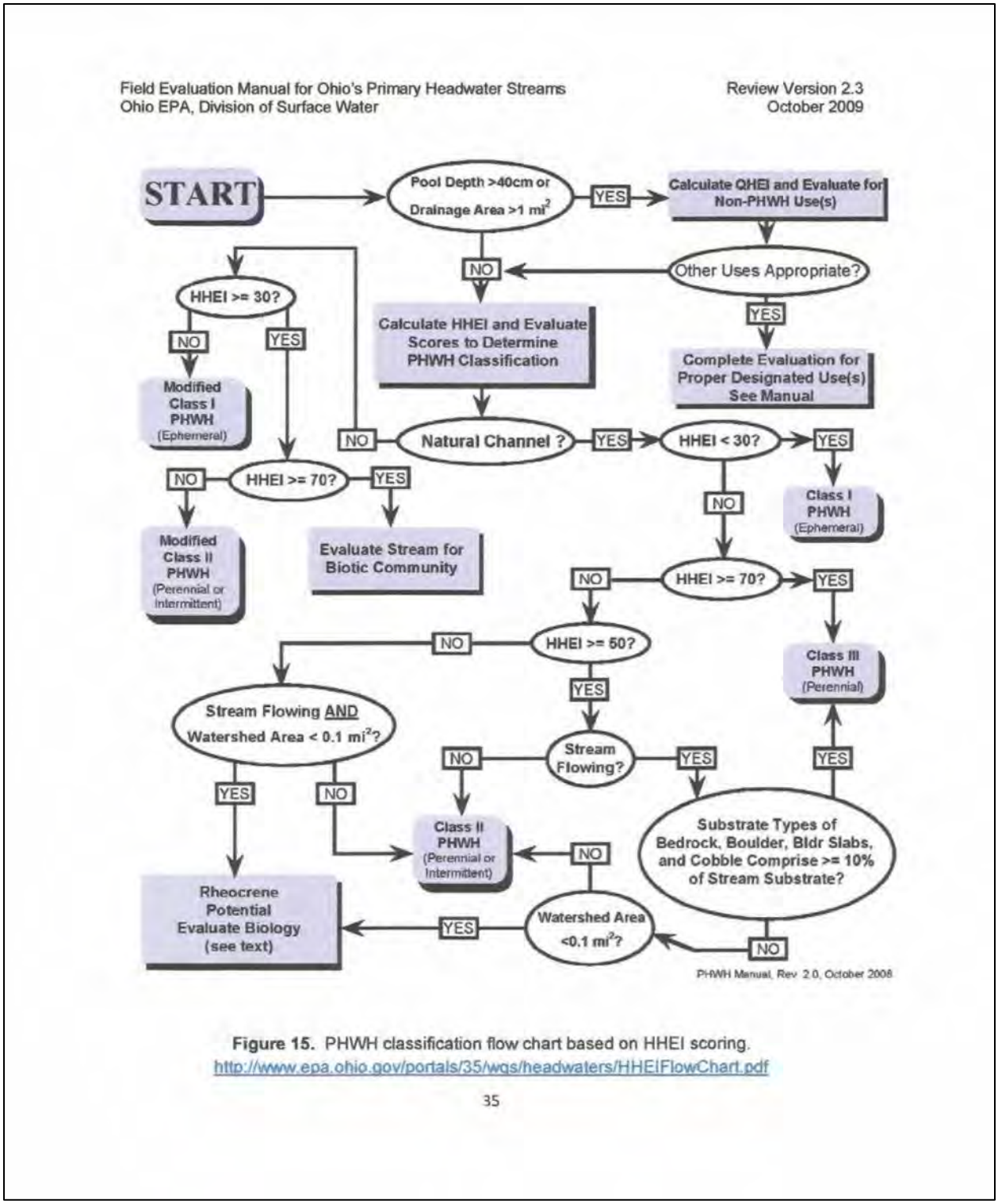

Figure 15. PHWH classification flow chart based on HHEI scoring.
http://www.epa.ohio.gov/portals/35/wqs/headwaters/HHEIFlowChart.pdf

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Figure 2-1. PHWH Classification Flow Chart Based on HHEI Scoring

Five reclaimed mine sites in Eastern Ohio containing reconstructed headwater streams were selected for scoring the HHEI on 200 foot reaches, where possible. These reconstructed streams ranged from ephemeral to intermittent streams and were representative of extraction activities of various coal seams with dissimilar lithology and a mixture of stream gradients. In addition, where possible in the drainage area below the reconstructed channels were selected in unmined streams to conduct biological testing on 200 foot reaches. Based on the river continuum concept[2] it is important to evaluate the adaptation of the biological communities as you move downstream. Streams change with increasing stream order, discharge and watershed area. Lower order streams in the headwaters that are typically shaded which provide course particulate organic matter from terrestrial sources and the energy base for consumers [3].

In addition, the chemical water quality, in comparison to target values, and floodplain soil tests at two sites were also conducted. At both the reconstructed and biological stream reaches, when feasible, seasonal water samples were collected by DMRM hydrologists and submitted to the DMRM's EPA certified laboratory to analyze typical mining effluent parameters. These results were compared to the coal mining NPDES technology based limits.

A comparison was also made between trapezoidal rock channel construction (a common practice post-1973 at many mine sites particularly for slopes greater than 4%) and the more modern approach of natural channel design (an innovative practice that began in Ohio post-2000 at slopes less than 4%).

A hand auger was used to obtain soil samples from the flood plain zone at three of the sites which included both the reconstructed stream and the biological site, which were submitted for laboratory testing. The results from the laboratory testing from the reconstructed streams

segments and biological stream segments were compared along with data obtained through the USGS Web Soil Survey.

2.1 Background Data Collection

Archived background file data from older C series permits was obtained from the Ohio Historical Society (OHS), and the more recent D series permits were obtained from files housed by the DMRM. Permit information was limited for C permit series and pertinent data was copied from the OHS files. Information from the more recent D permit files included pre-mining water quality data. DMRM had previously provided to OSU researchers Geographic Information System (GIS) files including shape files for abandoned mined lands and reclaimed C and D permits. GIS data was utilized to depict stream segment locations, area of the subwatershed mined, and pertinent distances between the stream segments.

2.2 Use of the Manual's HHEI Rapid Assessment

The Manual is designed to be used to evaluate streams with either continuous or periodic flowing water or a watershed area of less than one square mile and maximum pool depths less than 15.7 inches. The Manual uses the HHEI as a rapid assessment to determine the potential of aquatic life use based entirely on physical measurements. The assessment was conducted at the reconstructed stream segments and at the biological stream segments. By design there is a high probability of over-classifying a stream (class I-III); thus there is an increased confidence when the HHEI is accompanied with a biological evaluation of the stream. During the summer evaluation period there was generally a lack of water flowing in the reconstructed streams so biological evaluations were limited to two of the reconstructed stream sites.

At the reconstructed stream segments the physical data collection was completed with a total station survey instrument and traditional survey equipment (metal tape, rod, level, etc.). Bankfull width was determined in the field by OSU researchers by evaluating the stream morphology and associated indicators for bankfull width conditions. The sinuosity of the stream segment ranges from none to greater than three as measured by the number of bends per 200 ft. of channel.

All HHEI and HMFEI forms for biological and reconstructed streams are contained in Appendix C and referenced throughout the report.

2.3 Use of the Manual's HMFEI Biological Assessment

According to the Manual the overall condition of the benthic macroinvertebrate community can be evaluated using a modified version of the ODNR Stream Quality Monitoring scoring system for the State Scenic Rivers program. This methodology for PHWH streams is referred to as the HMFEI. This is a rapid bio-assessment field sampling method designed by staff at OEPA and has proven to be a good predictor of the various classes of streams in Ohio. HMFEI sampling was conducted on the unmined headwater stream reaches downstream or in close proximity(D-0958) to the reconstructed streams that had suitable habitat for sampling(riffles present), and at two of the reconstructed stream segments (D-0807 and D-0958).

Sampling was conducted using a D-framed net and where possible, a kick seine. The reaches were sampled from downstream to upstream kicking and jabbing all suitable habitats. All organisms collected were preserved in a solution of 70% alcohol. Voucher specimens of crayfish, fish, and salamanders were collected and preserved in separate jars. The samples were analyzed for identification down to the family level for all the macroinvertebrates using a stereoscope. Former Ohio EPA biologists, Roger Thoma and James Grow, assisted OSU's

consultant in identifying the crayfish, fish, salamanders and macroinvertebrates down to the species level. Once completed, the samples were scored using the macroinvertebrate scoring system. The scoring system for the HMFEI as developed in the Manual by OEPA follows:

- *IF Final HMFEI Score is > 19, Then CLASS III PHWH STREAM*
- *IF Final HMFEI Score is 7 to 19, Then CLASS II PHWH STREAM*
- *IF Final HMFEI Score is < 7, Then CLASS I PHWH STREAM*

Taxa data is contained in Appendix D.

In addition physical HHEI measurements were collected at the biological sites using traditional steel tapes and levels to measure the flood plain width, bankfull width, maximum pool depth, and stream gradient along with visual assessment of the stream segment substrate.

2.4 Use of DSWC Spreadsheet and USGS StreamStats

OSU researchers relied upon a suite of spreadsheet tools including the STREAM Modules, developed by the ODNR and OSU, and housed on the ODNR, Division of Soil and Water (DSWR)website. The main purpose of the spreadsheet is to aid in the analysis of geomorphology and hydraulic data that are obtained by making measurements along a reach of a wadable channel system. The channel system can be natural, modified, or constructed and does not necessarily need to be a “reference” reach. However, the spreadsheet is the most useful when data collection includes measurements on distinct bankfull fluvial features.

This ongoing project began in 1998 and currently freely provides various modules and spreadsheets of which the following modules were utilized during the course of this study[4]:

1. Reference Reach Spreadsheet for reducing channel survey data and calculating basic bankfull hydraulic characteristics,

2. Regime Equations for determining the dimensions of typical channel form,

3. Meander Pattern that dimensions a simple arc and line best fit of the sine-generated curve.

This spreadsheet allowed our team to input survey data taken in the field and model the stream reach's cross section, and it has the capability to depict the stream in elevation and plan view.[4] Utilizing the stream spreadsheet created by DSWC a geomorphic analysis was conducted using the data collected in the field and inputted into the spreadsheet. For each reconstructed stream segment surveyed three cross sections were taken, however only one is depicted in the report. Appendix B contains the associated spreadsheet data for the streams measured. This spreadsheet accounts for all the geomorphic characteristics of a stream segment, substrate, pool depth, bankfull width, stream gradient, and sinuosity which provides important data for the overall HHEI score.

The drainage area acreages and other important data, such as percent forest and flows, were obtained using the USGS StreamStats website[5] . According to Ohio State University's Professor Andrew Ward, the Ohio StreamStats website is one of the better developed sites in the nation (Greg Colton is the USGS developer for StreamStats in Ohio).

2.5 Soil and Water Quality data

Where reconstructed floodplain soils on low gradient streams were encountered, particle size laboratory testing of soils compared to soil profiles at unmined biological stream segments was performed. This data was compared to USDA web soil maps. DMRM staff collected water quality data at both the reconstructed streams, upstream and downstream of the stream reach, and

a representative sample for the biological stream segment. The water quality data collected by DMRM staff was then compared to the NPDES limits for coal mining.

2.6 Use of Stream Evolution Model

Numerous stream classification and channel evolution studies have been completed. One of the most recent notable is the work by Rosgen. Another researcher Simon, who worked for the USDA, Agriculture Research Service developed a stream evolution model 1986. This model has applicability to this study because it is helpful to understanding channel evolution associated with human intervention[6]. In this model, the pre-modified channel is assumed to be in equilibrium(stable) prior to man induced impacts (stage 1). The Stage 2 construction phase is an instantaneous man induced event, such as realignment and reshaping the banks, or in this case we apply the model to mining affected streams.

Rapid degradation occurs during Stage 3 phase as the channel deepens and the bed slope flattens. This causes instability and failures as the channel widens, and bank heights cause shear stresses affecting the bank material(Stage 4). Stage 5 is the aggradation phase as the stream is able to transport increased sediment loads. However, the stream will eventually reach a state of quasi equilibrium; a stable channel similar to the pre-disturbance channel(Stage 6)[12]. This model is applied to the reconstructed stream segments in this study by observing the morphological changes and cross section data as the reconstructed stream evolves along a timeline to a state of quasi-equilibrium.

3 CENTRAL OHIO COAL CO. C-209

3.1 Background and Location

Area mining and contour mining was conducted in the 1970's primarily with COCCO's Big Muskie dragline (one of largest draglines operating in the world at the time on various permits within the watershed). At this permit the mine spoil was graded to approximate original contours(AOC) and covered with eight inches of resoiling material. Six hundred and eighty three acres were affected on the permit, and mining was completed in 1979 (Figure 3.1).

submitted the application to the DMRM in December 1975 for a site located in Muskingum County, Meigs Twp. The application included a three year mining plan with 538 acres proposed to be affected in year 1, 275 acres in year two, and 153 acres in year three, for a total of 966 acres. The application was approved in April 1976, and included a bond rate of $ 4,300 per acre. The company deposited $2.3 million worth of bonds with the Division of Reclamation for the first year acreage. The company estimated reclamation costs to be approximately $2,800 per acre. In the application the company described the land use prior to mining as a pattern of forest brush and pastureland. The intended future use for the land was a grass vegetated cover for cattle grazing. The mining and reclamation plan proposed that mining would be completed within 12 months for each yearly segment and grading would begin within 90 days following completion of mining. Resoiling to a depth of eight inches would be completed six to 12 months after grading for each yearly segment. This would be followed by re-vegetation of the affected area the growing season during re-soiling or the first growing season

following resoiling. Fifty nine pounds of seed per acre were sowed that included a mixture of grasses and legumes. Lime and fertilizer were added per the soil tests performed.

The mining equipment included dozers, scrapers, a 45 cubic yard Marion shovel, and a 12.5 cubic yard dragline. The company conducted contour mining of the # 9 coal seam, using pan and dozer operation for the first cut, with subsequent cuts placed in the previous cut after coal removal using the Marion Shovel. All toxics encountered were placed at the bottom of the spoil and buried. Backfilling and grading were completed using D9 G Cat dozers, 41 dozers, and Cat scrapers. The final map date was June 8, 1979 with a final acreage of 683 to be reclaimed (Figure 3-1).

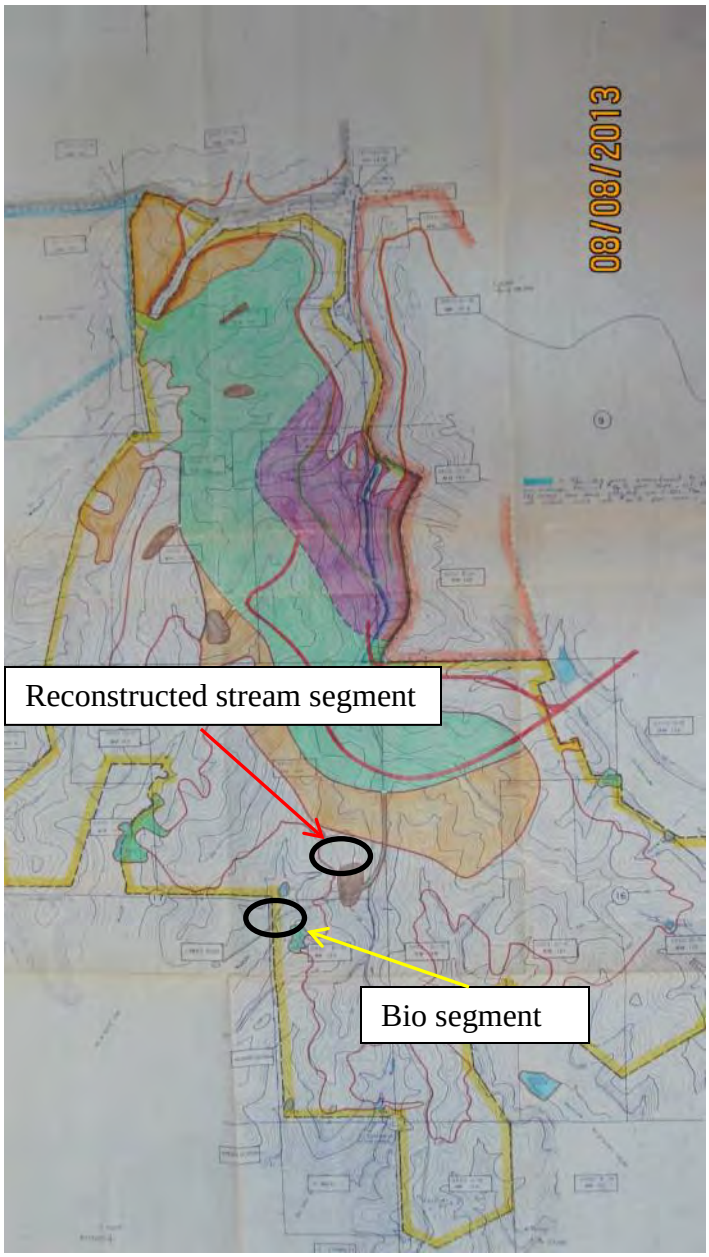

Figure 3-1. C-209 Final Permit Map and Locations of the Physical and Biological Sites

This reconstructed stream segment on Permit C-209 is located in Muskingum County within the Meigs creek watershed (Figures 3-1 and 3-2).

Figure 3-2. C-209 Reconstructed stream segment

The tributary watershed is depicted in Figure 3-3 below. These stream reaches were analyzed at this permitted site. The orange line is representative of the area of the watershed of the tributary that intersects the area of the C-0209 affected area. This area is roughly 68 acres. The overall area of the watershed is about 166 acres, and 41% of the watershed area was affected by mining on the permit C-0209. The USGS topographic map indicates this stream is an intermittent stream, however the reconstructed stream segment was measured at the extreme headwaters of the stream and exhibits characteristics of an ephemeral stream.

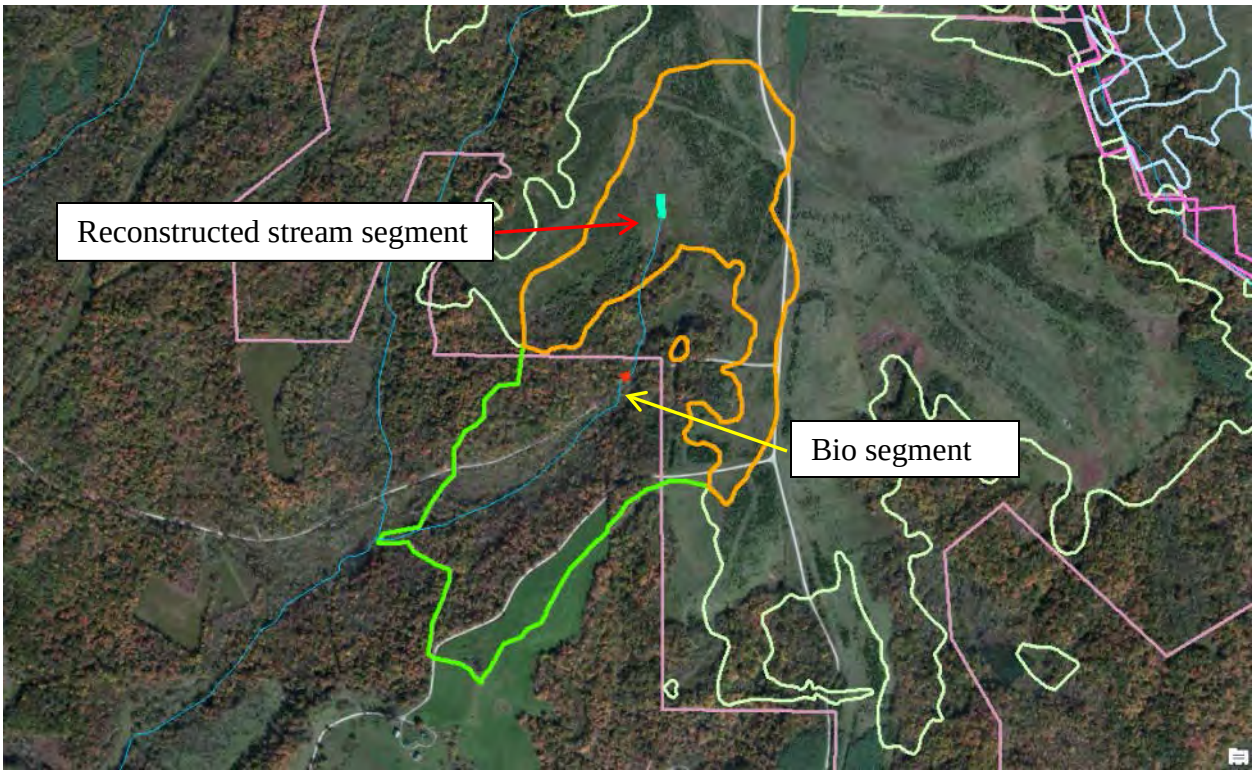

Figure 3-3. Watershed of C-209 permit

Figure 3-4. Upper reach of Reconstructed Stream Channel - MK/Meigs Watershed/C-209/SR #1

Figure 3-5. Lower reach of Reconstructed Stream Channel - MK/Meigs Watershed/C-209/SR #1

Figure 3-6. Cattails at bottom of Reconstructed Stream Channel

3.2 Reconstructed Stream Segment Analysis

The reconstructed stream reach has a drainage area of 0.12 square miles, and overall the drainage area is 0.26 square miles including both the reconstructed channel and the biological site. This number was attained using the StreamStats Ohio website. The reconstructed stream reach has a slope of 13% and receives an annual mean precipitation of 37.4 inches. This reach was designed and constructed as a typical trapezoidal channel.

The top half of the stream segment there was well vegetated with grasses and legumes and small invasive tree species, but the tree growth increases dramatically downstream (Figure 3-4). This may be attributed to the increased availability of both surface and groundwater as the stream segment approaches the outcrop of the underclay beneath the # 9 coal seam. This underclay acts as an aquitard and can be the location of seep areas observed at the lower end of the reconstructed stream segment (Figure 3-6). At the bottom half of the stream segment, OSU researchers observed trees of varying variety and circumferences thriving in the zone above the bankfill width, the flood plain zone, and adjacent riparian zones (Figures 3-4 and 3-5). Of

notable size was an ash tree with a circumference of 25”, an elm tree with a circumference of 38”, and other similar trees with circumferences of 32”, 44”, and 29” (Figures 3-7 & 3-8), along with varying sizes of hardwoods and conifers.

Figure 3-7 and Figure 3-8. Trees located in Reconstructed Stream Channel - MK/Meigs Watershed/C-209/SR#1

The physical survey of C-209 was conducted on December 1, 2013. The channel substrate was composed of four types; gravel, sand, clay or hardpan, and artificial. The majority of the substrate was labeled artificial representing 65%, (rock rip-rap) while second most dominant was clay or hardpan representing 25%.

Maximum pools in the stream were recorded on two different dates. The first recording was taken on August 15, 2013 with a maximum pool depth of seven cm. The second measurement was taken on December 1, 2013, and the maximum depth was 8.9 cm. The depths of these pools fluctuate throughout the year, however, the Manual indicates the preferred time for sampling pool depth is between June and September. Therefore, using the summer reading, the flow regime was classified as interstitial or subsurface flow with isolated pools. For most of the stream segment length there appeared to be no observable flow. As one proceeds downstream, the vegetation and the flood plain increased. At the lowest point of the stream reach

water was seen flowing as seeps, most likely attributed to the less permeable underclay located below the coal seam mined in the area(Figure 3-6).

Further geomorphic analysis of C-209's stream segment was completed using the DSWR spreadsheet where field measurements could be recorded and depictions created of the bankfull width, sinuosity, and stream gradient. The cross section view was created using the DSWR spreadsheet (Figure 3-9). The blue line in this figure represents the segment's bankfull width, and the red line depicts the flood prone width.

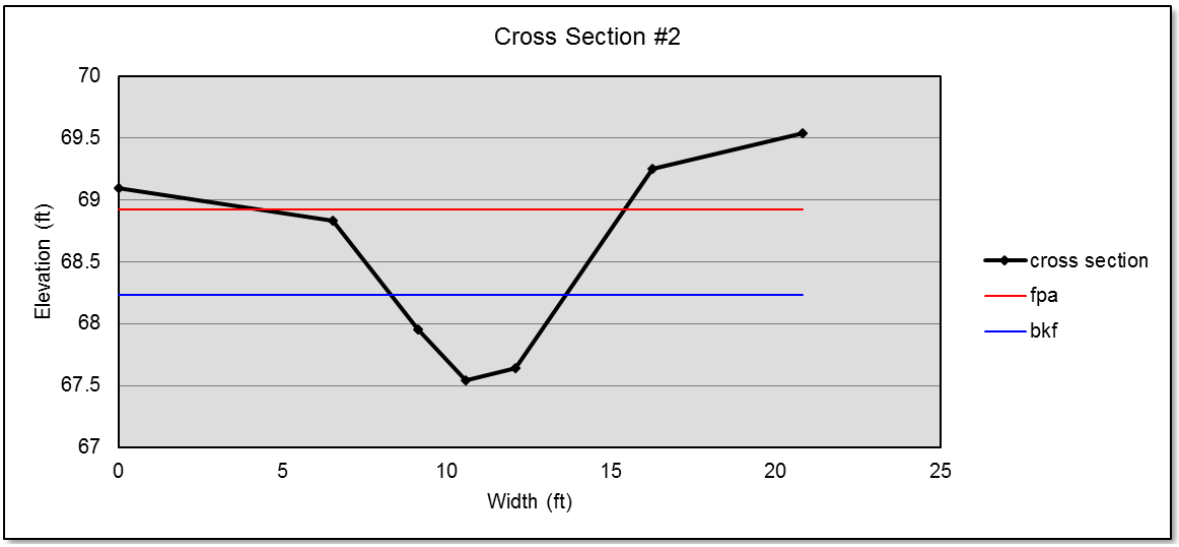

Figure 3-9. Ohio Power C – 0209 Cross Section #2

The average of the three bankfull widths of this reconstructed stream segment is 5.7 feet, and sinuosity was calculated to be 1.0(one bend per 200 feet). The stream gradient was a severe 12.6% slope. The HHEI score for the reconstructed stream on permit C-209 is 32. Using the Manual's stream matrix (Figure 2-1) this stream segment can be classified as a Modified Class II PHWH (Perennial or Intermittent). Considering the slope of the stream segment and the lack of observable flows, this stream segment exhibits characteristics more closely associated with an ephemeral stream and perhaps, should be classified as a Modified Class I stream. Given the

reconstructed stream's gradient (12.6%), lack of stream flow, and low HHEI score no biological sampling at this stream reach was conducted.

3.3 Biological Stream Segment Analysis

The bio site has a water shed area of 0.26 miles and sampling in the unmined stream, which is about a third of a mile downstream below the C-209 reconstructed site, was conducted on July 23, 2013 by OSU's consultant and ODNR, DMRM's intern (Figure 3-10).

Figure 3-10. OSU's Consultant Max Luehrs and DMRM intern Cassie Morrison conducting biological sampling at C-0209 site

The unmined stream had a fair to good flow downstream from the mined areas and the habitat also appeared to be good. The steam reach was 175 feet in length because the upstream end was restricted by a rectangular concrete spillway associated with an existing pond(Figure 3-13). This pond may have been an existing farm pond used for sediment control during mining since concrete spillways were not typical of sediment ponds proposed in coal mining applications .

Macroinvertebrate sampling was conducted on the headwater stream reach with riffles

present indicating suitable habitat for sampling (Figure 3-11 and 3-12). Voucher specimens of crayfish, fish, and salamanders were collected and preserved in separate jars. In addition there were Creek Cubs and Black Nosed Dace present.

Once species identification was completed; the samples were scored using the OEPA's macroinvertebrate scoring sheet. Sample ML-13-004 scored a 25, which exceeded the minimum of 20 needed for a Class III headwater stream. Class III streams are considered suitable for cool to cold water adapted aquatic species.

Figure 3-11. Lower reach Biological site /MK/Meigs watershed/C-0209/SS#1

Figure 3-12. Upper reach Biological site / MK/Meigs watershed/ C-0209/ SS # 1

Figure 3-13. Sediment pond located above Biological site /MK/Meigs watershed/C-0209/ SS # 1

The HHEI evaluation was completed on July 23, 2013. The substrate metric was estimated by allocating a percentage of every type of substrate present in the stream reach. There were five different substrate types observed; boulder at 20%, bedrock at 8%, cobble at 60%, gravel at 6%, and sand at 6%. From these percentages, the two most predominate substrate types were boulders and cobble resulting in a score of 33 for the substrate metric. The maximum pool depth was determined by averaging three measurements of 5.5”, 6”, and 7” which yielded an average of 6.17inches . The maximum pool depth metric scored 25 points. The final metric used in calculating the HHEI score was the bankfull width (BFW) metric. The bankfull width was determined by averaging the BFW measurements of 17’-9”, 19’, and 18’-4” which resulted in a bank full width of 18 feet and 4.5 inches and a metric score of 30. The overall HHEI score for the C-209 biological stream segment is 88. Using the OEPA stream matrix (Figure 2-1) this stream segment can be classified as a Class III PHWH (Perennial).

For the riparian zone, there was a riparian width of greater than 10 meters on the left bank and a riparian width of five-10 meters on the right bank. On both banks of the biological stream reach the floodplain consisted of a mature forest or wetland. At the time of the reach observation the stream was flowing. The stream had an observed sinuosity of greater than 3 and an observed stream gradient of between 2 feet/100 feet and 10 feet/100 feet which is moderate to severe as per the HHEI scoring sheet.

3.4 Water Quality Data for C-209 Biological and Reconstructed Stream Reaches

Geochemical sampling of the biological collection area and the downstream reconstructed stream segment was conducted on August 15, 2013 by DMRM’s hydrologist(Figure 3-14).

Samples were analyzed for mining parameters required in Ohio Administrative Code 1501:13-4-04(E) permit application requirements for information on environmental resources, surface water information. The ODNR DMRM environmental laboratory in Cambridge, Ohio analyzed the water samples for the following parameters: Total Acidity, Total Alkalinity, Total Aluminum, Total Iron, Total Manganese, pH, Specific Conductivity, Total Sulfate, Total Dissolved Solids, and Total Suspended Solids (Table 3-1). Results were compared to the Ohio EPA's NPDES reporting in the General Coal permit. All results were below the limits set in the Coal General NPDES permit. The NPDES limits for the following parameters are: pH of higher than six and lower than nine standard units, less than 80 mg/L of Total Suspended Solids (TSS), less than six mg/L of iron, and less than four mg/L of manganese. The analytical result reported for aluminum, iron, and manganese were very low compared to water that has been impacted by mining operations. Sulfate levels in the reconstructed stream channel and the biology sample location were still high for land that has been mined and reclaimed for an extended period of time. Mining techniques of the area are the most likely cause of the elevated sulfate values. The area mining conducted with the large shovels was a highly destructive method of extracting coal. The reclamation requirements of the "C" law permits would result in less topsoil cover on the disturbed areas of the permit. These differences in mining technique and reclamation could result in an overall higher sulfate level in the area.

Table 3-1. C-209 Water Quality Data

Site Name	Sample ID	Date	pH	acidity	alkalinity	TDS	TSS	Sulfate	Iron	Manganese	Aluminum	SC
C-209	C-209 BIO	8/15/2013	7.98	10.5	277	2440	46	1457	1.36	1.43	1.47	2510
	C-209 Downstream	8/15/2013	7.51	23.7	348	2670	5	1610	0.43	0.988	0.102	2790

Figure 3-14. Location of water sampling and soil boring at C-209

3.5 Soils Data for C-209 Reconstructed and Bio Stream Segments

Soil borings were conducted at the bottom third of the bio site in the flood plain zone (Figure 3-14) and at the bottom the reconstructed channel(Figure 3-15). The depth of the borings were approximately 12 inches.

Figure 3-15. Soil boring at bottom of reconstructed stream segment

According to the USDA Web Soil Survey following mining the reconstructed site contains Morristown silty clay loam with either eight to 15 percent slopes or 15 to 25 percent slopes, and the biological site contains the soil type Guernsey-Upshur silty clay loams, 15 to 25 percent slopes, eroded (Figure 3-16). Both of these soil types exhibit permeability that is moderately slow. This proves consistent with the results obtained from the laboratory testing where the reconstructed site exhibited a silty clay loam, and the biological site exhibited loam which encompasses all loam types (Table 3-2). This also confirms that the appropriate re-soiling materials were applied during the reclamation process.

Figure 3-16. Soil Map of C-209 Post Mining

Table 3-2. Particle Size Analysis C-209

Particle Size Analysis					
	(% of Total sample (wt/wt))				
	Coarse fragments	Total sand	Total silt	Total clay	
Sample	>2.0 mm	2.0-0.05 mm	50-2 µm	<2.0 µm	Textural class
C-209 Bio 1	8.3	27.0	46.1	26.9	L
C-209 SR1-2	3.0	13.5	56.8	29.7	SICL

3.6 C-209 Summary

The reconstructed stream segment had a HHEI score of 32, and when compared with the PHWH classification flow chart the stream segment is a Modified Class II PHWH (Perennial or Intermittent). The stream is an ephemeral stream and since the weight of evidence is lacking without a supporting biological assessment, the stream should be considered a Modified class I considering it's stream type in lieu of the Modified Class II using the HHEI score alone in this case. Using the "weight of evidence" approach, the combined HHEI score of 88 and the HMFEI score of 25 indicate that this downstream biologic stream segment is a Class III stream which is considered suitable for cool to cold water adapted aquatic species. The biological stream segment is located 1,700 feet downstream of the reconstructed stream channel and shows no impacts, or only minimal impacts, from mining and reclamation at the C-209 permit. After over 30 years following reclamation the tree growth in this reconstructed channel is excellent.

The original design of this reconstructed stream was a typical trapezoidal design used predominantly in the mining industry post 1973 to convey drainage over steep slopes. The large rock rip-rap placed in this reconstructed channel has become embedded in the soil and has provided an excellent environment for grass and tree growth within the bankfull width and the flood plain zone of the reconstructed stream channel. This may be attributable to the source of water concentrated in the channel during rainfall events and becoming available to plants as it seeps into the soils in the channel. Compared to bedrock prior to mining porosity of the mine spoil post mining also increases seepage that occurs in the lower section of the channel,. This tree cover in the headwaters provide riparian litter or course particulate organic matter(CPOM) that shredders and collectors feed on which provides the fine particulate matter that provides energy inputs to mid-order reaches[7]. Perhaps the CPOM produced at this site influenced the

Class III designation at the downstream biologic site.

It should be noted, however, it is not conclusive whether the trees were volunteers or planted by COCCO. American Electric Power, COCO's parent company, had conducted numerous carbon sequestration tree planting projects in the general area since the permit's release by the DMRM. The cross sections and observations of the reconstructed stream indicate the trapezoidal channel appears to form the characteristics of a two stage channel as a result of the morphological processes occurring over time.

The reconstructed stream has evolved to a state of quasi equilibrium(stable) and has recovered, where the wooded riparian vegetation is exhibiting significant recovery along the stream margin .

4 B&N COAL D-0958

4.1 Background and Location

This permit was a remining secondary coal recovery operation utilizing pan and dozers. It advanced and eliminated approximately 12,840 linear feet of unreclaimed highwall and extracted the #9 and 9a coal reserves (Figure 4-1). The site is located in Noble County, Jefferson and Elk Townships. Beginning in 1991, B & N Coal began removing the remaining coal reserves from the previously mined areas in the lower reaches of Rocky Run, a tributary of East Fork Duck Creek. The original issued permit called for 65 acres of mining, and upon completion the total amended area of the permit included 237 acres of affected area. Of this affected area, 81 acres were reclaimed through the remining of historic highwalls and pits representing 34% of the entire affected area (Figure 4-2).

The reclaimed land was re-vegetated to grassland/grazing land using a “forager fescue” seed mix. Undisturbed areas beyond the overlaying stratas above the auger areas contain trees such as hickory, walnut, oaks and beeches which had been left to maintain food sources for wildlife in the area. This permit included remining without the benefit of a modified NPDES effluent permit.

The location of the reconstructed stream segment and biological site are depicted in Figure 4-2. The natural drainage system was interrupted by past mining practices that left an unreclaimed highwall and pit complex, a mining practice very prevalent prior to 1973 (Figure 4-2). The Year 6 segment containing the reconstructed stream was planted in 1998 and released in 2003 by the DMRM.

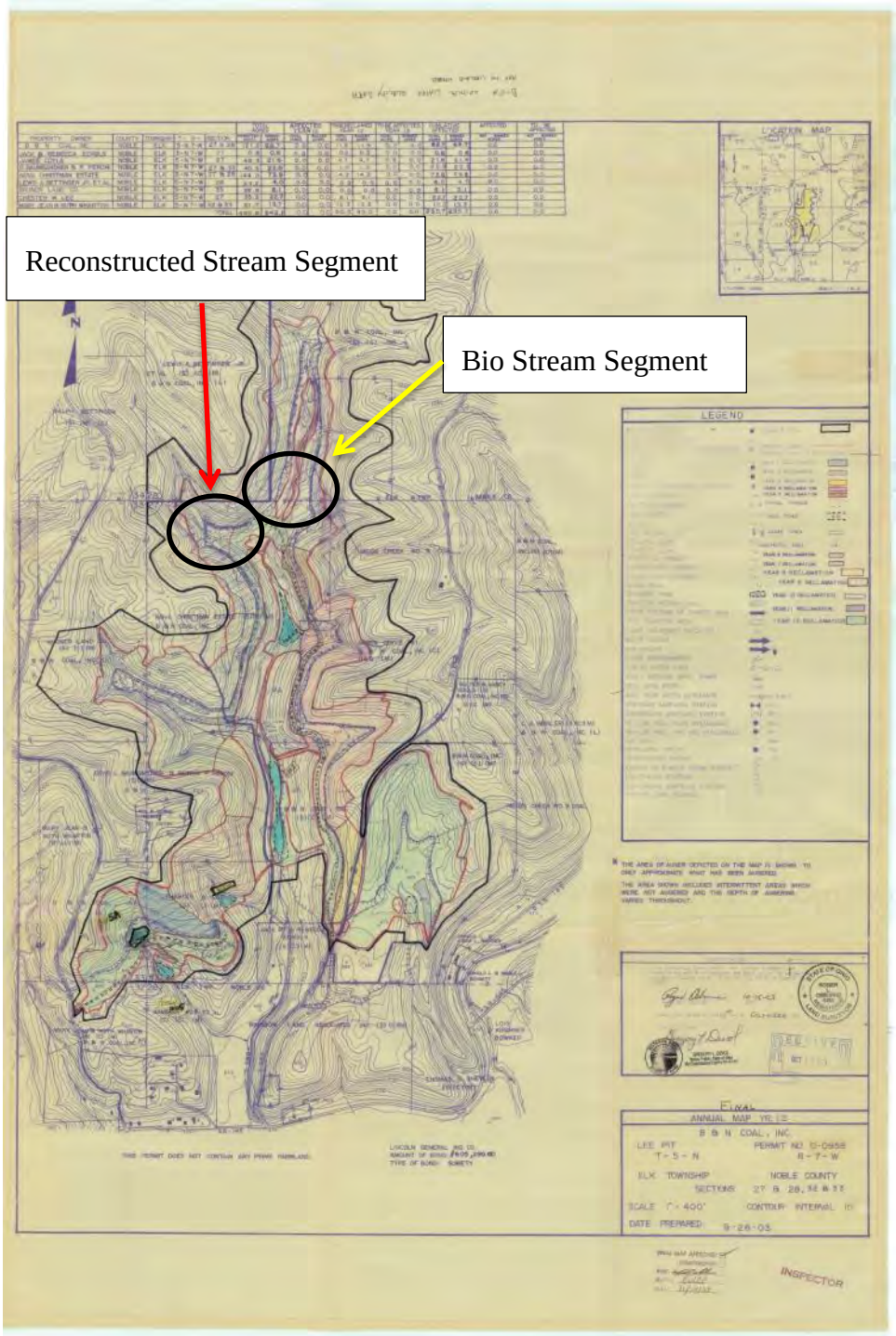

Figure 4-1. D-0958 Final Permit Map and Locations of Reconstructed and Biological Stream Segments

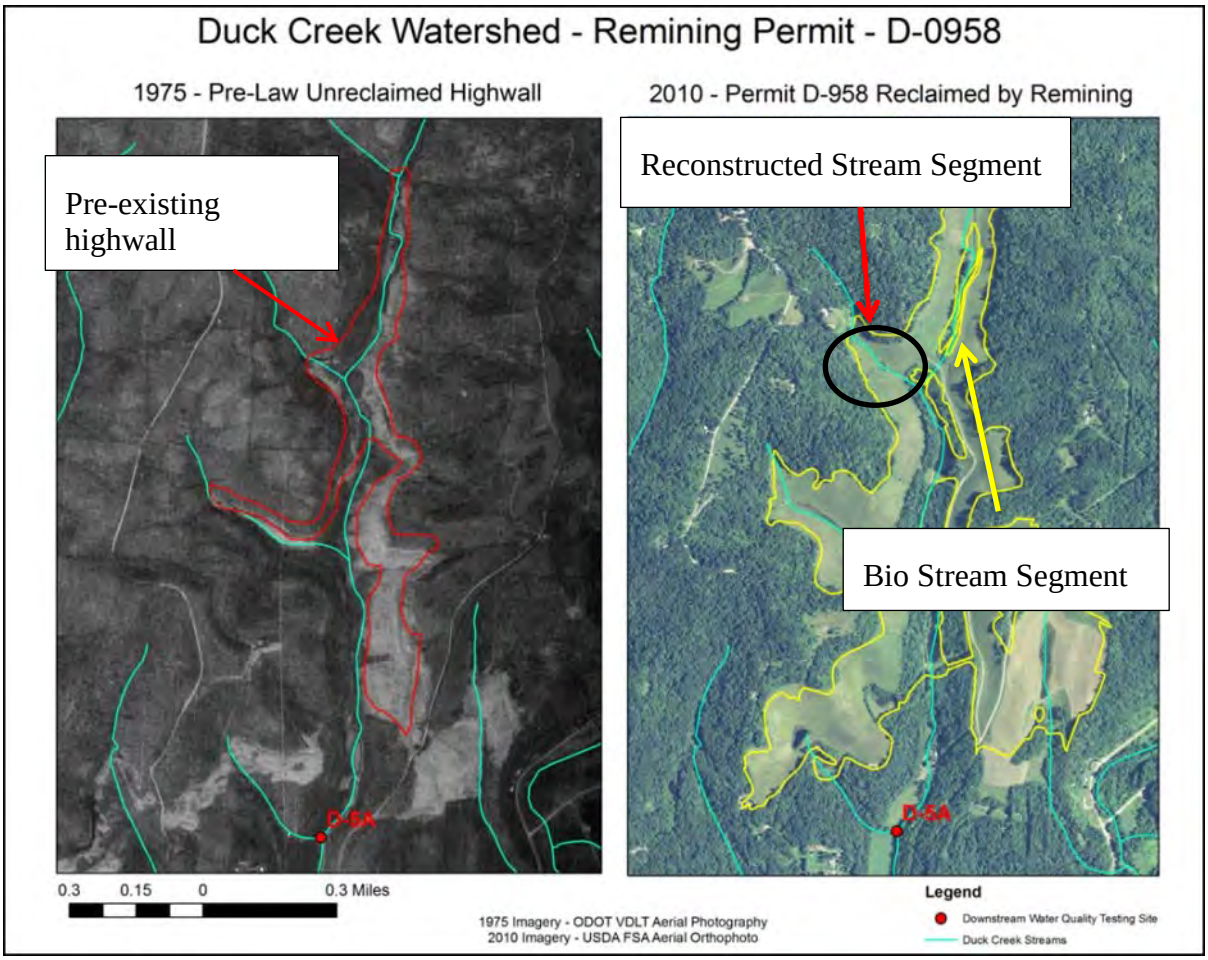

Figure 4-2. D-0958 Remining, Highwall Elimination, and Reconnected Stream (black oval)

Figure 4-3. Reconstructed and reconnected stream segment at D-0958

The reconstructed stream segment is located in the Rocky Run drainage area, a secondary order stream that lies within the East Fork Duck Creek subwatershed (Figure 4-3). Through the use of the StreamStats Ohio website it was determined the reconstructed stream reach has a drainage area of 0.14 square miles based on its location within the Rocky Run sub- watershed. Overall, the drainage area that includes both the reconstructed channel and the biological site is 0.7 square miles (Figure 4-4). The reconstructed stream reach has a slope of 1.5% and receives an annual mean precipitation of 39.7 inches. This reconstructed stream segment was field designed and constructed by B&N Coal Co. using DMRM's natural channel design guidelines for slopes less than 2%.

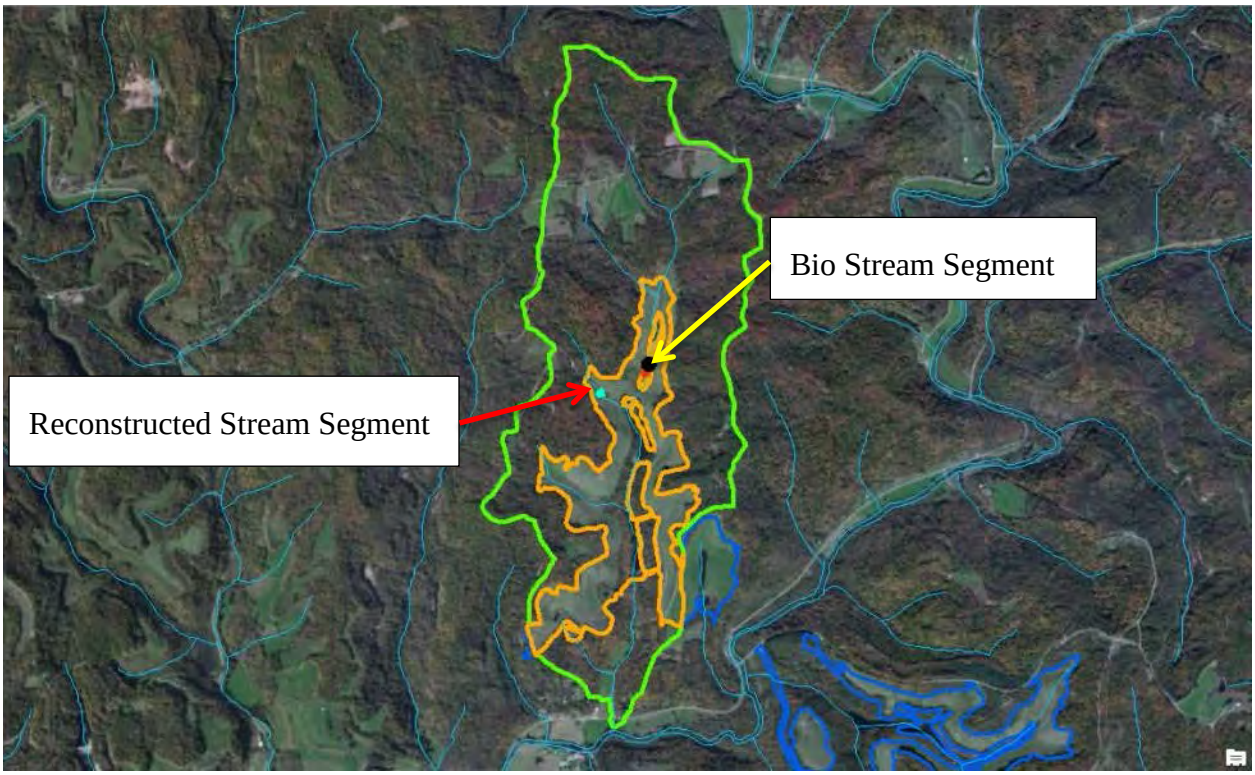

Figure 4-4. Permitted Affected Area with Tributary Watershed

The area encompassed in the orange line depicted in Figure 4-4 is representative of the watershed (1024 acres) intersecting D-0958's affected area. It encompasses 218.4 acres and represents approximately 21% of the watershed. The reconstructed watershed consists of 0.14 square miles, and approximately 0.031 square miles, or 22%, of the reconstructed tributary watershed affected by mining. The USGS topographic map indicates this stream is an perennial stream, however the reconstructed stream segment measured at the headwaters of the stream exhibits characteristics of an intermittent stream and is depicted as such on the application map.

4.2 Reconstructed Stream Segment Analysis

The survey for D-0958 was conducted on June 25, 2013. The channel substrate observed was composed of five types; boulder, cobbles, gravel, sand, and silt. The most dominate

substrates were silt and gravel combining for 62%. Maximum pool depths were recorded at six cm. The flow regime was identified as subsurface with isolated pools (interstitial).

Figure 4-5 depicts a cross section that is representative of our reach. The average bankfull width from the three cross section measurements is 8.8 ft. and sinuosity was calculated to be 1.9. The stream gradient was 1.5% which is considered flat to moderate. The compiled data results in a HHEI score of 47. Using the OEPA stream matrix this stream segment can be classified as a Modified Class II PHWH (Perennial or Intermittent).

Bankfull Dimensions	
0.9	x-section area (ft.sq.)
11.9	width (ft)
0.1	mean depth (ft)
0.1	max depth (ft)
12.0	wetted parimeter (ft)
0.1	hyd radi (ft)
162.5	width-depth ratio

Calculated BFW Flow: **76.608 cfs**
(BFW approx. 1-2 year RI)

Stream Stats Peak 2 year Flow: **98.1 cfs**

Percent Error: **21.91%**

Figure 4-5. D-0958 Cross Section

Figure 4-6. D-0958 Reconstructed stream segment

As can be seen from the cross section in Figure 4-5, the stream is bifurcated and numerous wetland species have invaded several sections of this reconstructed stream as well as volunteer trees in the riparian corridor (Figure 4-6). There is no evidence of erosion of the grass and legume cover which appears to be well established.

On June 4, 2014 OSU's consultant sampled the reconstructed stream channel for macroinvertebrates. Crayfish collection was stopped once abundance was established. Three mayfly taxa and four stonefly taxa were collected which largely accounted for the Ohio EPA macroinvertebrate index score of 28. This classified the reconstructed stream as a Class III headwater stream. The stream appears to be in quasi-equilibrium.

4.3 Biological Stream Segment Analysis

The adjacent unmined stream segment was selected in consultation with DMRM hydrologist since a suitable downstream site from the reconstructed channel was limited by the construction of large permanent pond downstream. The adjacent biological site had approximately 21% of the drainage area mined. The reconstructed channel had approximately 22 % of the drainage area mined. Therefore, it is reasonable to assume the results should be

indicative of downstream biotic communities if a pond were not present below the reconstructed stream segment that prevented the establishment of a downstream biological site.

The HHEI Form and a biotic community score was used to evaluate the D-0958 biological stream reach in a stream that is adjacent to the reconstructed stream.

The drainage area for this biological site is .7 square miles and of this area, about 21 % of it has been mined. The HHEI evaluation was completed on June 19, 2013. The substrate metric is estimated by allocating the percentage of every type of substrate present in the stream reach. There were four different substrate types; boulder at 20%, cobble at 35%, sand at 20%, and silt at 25%. From these percentages, the two most predominate substrate types were silt and cobble resulting in a score of 19. The maximum pool depth was calculated by averaging the measurements of 5.5”, 4”, and 4” which yielded an average of 4.5”. The maximum pool depth metric scored 25 points. The final metric used in calculating the HHEI score was the bank full width (BFW) metric. The bankfull width was calculated by averaging the measurements of 8’-5”, 7’-5”, and 10’-4” which resulted in a bank full width of eight feet and eight inches with a metric score of 20. The overall HHEI score for the D-0958 biological site is 64. Using the OEPA stream matrix (Figure 2-1), this stream segment can be classified as a Class III PHWH (Perennial).

There was a riparian width of five-10 meters on both sides of the stream. On both floodplain banks of the biological stream reach there were either mature forests or wetlands. At the time of the reach observation the stream was flowing, had an observed sinuosity of two curves per the stream reach length, and an observed stream gradient of moderate to severe (between 2 ft/100 ft and 10 ft/100 ft).

OSU's consultant conducted biological sampling on June 19, 2013. The stream had a fair to good flow and the habitat appeared to be good (Figure 4-7).

Sample ML-13-002 was taken and later analyzed using the Manual's scoring metric resulting in a score of 28, easily exceeding the minimum score of 20 for a Class III headwater stream. There were three mayfly families represented with four different taxa, which is unusual in streams coming from mined areas. Class III streams are considered suitable for cool to cold water adapted aquatic species. In addition there were crayfish and a larval Northern Two-lined Salamander found.

Figure 4-7. Biological stream segment at D-0958

4.4 Water Quality Data and Particle Size Analysis for D-0958 Bio and Reconstructed Stream Reaches

Intermediate flow geochemical sampling was conducted on June 25, 2013 by DMRM's hydrologist. A surface water sample was collected from the "Upstream" and "Downstream" locations of the reconstructed stream channel, while another was collected from the middle of biology sample area(Figure 4-8). Samples were analyzed for mining parameters required in

Ohio Administrative Code 1501:13-4-04(E) permit application requirements for information on environmental resources, surface water information. The ODNR DMRM environmental laboratory in Cambridge, Ohio analyzed the water samples.. Results were compared to the Ohio EPA technical based limits for NPDES reporting in the General Coal permit. All results were below the limits set in the Coal General NPDES permit. The analytical result reported for aluminum, iron, manganese, and sulfate were very low compared to water that has been impacted by mining operations (Table 4-1). The water quality in the reconstructed stream channel was slightly better in quality than the biology sample area, with less sulfates and total dissolved solids. This may be attributable to two factors; 1) the stream was reconnected allowing water from above the previous mining area to flow into the reconnected stream as a result of remining, and 2) the biological site was adjacent to the reconnected stream and not located downstream, which incorporates more variables in the drainage area.

Table 4-1 also compares the results from the pre-mining data collected for the coal application to the samples collected in the reconstructed stream channel(Figure 4-1). Overall the geochemical analysis has increased in quality. Total acidity in the stream channel has been eliminated, while alkalinity has increased. Sulfates in the reconstructed channel have also decreased by 50%. The increase in total iron is slight and not an impact to the environment; it can be attributed to the increased suspended solids in the samples collected. Remining of this site along with the reconstructed stream channel has provided a mitigating effect of the previous mining condition.

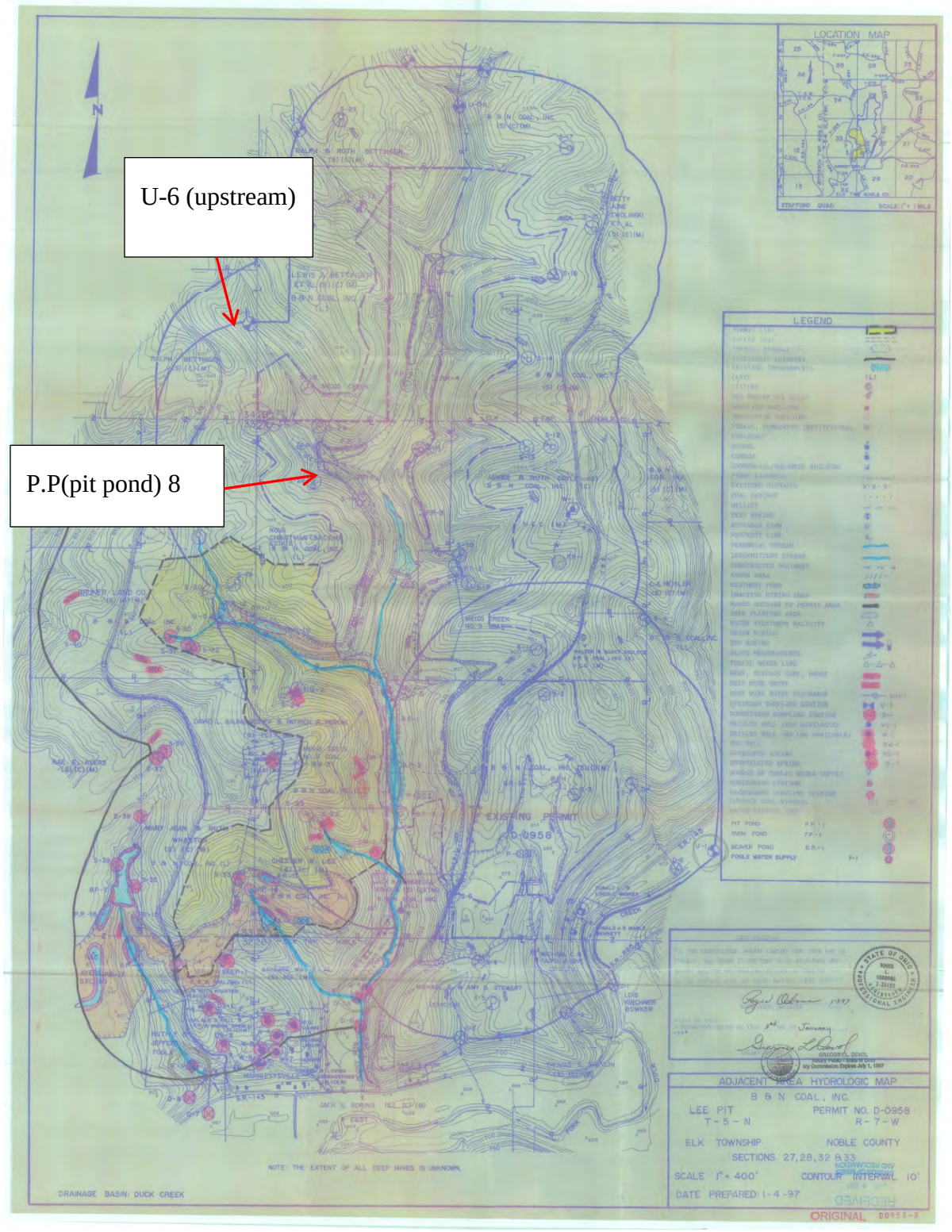

Figure 4-8. Location of pre-mining chemical water sampling at D-0958

Table 4-1. D-0958 Water Quality Data

Site Name	Sample ID	Date	pH	acidity	alkalinity	TDS	TSS	Sulfate	Iron	Manganese	Aluminum	SC
D-958	Pre Mining Upstream U-6	3/5/1992	8.1	12	148		10	48	0.12			270
		3/31/1992	8	8	136		12	50	0.15			280
	Pre Mining Downstream P.P. 8	3/5/1992	7.8	24	112		8	42	0.15			270
		3/31/1992	7.6	18	128		10	38	0.15			250
	D-958 Downstream	6/25/2013	8.44	0	163	200	24	27.4	0.276	0.032	0.505	367
	D-958 Up Stream	6/25/2013	8.07	0	199	245	36	28.3	1.14	0.123	2.3	429
	D-958 BIO	6/25/2013	7.82	2.38	255	620	6	255	0.386	0.362	0.087	960

4.5 Soils Data for D-0958 Reconstructed and Bio stream segments

Soil samples were taken in the flood plain zone at both the reconstructed stream and the biological site and sent to the laboratory for analysis. The reconstructed site exhibited a silty loam/silty clay loam and the biological site presented silty loam (Table 4- 2). According to the USDA Soil Survey, mining at the reconstructed site at D-0958 had 35 to 70% grades, and the soil type Gilpin-Upshur complex. The biological site had 25 to 70% grades, stone filled stream beds, and the soil type Barkcamp Channery sandy loam (Figure 4-9). This is consistent with the laboratory results. This also confirms that appropriate re-soiling materials were applied during the reclamation process.

Figure 4-9. Soil Map for D-0958

Table 4-2. Particle Size Analysis D-0958

Particle Size Analysis					
	(% of Total sample (wt/wt))				
	Coarse fragments	Total sand	Total silt	Total clay	
Sample	>2.0 mm	2.0-0.05 mm	50-2 µm	<2.0 µm	Textural class
D-958 Bio1	4.7	20.7	56.1	23.2	SIL
D-958 SR-1	0.9	10.6	69.9	19.5	SIL
D-958 XS-C	10.4	8.4	54.4	37.2	SICL

4.6 D-0958 Summary

The reconstructed stream segment HHEI Score was 47 and is classified as a Modified Class II PHWH intermittent stream, however a subsequent HMFEI score of 28 would classify the stream as a Class III stream. For the D-0958 biological site, a HHEI score of 64 was

calculated making the stream a Class II PHWH perennial/intermittent stream. At certain times during the summer low flow season water is not flowing in the channel, but isolated shallow pools are still present and measurable. Using the “Weight of Evidence” approach, the combined HHEI scores of 47 and 64 and HMFEI scores of 28 for both biological and reconstructed sites indicate the reconstructed stream segment and the biologic stream segment are Class III streams which is considered suitable for cool to cold water adapted aquatic species. This biologic stream segment is located 1,320 feet adjacent to the reconstructed stream channel and shows no apparent, or only minimal, impacts from mining and reclamation at the D-0958 permit. The cross sections and observations of the reconstructed stream indicate the natural channel design construction appears to form the characteristics of a two stage channel as a result of the morphological processes occurring over time. The intermittent stream is in a state of quasi-equilibrium recovering for 11 years after the stream reconstruction. It is also notable that this is a remining site that eliminated approximately two and one half miles of existing pre-law highwall. This resulted in returning surface water from overland flows and reconnected streams more directly to the receiving streams as a result of remining and reclamation of the land to AOC. See Chapter 9 for a more detailed discussion of the remining and water quality improvement at this permit through the process of remining.

5 B&N COAL D-0807

5.1 Background and Location

B&N Coal Co. submitted the application to the Division of Reclamation for a site located in Noble County, Jefferson and Elk Townships. The original 202 acre permit was approved in 1989 and was amended various times over the permit life. The total permitted area encompassed 925 acres. The mining and reclamation plan proposed that mining would be completed within 12 months for each yearly segment and grading would begin within 90 days following completion of mining. Resoiling to a depth of eight inches would be completed six to 12 months after grading for each yearly segment. This would be followed by revegetation of the affected area the growing season during resoiling or the first growing season following resoiling. Lime and fertilizer were added per the soil tests performed.

The mining equipment included dozers and scrapers to remove the overburden and a front end loader to load the coal. The company conducted contour mining using block cuts to mine the Meigs Creek # 9 coal seam. The # 9 coal outcropped at an elevation of approximately 845 feet and overburden depth ranged from 20 feet to 65 feet. All toxics encountered were placed at the bottom of the spoil and buried. Backfilling and grading were completed using pans and dozers. The final map was approved in March 2007 with a final amount of 627 acres to be reclaimed. The site was reclaimed with eight inches of resoiling material and the Year 12 segment containing the reconstructed stream was planted in 2001 and released in 2007 (Figure 5-1).

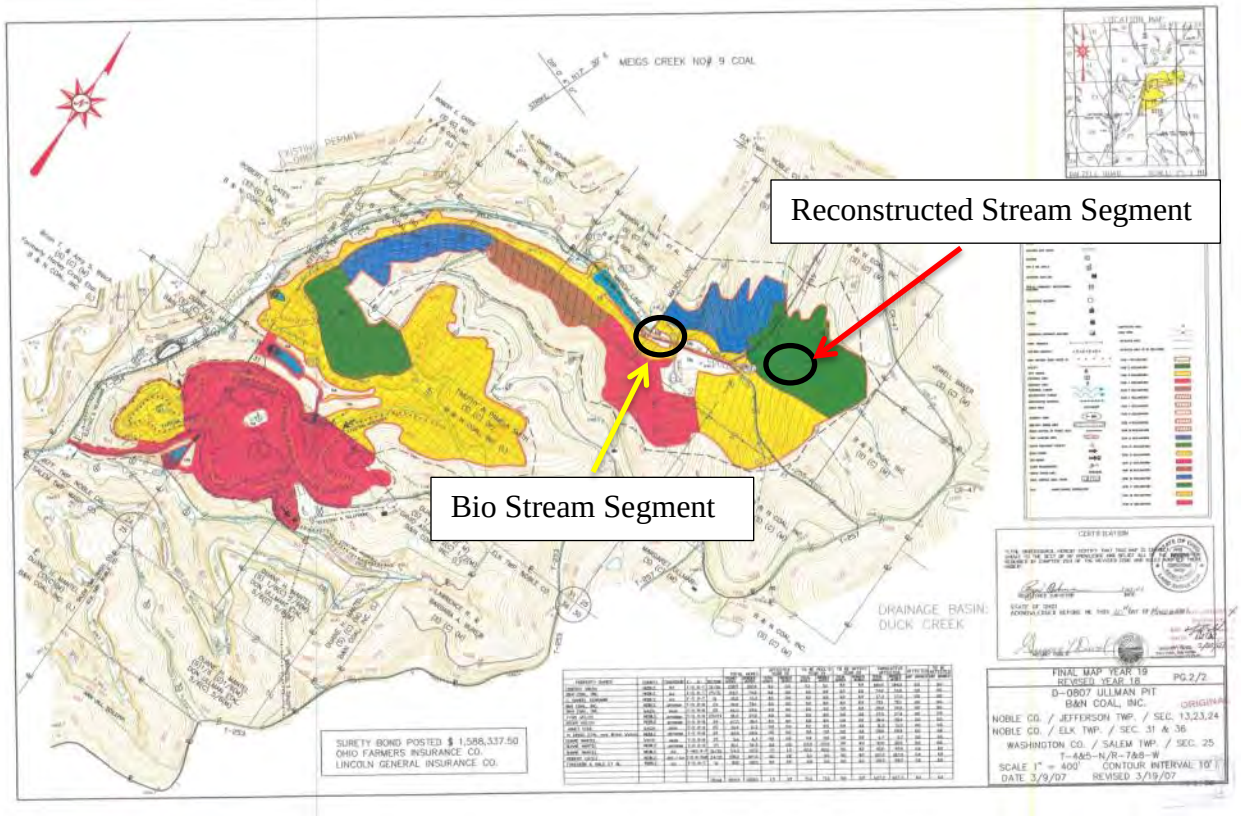

Figure 5-1. D-0807 Permit Map

The two reconstructed stream segments examined are located in Section 13, 23, 24 of Jefferson Twp. and Section 31 & 36 Elk Twp. in Noble County, Ohio. This is a headwater area that conveys drainage to a perennial creek named Gould's Run, a second order tributary draining into the East Fork of Duck Creek. The biological sites were a natural channel located below the reconstructed channel off the permitted area that receives drainage from the reconstructed channel, and a site in the reconstructed channel below the measured stream segments on the permit. Figures 5-2 depicts the locations of all stream segments analyzed.

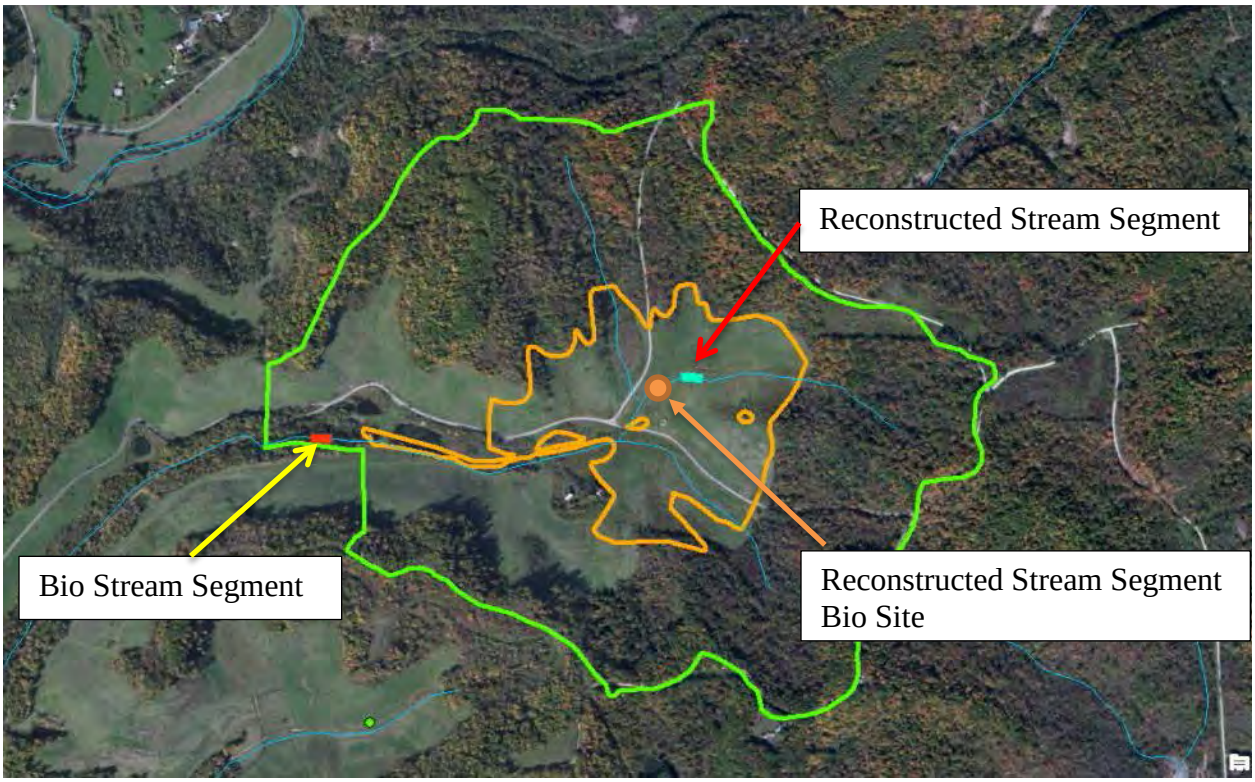

Figure 5-2. D-0807 Affected Area within Tibutary Watershed

The orange line encompasses an area representative of the watershed of the tributary intersecting D-0807's affected area. It encompasses 68.4 acres. The overall area of the watershed is approximately 378 acres, and the area affected by permit D-0807 mining represents 18 percent of this watershed. The USGS topographic map indicates this stream is an intermittent stream, which designation includes the measured stream segment.

5.2 Reconstructed Stream Segment Analysis

The reconstructed stream at D-0807 was split into two separate 200 foot reaches. Both are within the same drainage area and located approximately 50 feet apart (Figure 5-3). This permit site and reconstructed stream reaches are located within the East Fork Duck Creek

watershed. Each segment was analyzed separately, but the tributary area was calculated as one reach.

The reconstructed reach has a drainage area of 0.15 square miles based on its location within Gould's Run the tributary watershed. The overall drainage area depicted above has a drainage area of 0.59 square miles. The reconstructed stream has an annual mean precipitation of 39.6 inches.

Stream Segment number one

The initial survey of D-0807 stream segment number one was conducted on April 13, 2013(Figure 5-4). The channel substrate was composed of five types; boulders, cobble, gravel, sand, and silt; with the majority of the substrate being gravel and sand. These two substrate types combined to make up approximately 60% of the total substrate. Maximum pool depth recorded that day was 6.5 inches. (Figures 5-7 & 5-8).

A second survey was conducted on D-0807 stream segment number one on June 25, 2013. The substrate was consistent with the April assessment, however the stream reach was dry. No pools were found or recorded, and the D-0807 stream segment #1 exhibited characteristics of an ephemeral stream (water will flow and pool in this reach during and shortly after a rain event). A third recording was taken July 1, 2014 with the DMRM hydrologist to verify this stream classification. This survey was preformed following a rainfall event that occurred within the week. At this time the stream reach was flowing and had pool depths ranging from 4to 5 inches.

Figure 5-3. OSU's Consultant and DMRM hydrologist,
Cheryl Socotch at Reconstructed stream D-0807

Figure 5-4. OSU survey at site D-0807

Figure 5-5 is a representative cross-section of the stream segment number one. This view was created using the ODNR spreadsheet. The blue line represents the segments bankfull width, and the red line depicts the flood prone width.

Bankfull Dimensions	
0.5	x-section area (ft.sq.)
3.5	width (ft)
0.1	mean depth (ft)
0.2	max depth (ft)
3.5	wetted parimeter (ft)
0.1	hyd radi (ft)
25.3	width-depth ratio

Calculated BFW Flow: **82.08 cfs**
(BFW approx. 1-2 year RI)

Stream Stats Peak 2 year Flow: **87.3 cfs**

Percent Error: **5.97%**

Figure 5-5. D – 0807 Cross Section #2

The average bankfull width of this reconstructed stream segment is 3.9 ft. Sinuosity was calculated to be one, and the stream gradient was a 1% slope, considered to be flat. The HHEI score for D-0807 was 35. Using the OEPA Manual (Figure 2-1) this stream segment can be classified as a Modified Class II PHWH (Perennial or Intermittent).

Stream Segment number two

The initial survey of D-0807 stream segment number two was conducted on April 13, 2013. The channel substrate was composed of five types; boulders, cobble, gravel, sand, and silt. The majority of the substrate was cobble and sand, making up 57% of the channel substrate, and the maximum pool depth was 5.5 inches.

A second survey was conducted on D-0807 stream segment number two on June 25, 2013. The substrate was found to be the same as in April, and the maximum pools depth was two inches. The second survey in June determined the segment as a moist channel with isolated pools and interstitial flow.

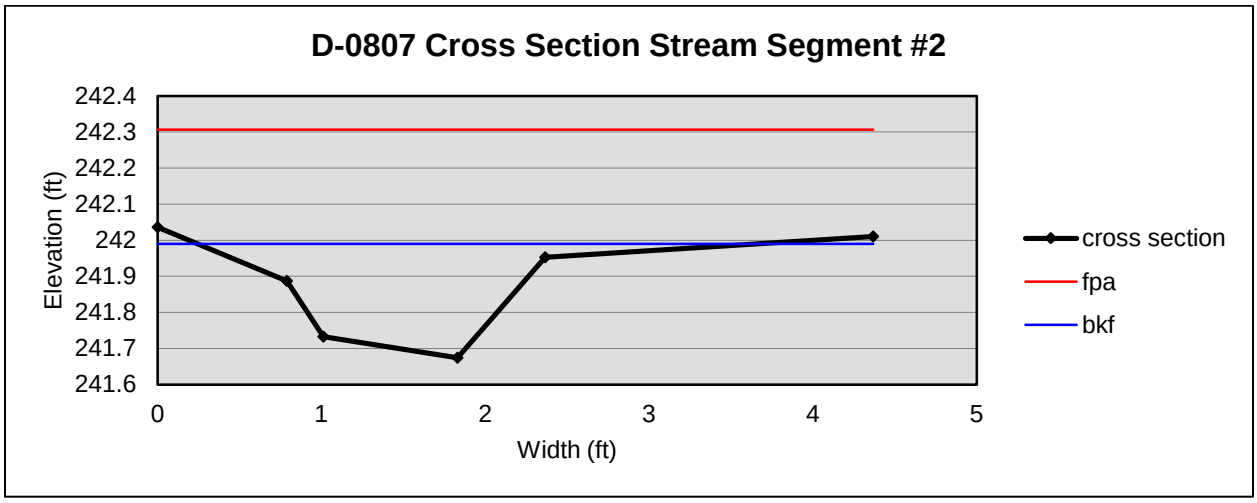

Figure 5-6. D – 0807 Cross Section #3

The average bankfull width, (blue line), of this reconstructed stream segment is 3.8 ft. (Figure 5-6). Sinuosity and stream gradient were calculations were done via the ODNR spreadsheet; sinuosity was calculated to be one, and the stream gradient slope was 2.0%, (considered flat). The HHEI score for D-0807 Stream Segment # two is 50. Using the OEPA Manual this stream segment can be classified as a Modified Class II PHWH (Perennial or Intermittent).

Figure 5-7. Stream Reach #1

Figure 5-8. Substrate in Stream Reach # 1

On June 4, 2014 OSU's consultant sampled the reconstructed stream for macroinvertebrates. The stream reach sampled extended from the culvert under Twp. Rd. 255 to the junction with the drain way coming in from Becker Road. This area is below the stream

segment number one, but still contained within the reconstructed stream channel (Figure 5-2). The channel above this point was choked with algae for several hundred feet before becoming dry. Sampling in this section was not feasible due to these conditions. The most abundant organisms were creek chubs and amphipods; collection of these was stopped after establishing abundance. In the section of approximately 450 linear feet sampled, there were several places where the flow was interstitial below the limestone rip rap. The source of water for this stream segment may be attributable to the reestablishment of the groundwater table following mining. Four northern two lined salamanders were collected which would indicate perennial flow. In addition, two mayfly taxa and one stonefly taxa were collected. The Ohio EPA macroinvertebrate index score was 16, making it a Class II headwater stream. Biological Stream Segment Analysis

The HHEI Form was also used to evaluate the D-0807 biological stream reach and depicted the biological diversity downstream from the reconstructed stream subsequent to mining of the site. The HHEI score for the D-0807 biological site is 73.

The drainage area encompassing the biological site is 0.59 square miles, and of this area, about 18 percent has been mined. The HHEI evaluation was conducted on June 19, 2013. There were six different substrate types ; boulder at 10%, cobble at 30%, sand at 20%, silt at 5%, fine detritus at 5%, and clay or hardpan at 30%. From these percentages, the two most predominate substrate types were cobble and clay or hardpan resulting in a score of 18 for the substrate metric. The maximum pool depth was calculated by averaging the measurements of 10”, 11”, and 9” which yielded an average of 10” or 28 cm. The maximum pool depth metric scored 25 points. The final metric used in calculating the HHEI score was the bankfull width (BFW) metric. The bankfull width was calculated by averaging the measurements of 12’-6”, 9’-4”, 9’-

9”, and 12’-4” which resulted in a bank full width of 10 feet 11.5 inches with a metric score of 25. The sum of these scores for overall HHEI score for the D-0807 biological site is 73. Using the OEPA stream matrix (Figure 2-1), this stream segment can be classified as a Class III PHWH (Perennial).

For the riparian zone, there was a riparian width of greater than10 meters on the left and greater than 5 meters on the right side. On both banks of the biological stream reach there was a floodplain quality of a mature forest or wetland. At the time of the reach observation the stream regime was flowing. The stream had an observed sinuosity of 2 and an observed stream gradient determined to be moderate to severe.

OSU’s consultant conducted biological sampling on June 19 2013. The stream had a fair to good flow and the habitat appeared to be good (Figure 5-9).

Figure 5-9. Biological Sampling D-0807

However, the lower two thirds of the 200 foot sample reach consisted of cobble to boulder sized rocks embedded in clay hardpan. This yielded few specimens. The upper third had a good amount of loose shale substrate which yielded the vast majority of the specimens collected. Sample ML-13-001 was taken and later analysis using Ohio EPA's HMFEI scoring metric showed a score of 24, which meets the minimum of 20 for a Class III headwater stream. The abundance of all taxa was low, with the exception of Tricoptera (Caddis flies). Class III streams are considered suitable for cool to cold water adapted aquatic species. In addition there were Creek Cubs, Black Nosed Dace present, along with crayfish and a larval Northern Two-lined Salamander.

5.3 Water Quality Data and Particle Size Analysis for D-0807 Bio and Reconstructed stream reaches

Intermediate flow geochemical sampling was conducted on June 25, 2013 and July 1, 2014 by DMRM's hydrologist (Figure 5-10). A surface water sample was collected from the "Downstream" or bottom of the reconstructed stream channel, while another was collected from the middle of biology sample area. Samples were analyzed for mining parameters required in Ohio Administrative Code 1501:13-4-04(E) permit application requirements for information on environmental resources, surface water information. Results were compared to the Ohio EPA technical based limits for NPDES reporting in the General Coal permit. All results were below the limits set in the Coal General NPDES permit. The EPA technical based limits for the following parameters are: pH of higher than six and lower than nine standard units, less than 80 mg/L of Total Suspended Solids (TSS), less than six mg/L of iron, and less than four mg/L of manganese. The analytical result reported for aluminum, iron, manganese, and sulfate were very

low compared to water that has been impacted by mining operations (Table 5-1). The water quality in the reconstructed stream channel was slightly better in quality than the biology sample area, with less sulfates and total dissolved solids.

Table 5-1 also compares the results from the pre-mining data (S-20 and D-16) collected for the coal application to the samples collected in the reconstructed stream channel and Figure 5-10 shows their relative location. Overall the geochemical analysis shows no impact to quality of the reconstructed stream.

Table 5-1. D-0807 Water Quality Data

Site Name	Sample ID	Date	pH	acidity	alkalinity	TDS	TSS	Sulfate	Iron	Manganese	Aluminum	SC
D-807	Pre Mining Upstream S-20	4/11/1996	7.3	30	150		28	104	0.02	0.1		420
		9/5/1996	7.6	0	158		12	116	0.06	0.2		460
	Pre Mining Downstream D-16	4/11/1996	7.7	22	94		6	68	0.04	0.2		260
		9/5/1996	7.8	0	96		14	62	0.06	0.2		360
	D-807 BIO	6/25/2013	7.67	9.46	167	1460	26	847	0.197	0.536	0.121	1770
	D-807 Stream Pool	7/1/2014	7.77	5.42	162	340	15	80.4	0.839	0.357	1.83	506

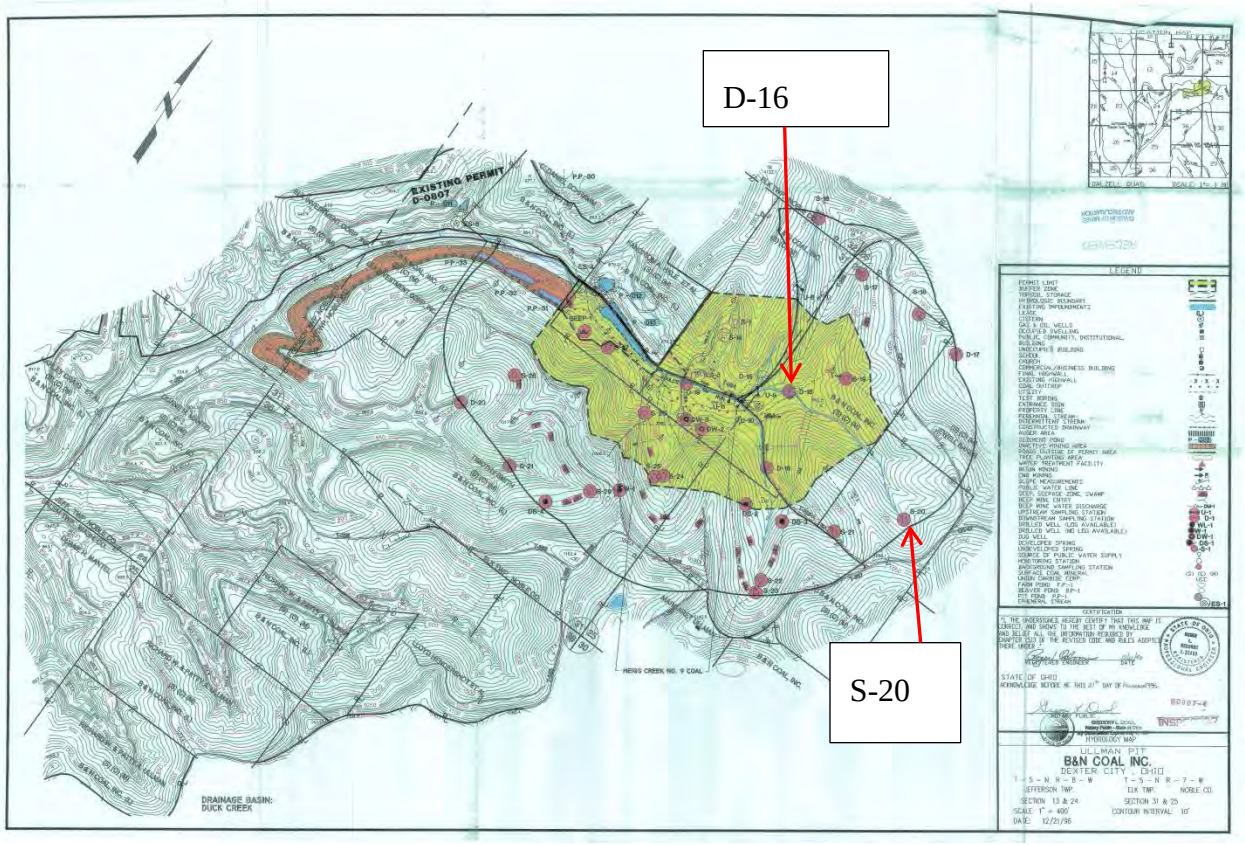

Figure 5-10. Pre mining Chemical sampling D-0807 upstream S-20 and downstream D-16

5.4 Soils Data for D-0807 Reconstructed and Bio stream segments

According to the soil map for D-0807 (Figure 5-11), the reconstructed channel has the soil type Brookside-Vandalia complex, 15 to 25 percent slopes, eroded. The biological site has the soil type Chagrin silt loam, and occasionally flooded. These soil types are consistent with what the lab analysis for both the reconstructed and the biological sites where, it was determined that the soil type is a silty clay loam. When comparing the particle size percent sand, silt and clay there is a consistent correlation between the unmined natural flood plain soils and the soils tested at the reconstructed flood plain. The resoiling materials appear to have excellent properties with respect to particle size suitable for vegetative growth (Table 5-2).

Figure 5-11. Soil Map for D-0807 and reconstructed stream segment

Table 5-2. Particle Size Analysis D-0807

Particle Size Analysis					
	(% of Total sample (wt/wt))				
	Coarse fragments	Total sand	Total silt	Total clay	
Sample	>2.0 mm	2.0-0.05 mm	50-2 µm	<2.0 µm	Textural class
D-807 Bio 1	0.5	9.7	63.9	26.4	SIL
D-807 SR1	16.0	13.5	49.6	36.9	GSICL
D-807 SR2	14.5	14.2	51.0	34.8	SICL

5.5 Summary D-0807

The reconstructed stream segment HHEI score was 35 and is classified as a Modified Class II PHWH intermittent stream. At certain times during the summer low flow season water is not flowing in the channel, but several pools are present and measureable. This may be attributable to the permeability of the material in the substrate. The morphology and the cross sections of the stream channel resembles a two stage channel, indicating the stream has formed this configuration through morphological processes or the mine operator created this configuration during construction. It may be combination of both. This intermittent stream seven years after reconstruction is in a state of quasi-equilibrium, and has recovered. Using the "Weight of Evidence" approach, the combined HHEI score of 73 and the HMFEI score of 24 indicate this biologic stream segment is a Class III stream considered suitable for cool to cold water adapted aquatic species. This biological stream segment is located 4,120 feet downstream of the reconstructed stream channel and shows no apparent, or only minimal, impacts from mining and reclamation at the D-0807 permit. The downstream biological site indicates a Class III stream with a diverse biologic community.

The results of our study have been compared with the study currently underway by B&N Coal Co.'s consultant Kleski Environmental further downstream at this permit where data was presented in an interim update at 2013 IMCC meeting. (Figure 5-12)

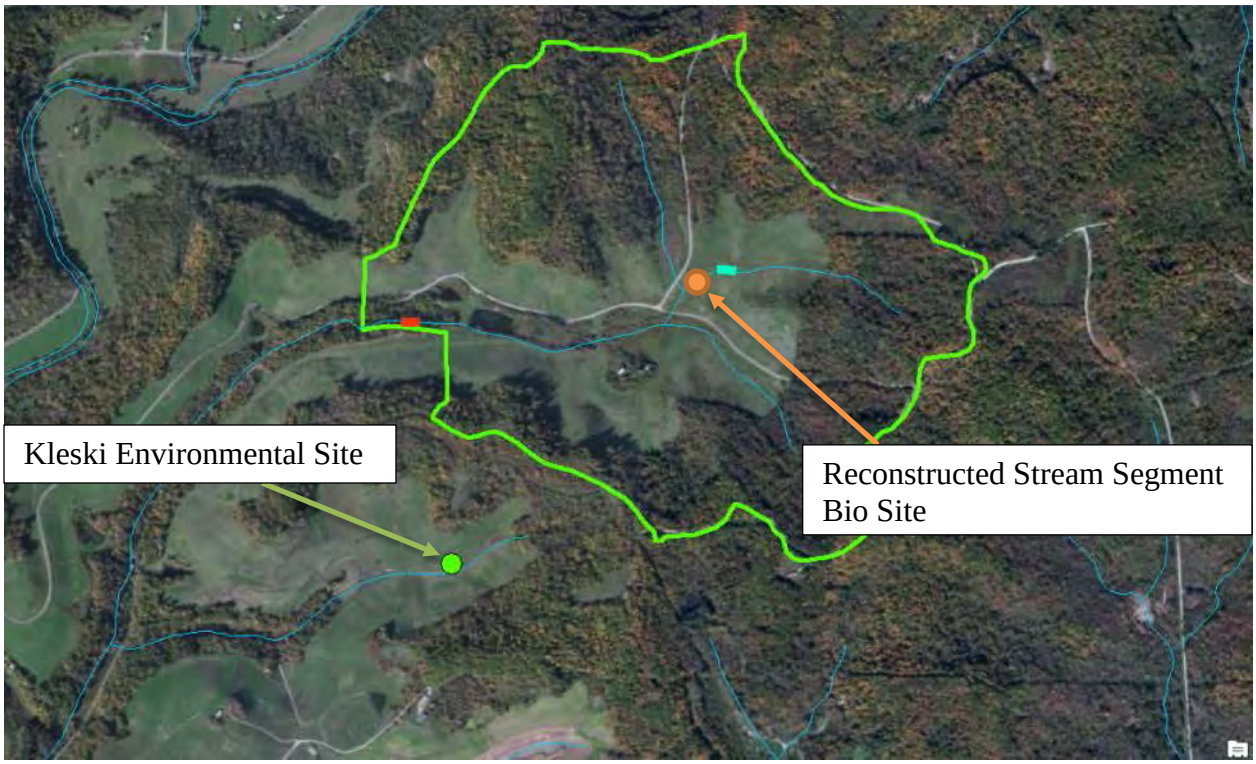

Figure 5-12. Site Locations in Respect to D-0807 Location

Table 5-3 and 5-4 below depict the HHEI and HMFEI scores calculated for the reconstructed stream segments, a monitoring site downstream of the reconstructed stream segments, and water quality data for both sites studied. Within these tables are numerical values obtained from our study at D-0807 on the reconstructed and biological sites. Kleski found their reconstructed stream reaches to be Class III (Perennial), whereas our reach was Class II (Intermittent). Variations in watershed size, stream location, and the physical make-up of the stream can cause HHEI values to vary slightly. Biologically, HHEI, HMFEI, pH, and iron values are comparable. These two streams would behave the same, and thus are both Class III (Perennial).

Table 5-3. Comparative D-0807 Reconstructed Site Scores

	Kleski Environmental		OSU Researchers	
Site	#1	#2	Segment #1	Segment #2
HHEI	N/A	72	35	50
HMFEI	17	22	N/A	N/A
Taxa Richness	11	10		
EPT Richness	4	6		
pH	N/A	7.81		7.7
Acidity	N/A	11.16		5.4
SC	N/A	1522		
Iron	N/A	0.15		0.84

Table 5-4. Comparative D-0807 Biological Site Scores

	Kleski Environmental	OSU Researchers
Site	#3	Biological Segment
HHEI	68	73
HMFEI	23	24
Taxa Richness	11	
EPT Richness	4	
pH	8.02	7.6
Acidity	11.45	9.46
SC	1907	
Iron	0.28	0.21

The D-0807 Ullman V site that Kleski evaluated has been reclaimed for over four years and included remining. B&N Coal Co. reconstructed the stream using the natural channel design approach. The three sites that were monitored include sites #1 and #2 on the fill and #3 downstream of project (Figures 5-13, 5-14, and 5-15).

Figure 5-13. Site #1

Figure 5-14. Site #2

Figure 5-15. Site #3

The Kleski results for the HHEI and HMFEI scoring are consistent with the data obtained by OSU researchers for the biological sites surrounding the B&N, Inc. D-0807 permit (Table 5-4). The scores associated with the reconstructed stream segments differed somewhat, however there are many variables involved in the scoring system. The water quality data is very consistent at both the biological and reconstructed stream sites for the Kleski study when compared with this study.

6 VALLEY MINING C-1305

6.1 Background and Location

Valley Mining submitted the application to the Division of Reclamation on December 22, 1979 for a site located in Jefferson County, Mt. Pleasant Twp., and Sections 34 & 35. The application included a two year mining plan with 33.88 acres proposed in year one and 36.3 acres in year two, for a total proposed acreage to be affected of 70 acres. The application was approved on February 12, 1980 and included a bond rate of $ 3,400 per acre. The company placed on deposit with the Division bond for the first year acreage totaling $ 114,920 dollars. The company estimated reclamation costs to be approximately $ 1,000 per acre. In the application the company described the land use prior to mining as pasture land used for grazing and feeding of livestock. The intended future land use was a grass vegetated cover for future livestock grazing. The mining and reclamation plan proposed that mining would be completed within 12 months for each yearly segment, and grading would begin within 90 days following completion of mining. Reclamation followed 500 feet from the mining operation. Resoiling, to a minimum depth of six inches would be completed six to 12 months after grading for each yearly segment. This would be followed by revegetation of the affected area the growing season during resoiling or the first growing season following resoiling. Forty four pounds of seed per acre were sowed that included a mixture of grasses and legumes. Lime and fertilizer were added per the soil tests performed.

The mining equipment included D9 Cat dozers, Cat 14 yd. scrapers, a Cat 7yd loader and a Salem auger with a 24 inch cutting head. The company conducted contour and blocking along with auger mining of the # 9 coal seam. All toxics encountered were buried in the pit and

covered with four feet on nontoxic spoil material placed at the bottom of the spoil and reclaimed. Backfilling and grading were completed using D9 G Cat dozers, and Cat scrapers. The final map date was June 22, 1981 (Figure 6-1) with a final acreage of 687 acres to be reclaimed.

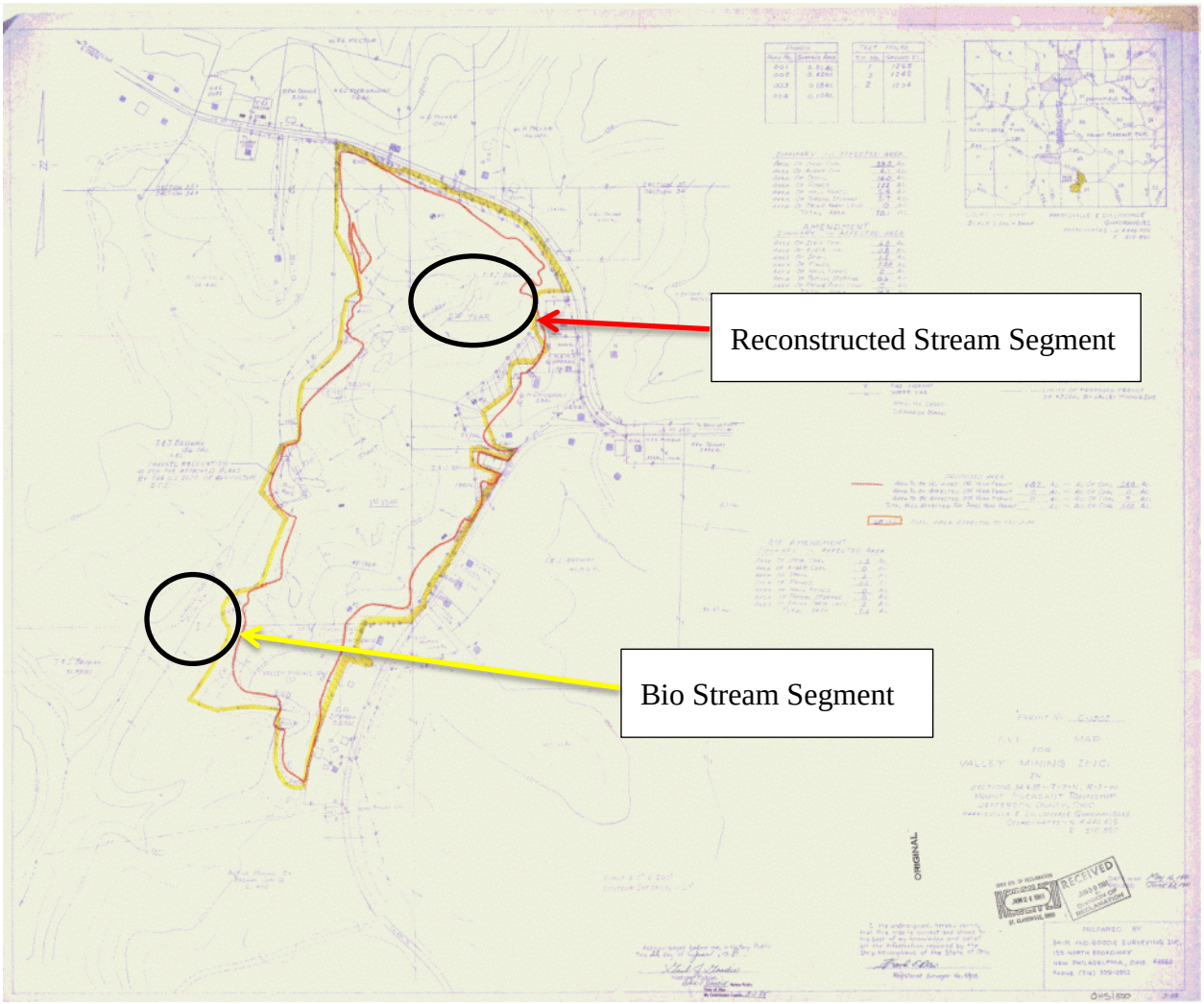

Figure 6-1. C-1305 Final Map, Submitted June 1981

The orange line encompasses an area representative of the watershed of the tributary intersecting the C-1305 affected area (Figure 6-2). This encompassed area is 72 acres. The overall area of the watershed is roughly 173 acres so the watershed affected by the permitted C-1305 mined area is approximately 41 percent of the entire watershed.

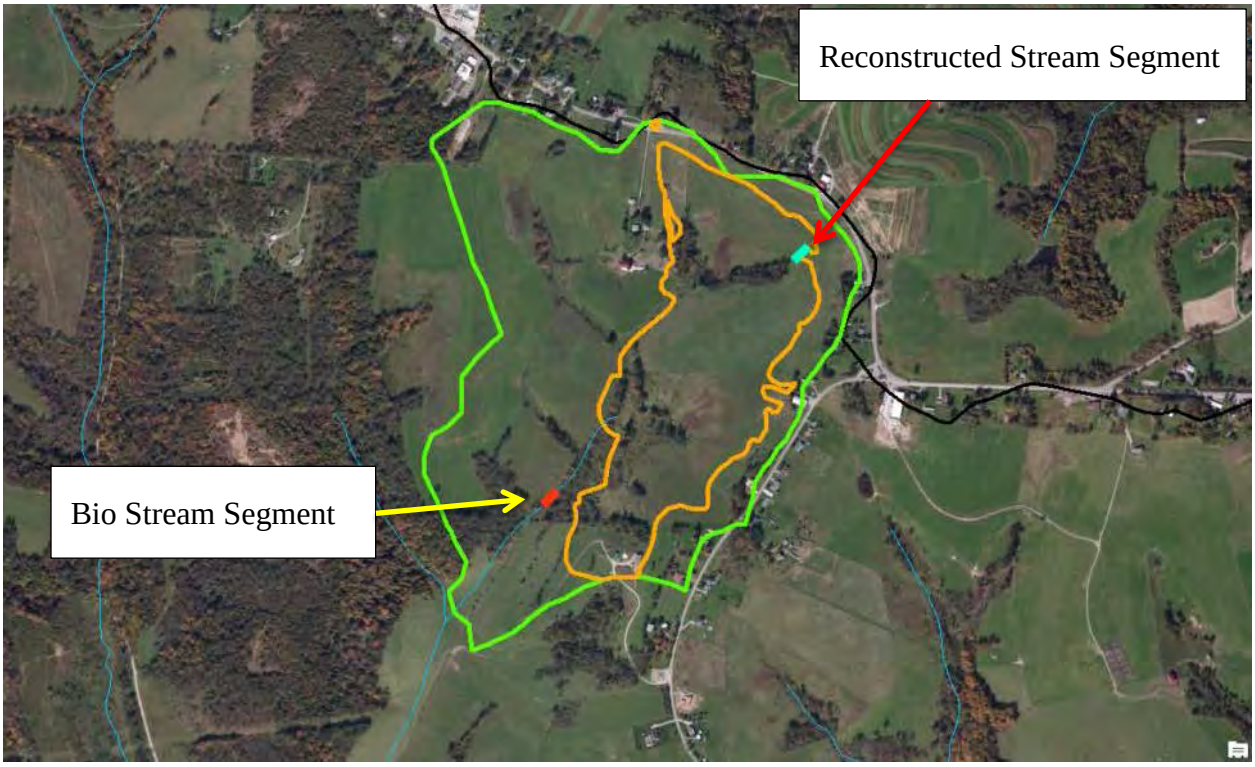

Figure 6-2. C-1305 Affected Area within the Unnamed Tibutary Watershed

6.2 Reconstructed Stream Segment Analysis

Figure 6-3. C-1305

The stream segment studied is located in Section 35, of Mt. Pleasant Twp. in Jefferson County, Ohio. The drainage system examined was a 200 foot section of a traditional trapezoidal rip rap construction created by the Valley Mining Company as part of their mining plan (Figure 6-3). This is a headwater area that conveys drainage to a perennial stream named Crabapple Creek. The reconstructed stream at this site has a drainage area of 0.086 square miles, and the total drainage area including the biological site is 0.32 square miles. Average rainfall in this area is 39.6 inches per year. No stream designation was indicated on the USGS or application map, therefore the stream segment is a drainage swale or ephemeral type stream.

The survey of C-1305 was conducted on December 22, 2013. The channel substrate was composed of approximately 70% limestone rock rip-rap. Other material found in the substrate included; cobble, sand, silt, and clay or hardpan. A single recording of the pool depths was taken in this reach. No water flowing in this channel, and thus no pools were found or recorded. This led to the stream to be classified as a dry channel with no water flowing except during or after rainfall events (ephemeral).

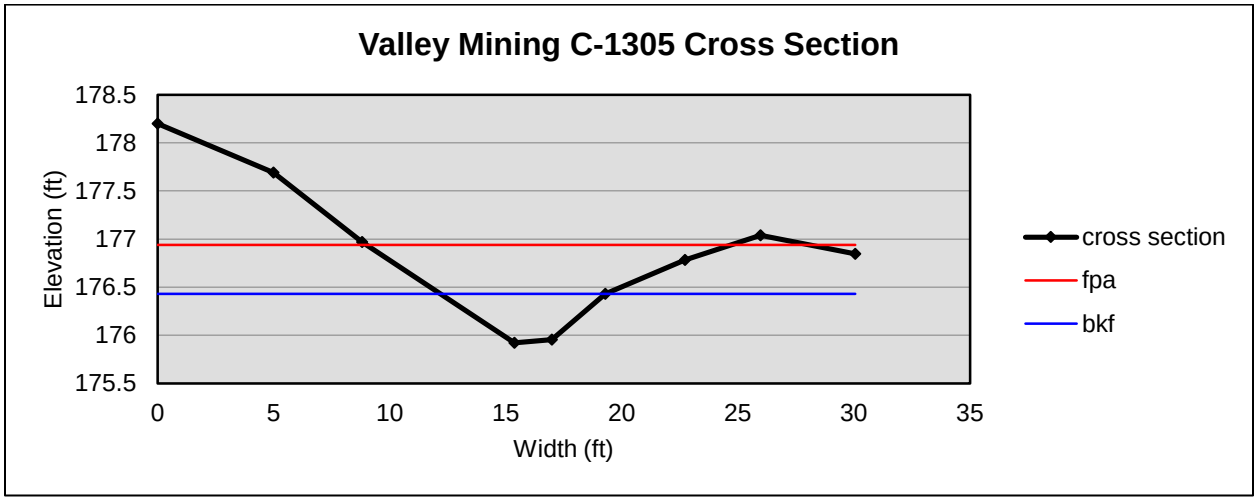

Figure 6-4. Valley Mining C-1305 Stream Cross Section

This reach had an average bankfull width of 11.5 ft. (Figure 6-4). As before this takes into account all three cross sections and values recorded. Sinuosity and stream gradient calculations were done via the ODNR excel spreadsheet using plan and profile views. Sinuosity was calculated to be one, and the stream gradient was an 8.7% slope, which is considered moderate to severe. The HHEI score for C-1305 reconstructed stream is 28 and this stream segment is an ephemeral type stream, or a modified Class I stream.

Figure 6-5. Looking down the reconstructed channel C-1307

Figure 6-6. Stream Segment Entering into non mined wooded area

6.3 Biological Stream Segment Analysis

Figure 6-7. C-1305 Bio site

Figure 6-8. C-1305 Bio site

The HHEI form was used to evaluate the C-1305 biological stream reach and provides the "weight of evidence" that depicts the potential biological diversity downstream from the reconstructed stream segment.

The drainage area for this site is 0.27 square miles and, of this area, approximately 41 percent of it has been mined. The HHEI evaluation was completed on July 9, 2014. The substrate metric is estimated by allocating the percentage of every type of substrate present in the stream reach. There were four different substrate types observed; boulder slabs at 10%, cobble at 15%, sand at 5%, and silt at 70%. From these percentages, the two most predominate substrate types were cobble and silt resulting in a score of 19 for the substrate metric. The maximum pool depth was calculated by averaging the measurements of 7.5" and 5.25" which yielded an average of 6.38 inches. The maximum pool depth metric scored 25 points. The final metric used in calculating the HHEI score was the bankfull width metric. The bankfull width was calculated by averaging the measurements of 6'-9", 8'-6" and 10' which resulted in a bankfull width of 8 feet and 5.25 inches with a metric score of 20. The sum of these scores for the overall HHEI score for the C-1305 biological site is 64. Using the Manual's stream matrix (Figure 2-1), this stream segment can be classified as a Class III PHWH Perennial.

For the riparian zone, there was a riparian width of greater than 10 meters on both the left and right side of the stream. On both banks of the biological stream reach the floodplain consisted of immature forest, shrub or old fields. At the time of the reach observation the stream regime was flowing. The stream had an observed sinuosity of greater than three and an observed stream gradient of moderate to severe.

OSU's consultant conducted biological sampling was conducted on July 17, 2013 with the assistance of two ODNR interns. Sampling started on the downstream end of the 200 foot reach.

Due to the small size of this stream, the use of the kick seine was abandoned in favor of the D-framed net. The stream was bordered with heavy brush and some vines and limbs had to be pruned back to allow access. The quality of the substrate was poor with few rocks of any size present. Most of the organisms captured were located in the vegetated stream edges. Amphipods, adult water bugs, and beetles were the dominant taxa collected. The sample scored a 14 using OEPA's HMFEI index for headwater streams, which makes it a Class II headwater stream. It should be noted, however, two Cambarus Bartonii cavates crayfish, and three Northern Two-lined Salamander larva were also collected. The larval Northern Two-lined salamanders are a class III-PHWH stream indicator species, however, according to Mike Bolton of the OEPA, the agency is currently only using the HMFEI score for stream classification.

6.4 Water Quality Data

High flow geochemical sampling was conducted on March 16, 2015 by DMRM's hydrologist. A surface water sample was collected from the "Downstream" or bottom of the reconstructed stream channel, while low flow samples were collected from the middle of biology sample area on October 2, 2013 and July 9, 2014. Samples were analyzed for mining parameters required in Ohio Administrative Code 1501:13-4-04(E) permit application requirements for information on environmental resources, surface water information. Results were compared to the Ohio EPA technical based limits for NPDES reporting in the General Coal permit. All results were below the limits set in the Coal General NPDES permit. The EPA technical based limits for the following parameters are: pH of higher than six and lower than nine standard units, less than 80 mg/L of Total Suspended Solids (TSS), less than six mg/L of iron, and less than four mg/L of manganese. The analytical result reported for aluminum, iron, and manganese were very low compared to water that has been impacted by mining operations (Table 6-1). The water quality

in the reconstructed stream channel was slightly better in quality than the biology sample area, with less sulfates and total dissolved solids.

Table 6-1. C-1305 Water Quality Data

Site Name	Sample ID	Date	pH	acidity	alkalinity	TDS	TSS	Sulfate	Iron	Manganese	Aluminum	SC
C-1305	C-1305 Downstream	3/16/2015	7.18	9.18	141	707	11	279	<0.05	0.196	0.072	1070
	C-1305 BIO	10/2/2013	7.39	21.2	246	1040	11	419	0.138	0.112	0.143	1360
	C-1305 BIO	7/9/2014	8.05	3.42	204	1110	27	565	0.377	0.108	0.834	1410

6.5 Summary C-1305

Reclamation of the site began over 34 years ago. The reconstructed stream segment had a HHEI score of 28 and when compared with the PHWH classification flow chart the stream segment is a Modified Class I PHWH (Ephemeral). Using the “Weight of Evidence” approach the combined HHEI score of 64 and the HMFEI score of 14 indicate the downstream biologic stream segment is a Class II PHWH stream. The biological stream segment is located 3,300 feet downstream of the reconstructed stream channel and shows no impacts, or only minimal impacts, from mining and reclamation at the C-1305 permit. The original design of this reconstructed stream was a typical trapezoidal design used predominantly in the mining industry to convey drainage over steep slopes. The cross sections and observations of the reconstructed stream indicate the trapezoidal channel appears to form the characteristics of a two stage channel as a result of the morphological processes occurring over time.

Some scouring was observed in the transition from our reconstructed stream to natural channel. The bed of the channel along with the banks were being “cut” allowing for sediment transport. As a result, the grade of the channel steepened, banks became more vertical, and flow rates visibly increased. (See figure 6-6)This transition zone perhaps would greatly benefit from some type of channel stabilization. Utilizing a rock lined channel, such as rip rap, would help to reduce bank and bed scour, as well as sediment transport. Only one tree approximately 10 inches in diameter was growing in the reconstructed channel. This may be due to the surrounding land use is agriculture and trees may of have been seen as an intrusive species to this type of land use by the landowner. The reconstructed stream is in a state of quasi equilibrium and has recovered.

7 WILLS CREEK ENERGY D-0019

7.1 Background and Location

Wills Creek Energy submitted the application to the Division of Reclamation in November 1981 for a site located in Perry County, Harrison Twp. The application included a three year mining plan proposing to affect a total of 94 acres. In the application the company described the land use prior to mining as a pattern of forest brush and pastureland and the intended future use for the land was pasture land. None of the permitted area was within 100 feet of an intermittent or perennial stream. The mining and reclamation plan proposed that mining would be completed within 12 months for each yearly segment, and grading would begin within 90 days following completion of mining. Resoiling to a depth of six inches would be completed six to 12 months after grading for each yearly segment. This would be followed by revegetation of the affected area the growing season during resoiling or the first growing season following resoiling. Lime and fertilizer were added per the soil tests performed.

The mining equipment included dozers and scrapers to remove the overburden, and a front end loader to load the coal. The company conducted contour mining using block cuts to mine the Middle Kittanning # 6 coal seam. The coal outcropped at an elevation of approximately 886 feet and overburden depth ranged from 40 feet to 60 feet. All toxics encountered were placed at the bottom of the spoil and buried. Backfilling and grading were completed using pans and dozers, and approximately 290,000 tons of coal were removed. The final map date was October 31, 1984 with a final amount of 81 acres to be reclaimed (Figure 7-1). Based on overburden analysis the water quality at the site was anticipated to reflect the following parameters; Fe .8 mg/l, Mn 3.0 mg/l, pH 5.8, and TSS 15 mg/l.

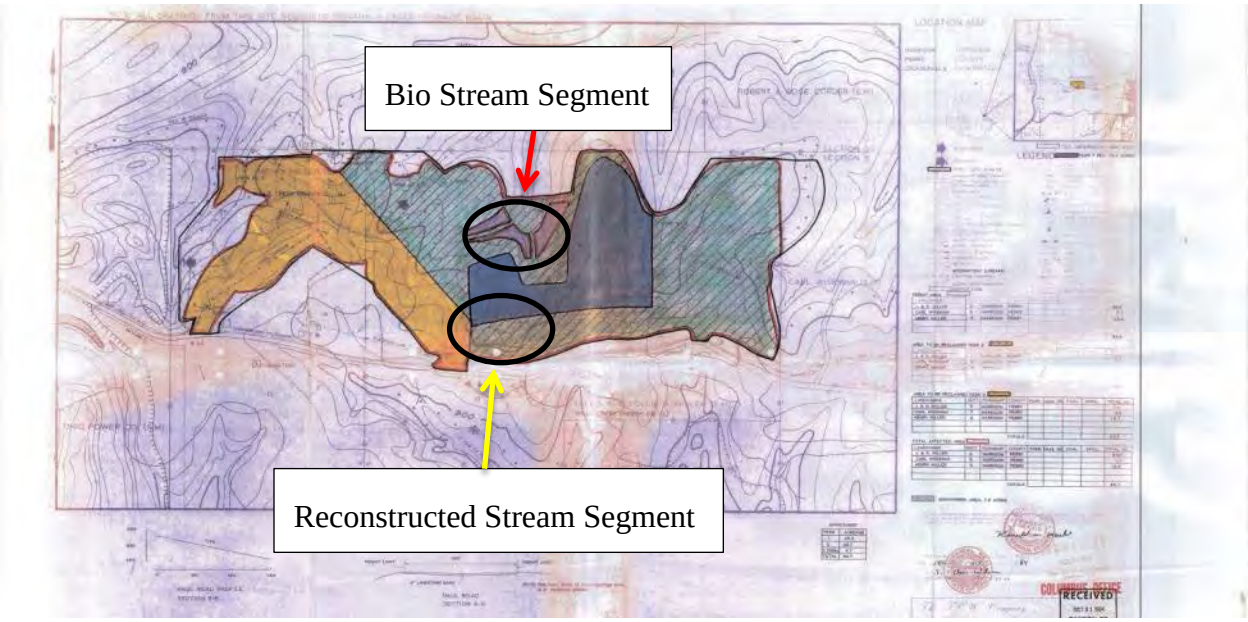

Figure 7-1. D-0019 Final map

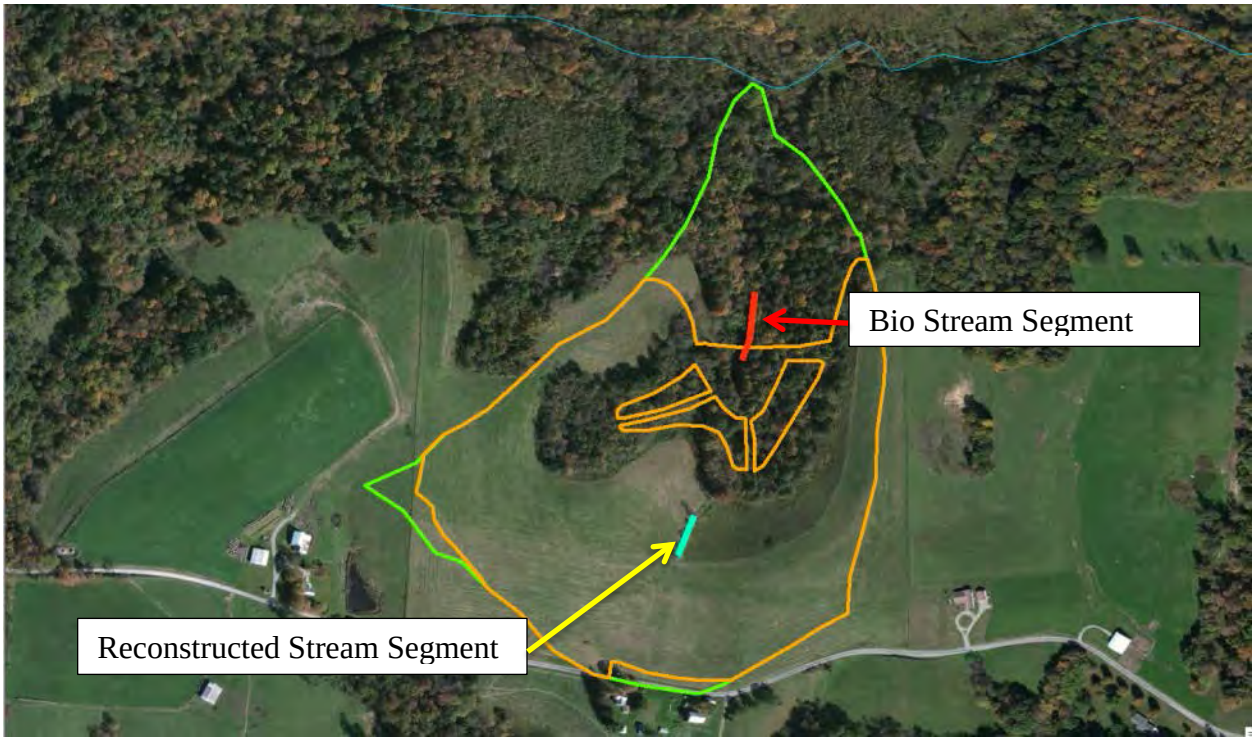

Figure 7-2. D-0019 Affected area within tibutary watershed

The orange line encompasses an area representative of the watershed of the unnamed tributary intersecting D-0019's affected area. This area encompasses 31 acres. The overall area of the

watershed is approximately 43 acres, or 0.067 square miles, so the watershed affected by permit D-0019 mined area is about 72 percent of the watershed. No stream designation was indicated on the USGS or application map, therefore the stream segment is a drainage swale or ephemeral type stream.

7.2 Reconstructed Stream Segment Analysis

The survey of D-0019 was conducted on December 22, 2013. The average bankfull width is 12.6 ft. (Figure 7-3). Sinuosity was calculated to be one, and the stream gradient was 19 % (considered severe). The HHEI score for Willis Creek D-0019 is 24, this stream segment is an ephemeral type stream, or a modified Class I stream.

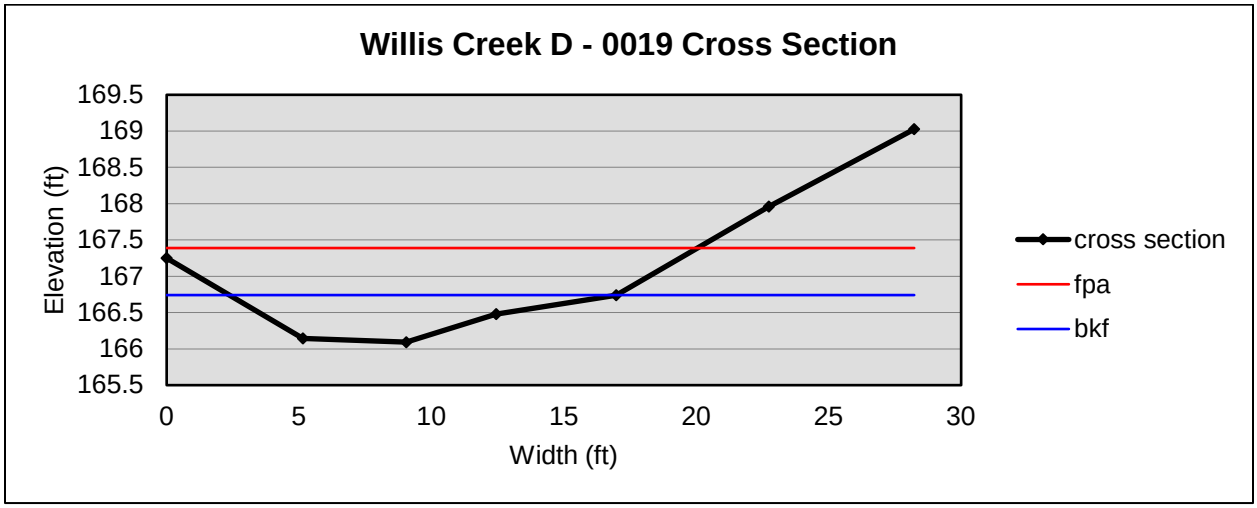

Figure 7-3. Willis Creek D-0019 stream cross section

Figure 7-4. D-0019 reconstructed stream

Figure 7-5. Reconstructed stream channel and surrounding agriculture area

Figure 7-6. Reconstructed stream looking downstream

Figure 7-7. Reconstructed stream reach looking upstream

7.3 Biological Stream Segment Analysis

The Primary Headwater Habitat Evaluation Form was also used to evaluate the D-0019 Biological stream reach and depicts the biological diversity downstream from the reconstructed stream subsequent to mining of the site. The overall HHEI score for the D-0019 biological site is 41. In evaluating the stream segment for D-0019's biological site, the HHEI Form was used to help demonstrate the recovery of biological entities downstream from the physical site of the remining. The drainage area for this site is 0.067 square miles and of this area, about 72 percent of it has been mined. The HHEI evaluation was completed on October 8, 2014. There were six

different substrate types observed; boulder at 5%, cobble at 15%, gravel at 30% sand at 30%, silt at 10%, and leaf pack/woody debris at 10% present. From these percentages, the two most predominate substrate types were cobble and sand resulting in a score of 21 for the substrate metric. There was no water in the stream at the time of the visit yielding a score of zero for the pool depth metric. The bankfull width was calculated by averaging the measurements of 7’-4”, 11’-10”, and 9’-2” which resulted in a bank full width of 9 feet and 5 inches with a metric score of 20. The sum of these scores for the overall HHEI score for the D-0019 biological site is 66. Using the OEPA stream matrix (Figure 2-1), this stream segment can be classified as a Class III PHWH (Perennial).

For the riparian zone, there was a riparian width of less than five meters on the right side of the stream and no observed riparian width on the left. On both banks of the biological stream reach there the floodplain consisted of mature forest and wetland. At the time of the reach observation the stream regime was stream flowing. The stream had an observed sinuosity of greater than three and had an observed stream gradient of moderate (2 ft/100 ft).

On October 8, 2013 the biological segment, which is the main stream draining Permit D-0019 was sampled by OSU’s consultant Max Luehrs and DMRM’s hydrologist Laura Bibey. The sample reach began below a cattail filled sediment pond, (Figure 7-8) but did not include the surge pool below the steel casing outlet pipe (Figure 7-9). Very few organisms were collected, but there was a Stonefly (Plecoptera) and a Caddisfly (Tricoptera) and four larval Northern Two-lined Salamanders collected. The larval Northern Two-lined salamanders are a class III-PHWH stream indicator species, however, the agency is currently only using the MFEI score for stream classification. The biological stream segment scored a 12 using the Manual’s index, which indicates a class II PHWH stream (Figure 7-10).

Figure 7-8. Sediment pond above biological site

Figure 7-9. Pipe outlet from pond into biological stream site

Figure 7-10. Biological stream site

7.4 Water Quality Data Analysis for D-19 Reconstructed stream and biological reaches

Low flow geochemical sampling was conducted on October 2, 2013 by DMRM's hydrologist. A surface water sample was collected from the middle of biology sample area. The reconstructed stream channel is ephemeral in nature therefore no samples could be collected from the channel. The sample was analyzed for mining parameters required in Ohio Administrative Code 1501:13-4-04(E) permit application requirements for information on environmental resources, surface water information Results were compared to the Ohio EPA technical based limits for NPDES reporting in the General Coal permit (Table 7-1). All results were below the limits set in the Coal General NPDES permit. The EPA technical based limits for the following parameters are: pH of higher than six and lower than nine standard units, less than 80 mg/L of Total Suspended Solids (TSS), less than six mg/L of iron, and less than four mg/L of manganese. The analytical

result reported for aluminum, iron, manganese, and sulfate were very low compared to water that has been impacted by mining operations.

Table 7-1. D-0019 Water Quality Data

Site Name	Sample ID	Date	pH	acidity	alkalinity	TDS	TSS	Sulfate	Iron	Manganese	Aluminum	SC
D-19	D-19 BIO	10/2/2013	6.98	17.1	107	247	17	77.6	0.123	0.323	0.089	383

7.5 Summary D-0019

Reclamation of the site began over 30 years ago. The reconstructed stream segment had a HHEI score of 24, an ephemeral Class I stream. The channel substrate was composed of solely of two to three inch intermediate axis of rock rip-rap artificial material placed from flood plain bank to flood plain bank, and the channel was not trapezoidal shaped, but flat with the contour of the hillside (Figure 7-6). No pools or flow in the stream were observed, however, groundwater could be heard flowing below the surface, perhaps at the bottom of the rock channel. In addition, determining bankfull width for this stream segment was difficult due to the amount of rock rip rap placed in the channel. The original design of this reconstructed stream was a typical trapezoidal design used predominantly in the mining industry to convey drainage over steep slopes. The reconstructed stream remains in the construction phase two since there has been no morphological processes observed in the channel, although there was not any sign of instability or erosion of the channel. The drainage area of the reconstructed channel is primary developed for agriculture which may explain the lack of tree growth in the riparian zones. (Figure 7-5).

A number of volunteer trees species are growing within the rock channel, one notable 20 inch diameter elm tree exists at the head of the reconstructed channel. (Figures 7-5, and 7-7).

For the biological segment the HHEI score was 41, however the HMFEI score of 12 indicate this biologic stream segment is a Class II stream. The biological stream segment is located 1,600 feet downstream of the reconstructed stream channel and shows no impacts or only minimal impacts from mining and reclamation at the D-0019 permit.

8 OTHER STUDIES

8.1 A Report on the Accumulative Off- Site Impacts from a Large Area Mine in Southeast Ohio[8]

This report focused on the "Big Muskie" mining activities, the largest dragline mining machine in the country during its operation, operated by the COCCO. The purpose of the report was to gather any available information from all sources to determine the off-site impacts from this large surface mine area over a 12 year period. Collins Fork, a watershed of 6 square miles was studied, located upstream of the fish sampling site and 2.7 miles from the mouth. Post 1972 mining began in 1976 and was completed in 1992. Of the total watershed, 91 % was mined and returned to grassland. It was estimated the mining impacted 5.5 miles of intermittent streams. Rannels Creek is a watershed of 5.5 miles and located upstream from the fish sampling site and one mile from the mouth. Of the total watershed, 85% was mined and returned to grassland.

OSMRE researchers obtained fish study results, macro invertebrate results, and Qualitative Habitat Evaluation Index (QHEI) from the OEPA. Water quality results were obtained from the COCCO and OEPA. All of the analysis showed alkaline mine drainage, with high levels of hardness, sulfates, and conductivity. The OEPA performed QHEI scoring at the Collins Fork and Rannels Creek in 1987 and 1999. In 1987, Collins Fork scored 45, and Rannels Creek scored 45.5. In 1999 the scores improved to 60.5 and 55 respectively. OEPA noted that during sampling in 1999 there was a severe drought and the streams were flowing compared to adjacent unmined streams that were dry. OSM indicated the observance of flows in the mined watersheds was attributed to the porous spoil material that provided a "sponge effect" for

groundwater flows. There were also numerous permanent impoundments created by the mining operation that provided numerous recharge areas to the groundwater system. A fish study using the Index of Biological Integrity (IBI) for Collins Fork in 1982 scored 12, and 17 in 1987, and 32 in 1999. Rannels Creek's IBI score in 1987 was 27 and 32 in 1999. A score of 44 is needed to attain warm water habitat. Macro invertebrates were also measured using the OPEA Invertebrate Community Index (ICI). For Collins Fork the ICI was 30 in 1987, and in 1999. Rannels Creek's ICI was 36 in 1987. A score of 36 is needed to attain warm water habitat.

The data reviewed indicate that both streams were impacted prior to the study period. Road crossing and beaver pond obstructions in the streams could be limiting fish movement downstream. The streams appeared to recover significantly during the study period of 12 years.

8.2 Preliminary Findings for the Study "Evaluating the Ecological Lift Provided by Remining"[9]

The focus of the study was to evaluate both temporal and spatial changes in aquatic communities downstream of undisturbed sites and remined sites in small headwater streams. The principal goal of the study was to measure the ecological lift provided to a stream's aquatic community as a result of the remining activity. The secondary goal of the study was to anticipate the ecological lift provided to an aquatic community by remining.

Stream selection criteria included streams that met OEPA's definition of Primary Headwater stream with a watershed less than one square mile and pools less than 40 cm, and located within the Duck Creek Watershed. The streams also met one of three categories of mining; permitted for mining, permitted for remining/AML site, or no mining (may have other disturbances).

The following results from five mine sites totaling 14 study segments were presented, all representing different ages of mining or remining :

1. The Lee Pit is a 12 year old remining site, where a stream was reconstructed using natural channel design. Two sites are being monitored; site # 1 on the fill and site # 2 below the fill. Site # 1 had a HHEI score of 57 and a HMFEI score of 24. Site # 2 had a HHEI score of 57 and a HMFEI score of 43. The pH at site # 1 was measured at 8.2 and site # 2 at 7.95.
2. West Fork I/II is a current remining site (Figures 8-1 and 8-2) where site # 1 is downstream of the phase 1 reclamation area, site # 2 is downstream of the active mining area, and site # 3 is downstream of the unreclaimed remined site. The HHEI values for sites # 1,2, and 3 were 66, 57 and 60 respectively. The HMFEI scores for sites # 1, 2, and 3 were 22, 15, and 5 respectively. The pH values for site #1 were measured at 7.3, for site # 2 at 7.0, and site # 3 at 3.95.

Figure 8-1. 1950's vintage photo of proposed B&N Coal D-2218 remining operations(West Fork)

Figure 8-2. B&N Coal D-2218 remining operation in West Fork

3. Barnesridge is a 13 year old reclamation area of an undisturbed area where a stream was reconstructed using SMCRA criteria. Site # 1 and # 2 are located on the fill and site # 3 is located downstream of the project. The HHEI values are 44 for site # 1, 63 for site # 2, and 77 for site # 3. The HMFEI score for sites # 1, 2, and 3 were 17,33, and 25 respectively. The pH values for site #1 were measured at 7.85, site # 2 at 7.95 and site # 3 at 8.0.
4. Estadt V is a 15 year old remining site where three sites were monitored, site # 1 on the fill, site # 2 outfalls from the pond, and site # 3 is downstream of the project. The HHEI values are 63 for site # 1, 74 for site # 2, and 76 for site # 3. The HMFEI score for sites # 1, 2, and 3 were 5, 25, and 37 respectively. The pH values for site #1 were measured at 3.8, site # 2 at 7.9 and site # 3 at 8.0.

5. Ullman site (see Chapter 5)

It is evident from the preliminary data that water quality within mine sites and remined sites vary widely and that macro invertebrate communities group according to a range of chemical water quality. It is also evident from the statistical results that other variables may be influencing the macro invertebrate communities. One group of macro invertebrates dominated the other three totaling more than half the study segments. Two cluster groups based on chemistry were not significantly different.

9 REMINING AND RECONNECTING STREAMS

9.1 Background

A typical remining operation involves advancing existing highwalls and removing overburden with one or two cuts into the contour of the hillside. Prior to the start of remining , strategically placed sediment control structures are located throughout the permitted area to control and treat all surface water to NPDES mining standards, or modified standards. Designated topsoil and subsoils are removed and stored for subsequent resoiling operations; after remining is completed, revegetation follows. Typical site conditions usually include old highwalls and water filled unreclaimed pits that need to be treated and pumped to nearby sediment control structure prior to advancing the highwall. Previous mining operations often employed the use of augers to extract additional coal reserves after termination of the last cut into the highwall. These perched water filled impoundments combined with past auger mining are often the source of acid mine drainage and sedimentation in the watershed. Last cut pyritic materials are often exposed to weathering processes. They can be found close to the surface since these layers generally reside close to the coal seam and end up on top of the generated spoil. Researchers theorize that over time the unreclaimed pits and spoil complex create a pseudo karst characteristic[10]. This provides preferred flow paths for groundwater to follow exiting the complex in the form of seeps on the outslope of the spoil banks. This exerts differential pressures on the spoil complex creating large voids and flow paths in the spoils. This phenomenon disrupts the hydrologic balance of the subwatershed. Remining and reclamation of the pit and spoil

complex may reduce those paths through the proper placement of the spoil material in the unreclaimed pit area by isolating toxic material. Reconnecting the streams and surface drainage during reclamation of the remining site to an overland flow greatly reduces water coming in contact with toxics in the spoil complex. Remining also facilitates restoring the hydrologic balance to the watershed by re- connecting disconnected streams from past mining and increasing the base flow into the local receiving streams.

Using a “box cut” method of contour mining, B&N Coal Co. on permit D-0958 advances the existing remnant highwall and placed spoil generated by the cuts into the unreclaimed pits. This eliminated perched water collection areas. The newly generated spoil material was generally blended with the existing spoil banks creating a stable configuration and a proper slope (usually no greater than a 3:1). That conveyed surface water directly into the adjacent streams and watercourses by reconnecting stream segments previously disconnected by pre-law mining. A lower permeability layer of topsoil and subsoils is applied to the graded spoil material providing a medium for revegetating the affected areas which completes the remining process.

OSU researchers utilized ODOT’s Lidar images to construct a 3-D image of the reconstructed stream on permit D-0958(Figure 9-1).

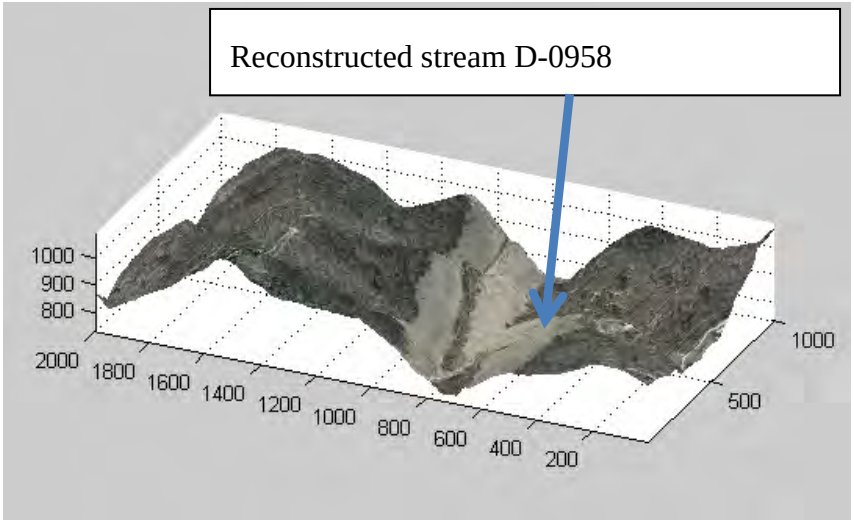

Figure 9-1. 3-D Lidar image at D-0958

Reconnecting streams is a common occurrence on remining areas and an important component to watershed restoration. During remining streams are both reconstructed and reconnected. Headwater stream segments are reconnected throughout the remining process.

Reclamation and revegetation will return the land to a productive ecosystem. Additionally, the revegetation will ultimately improve recharge to the ground-water system which, in conjunction with the large storage capacity of mine spoils, permits base flow to streams through protracted periods of drought[8]. Abandoned highwalls, pits, spoil piles and ridges are regraded to eliminate unnatural impoundments, create positive drainage, eliminate vertical ground water migration through unconsolidated acid spoils, return the area to approximate the original contour, and blend into the surrounding topography.

These BMPs need to be further evaluated and encouraged in the watersheds where previous mining has disrupted and redirected the surface drainage into pits created by the past mining operations. In addition thousands of feet of unstable/ dangerous highwall features are eliminated

(Figure 8-2). The primary goal in reclaiming previously mined areas should be the stabilization of the upper steep gradient ephemeral channels that are typical of channels in remine areas.

The end result of this remining activity is a greater quantity of surface water is returned to the receiving streams providing an ecological lift to the subwatershed.

9.2 Evaluating Flows at Remining Sites

Future evaluations may be performed by the mine operator or their consultant to examine how drainage changes once unreclaimed highwalls are reclaimed. This could significantly affect drainage runoff volumes discharging into the receiving streams.

To calculate this volume, a procedure that may be employed uses runoff curve number calculations to estimate how much run off will be impeded by highwall/pit complex collection. The runoff curve number can be found for any specific study area by referencing the United States Department of Agriculture *Urban Hydrology for Small Watersheds* technical release, however, the curve number used for hypothetical calculations of highwall remined areas and subsequent reclamation will be 85 (as referenced through the DMRM "Reconstructed Stream Design Guidelines" (Appendix E)). An average rainfall event will need to be established in order to proceed with the calculations. After this number is acquired and a rainfall value (P) is established, one will follow the run off curve number calculations of: $S=\frac{1000}{CN}-10$, $I_a=0.05S$, and finally, $Q=\frac{(P-I_a)^2}{P-I_a+S}$. This will yield a runoff in inches which can then be converted to any desired units. Given the watershed area, one will multiply the runoff value by the area to find the total volume of runoff that will be flowing through the uninhibited stream.

The next step in the procedure will be to establish how much runoff the highwall /pit complex inhibits runoff volumes. Looking at a map of the tributary watershed, where there are highwalls/pits, the drainage area above the highwalls can be assumed to be inhibited by the highwall/pit complex and contained as temporary storage. By taking the areas inhibited by the highwall/pit complex, subtracting them from the overall area, and then proceeding with the run off curve number procedure stated above, one will find the total volume of runoff flowing through the inhibited stream. This value can then be used to compare the total volume between the two different scenarios. It's expected the total runoff for an inhibited stream will be substantially lower than an uninhibited stream.

Using the hydraulic conductivity values of k_v=2e-4 ft/min and k_h=1.8e-3 ft/min for typical mine spoil in Coshocton County[11], one can determine the amount of time it would take the water temporarily stored by the highwall/pit complex to return to the stream. This procedure, however, is theoretical and was not tested or verified in this study. In order for this to become a viable procedure to examine the relationship of highwall/pit complex temporary storage and runoff, future studies are recommended to establish the validity of this method.

Remining BMPs not only induce improvement in terms of the water quality, but there is a definite and quantifiable improvement in terms of the ecological conditions. Several studies are underway in Ohio to provide more data to support this thesis. For example, the West Fork I/II area , B&N Coal Co. is extensively remining the area over the last 7 years, and the stream systems affected are being closely evaluated by the company(Figure 8-2).

9.3 Remining Water Quality, B&N Coal Co., D-0958

Beginning in 1991, B & N Coal began removing the remaining coal reserves from the previously mined areas in the lower reaches of Rocky Run, a tributary of East Fork Duck Creek. The original permit issued called for 65.1 acres of mining and, upon completion, the total area of the permit included 237.5 acres of affected area. Of this affected area, 81 acres were reclaimed through the remining of historic highwalls and pits representing 34% of the entire affected area . Approximately 12,840 linear feet of unreclaimed highwall were eliminated (Figure 9-4). The reclaimed land was revegetated to grassland/grazing land using a "forager fescue" seed mix. Undisturbed areas towards the overlaying undisturbed auger areas contain trees such as hickory, walnut, oaks and beeches which had been left to maintain food sources for wildlife in the area. This permit included remining without the benefit of a modified NPDES effluent permit.

The Cumulative Hydrologic Impact Assessment produced by the permitting staff at ODNR's DMRM stated the following regarding the streams and affected areas prior to the initiation of remining in 1991:

> *"Some of the springs and streams in the area have poor quality water as a result of pre-1977 mining in the area. The poor quality water is not the direct result of mining, but rather the lack of proper reclamation. Toxics, including the coal seam itself, were left exposed and mixed throughout the spoil. The contact of groundwater and surface water with these toxics has resulted in the poor quality of some water in the area. Also these streams and springs loosen uncompacted spoil, and as a result of this and lower pH values of the water, these streams and springs more readily dissolve and carry material allowing for greater TSS and hardness figures. The unreclaimed areas are currently influencing water quality as exhibited by poor to very poor quality at sampling sites D-2, D-5A, S-4, and S-6." – Original Permit Application and Cumulative Hydrologic Impact Assessment (D-0958)*

Pre- and post-mining water quality data was gathered in accordance with NPDES standards for water quality monitoring. Figure 9-3 depicts how the pH and acidity values in Rocky Run changed prior to, during, and since the implementation of remining. Note the improvements in water quality for both pH and acidity when comparing pre-mining sampling to post remining. The sampling site locations are depicted in Figure 9-4.

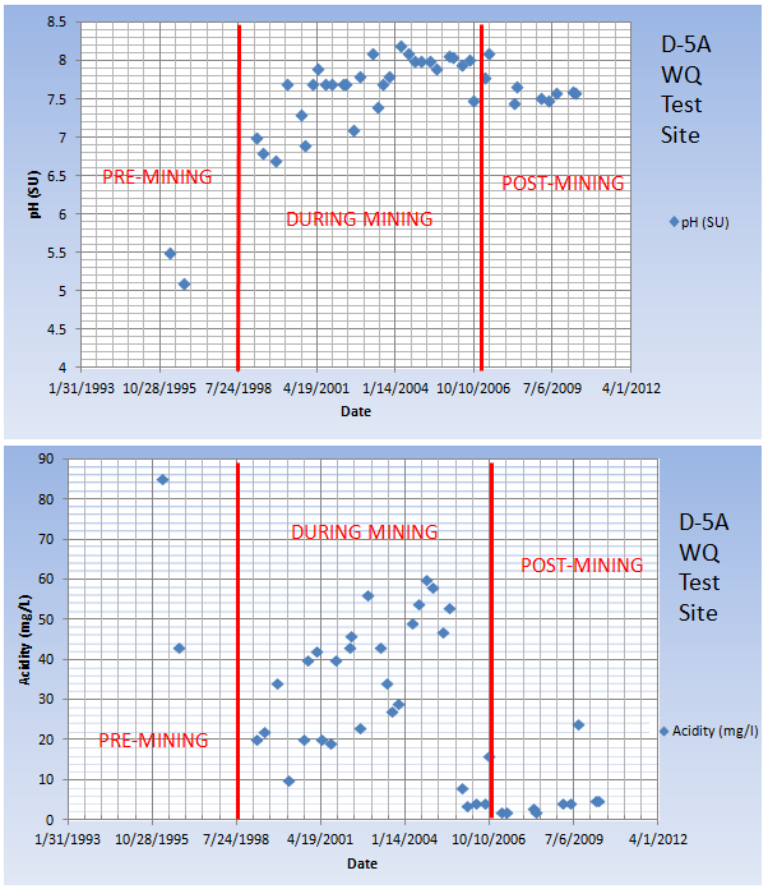

Figure 9-2. D-0958 remining water quality data

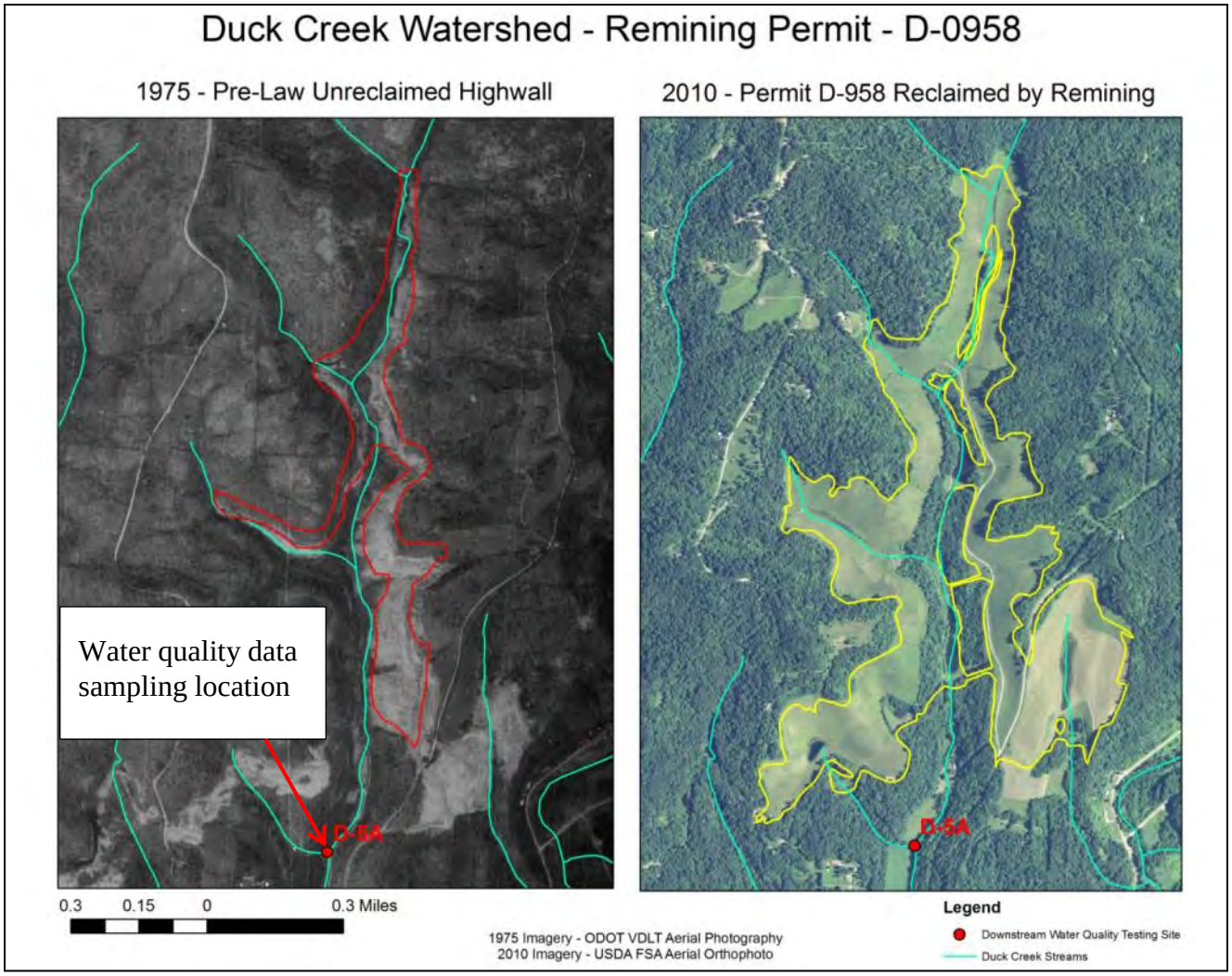

Figure 9-3. Duck Creek Remining Permit

10 STREAM SUMMARY

10.1 Stream Flows

OSU researchers evaluated changes in peak flow and runoff volumes for some of the watersheds containing the lower gradient stream segments. Using the rational method and the Kirpich Equation($t_c = 0.00778L^{0.77}S^{-0.385}$), 2 year peak flows could be estimated, and StreamStats was referenced to determine the accuracy of our bankfull width field calculations.

There is a 30-40% error factor when comparing calculated flows with predicted flows using StreamStats, however, the percent error between the recorded values and StreamStat values were 21.97% error for D-958 and 5.97% error for D-807. These being below the percent error show that both StreamStats and calculated values are within an acceptable range of each other. The calculations employed in StreamStats are based on the "Rural Method of Ohio." Typically the 1-2 year recurrent flows represent bankfull width. [12] In some instances there is a considerable percent error between the estimated flow for the Kirpich Equation and StreamStats. There are a number of different variables in approach that can cause such an error. Our team conducted a detailed field survey of each site laying out the center line of the stream and the bed cross section along our segment of interest, and the bankfull width. This theoretically would allow for a more detailed estimation of the geometry of the stream than StreamStats. A possible source of error could be the demarcation of the bankfull width at the steep trapezoidal rock channels in the field. Peak flows and runoff volumes for the D-019, C-209, and C-1305 were not calculated due to the difficulty of comparing field data for higher gradient streams in the extreme headwaters to data in StreamStats.

The flows of all streams reconstructed on the mining area or below the mining area can be impacted by the mining according to past research.

Research published by J.Hawkins P.G. *et. al* . on the increased stream base flow due to surface mining and subsequent reclamation can be summarized as follows:

- Streams fed by base flow from heavily mined areas tend to continue flowing through a protracted drought; whereas streams in adjacent unmined areas will exhibit less base flow per unit area or tend to go dry during the drought. This is indicative of not only higher recharge of the mine spoil, but also of a much higher storage capacity (effective porosity) for this additional recharging water[13]. An overall increase in-stream flow is due mainly to the higher base flow during summer low-flow periods, which is caused primarily by the decrease in evapotranspiration. Streams originating from surface mining areas tend to continue to flow during periods of drought when prior to mining they did not. The conversion of hardwood forest cover to grasses greatly contributes to the increased infiltration. The resultant increases in-stream base flow is also directly proportional to the area of deforestation[14].
- The increased infiltration rates are facilitated by the development of macro pores in the mine soil and cause the effective reduction of peak runoff rates and dramatically increase the length of the recession limb of storm events[15].
- The heavily-mined watershed continued to discharge during a protracted dry spell when similar nearby unmined watersheds stopped flowing which was attributed some to increased storage capacity of mine spoil. In addition, the substantially increased ground-water storage exhibited by mine spoil coupled with the increased infiltration facilitated by decreased evapotranspiration would support stream flow below reclaimed mine sites during periods of drought[16].
- Researchers observed that at a time when mined watersheds in southwestern Indiana were yielding about 0.27 cubic feet per minute per square mile (September and October 1964), other nearby watersheds were dry[17].

- Spoil is capable of storing much larger quantities of ground water than the pre-existing strata; if more water infiltrates into the spoil much of it can be stored and released gradually over longer periods of time. Effective porosity of mine spoils has been measured approaching 20%; whereas, pre-mining porosity values in fractured strata are generally less than 1%[10] .
- Spoil can store large quantities of water that eventually discharge as base flow to the streams and function as reservoirs. Peak storm flow show reductions commensurate with the area of the watershed disturbed[18].
- J. Hawkins, P.G. extrapolated data from a study by Helgesen and Razem [19] and determined that it can take 22 months or more for the water table to re-establish in surface mine spoil following surface mining.
- The saturated groundwater thickness model is dependent upon the ratios of sandstone to shale, age of spoil following mining, total spoil thickness, and distance to the highwall. The saturated thickness can be forecasted at greater accuracy for spoils up to 60 months following mining and reclamation and less accurate for spoil greater than 60 months after reclamation**Error! Bookmark not defined.** .

Once the water table is reestablished in mine spoil, this groundwater source provides a continuous source of water for reconstructed streams that are at or below this elevation and for receiving streams in the watershed that are below this elevation. The overall effect of mining and streams flows on the hydrologic regime of the watershed was outside the scope of this study, but is noteworthy because several seep areas were observed at the outcrop of the mining areas which added flow to the reconstructed streams. These seep areas combined with the concentrated flows in the channels provide an excellent source of water for tree growth and the biotic community within the bankfull width of the channel.

10.2 Stream Design

10.2.1 Trapezoidal Design Approach

In studying mining practices, when reconstructing streams after the mining process, trapezoidal rock lined channels were often used for higher gradient slopes. This approach was used at C-209, C-1305, and D-0019. These channels are shaped or graded and protected with an erosion resistant rock riprap underlain with filter or bedding material which to conveys stormwater runoff without allowing channel erosion. Rock channel protection provides for the safe conveyance of runoff from areas of concentrated flow without damage from erosion or flooding, and is used where vegetated waterway/conveyance channel/swales would be inadequate. A rock lined channel may also be necessary to control seepage, piping, and sloughing or slides. The riprap section extends up the side slopes to the designed depth. The earth above the rock is vegetated or otherwise protected.

This practice applies where the following conditions exist:

- Concentrated runoff that will cause erosion unless liner is provided,
- Steep grades, wetness, seepage, prolonged base flow, or piping would cause erosion,
- Damage by vehicles or animals will make the establishment or maintenance of vegetation difficult,
- Soils are highly erosive or other soil or climatic conditions preclude the use of vegetation, or
- Velocities are expected that will erode the channel or outlet without permission.

10.2.2 Natural Channel Approach

The natural design approach is possible because the form of naturally existing channels is largely predictable and proportional. This approach was used at D-807 and D-958. To the extent that

these geomorphic relationships can be defined, they can be used for designing channels. The proportionate relationships of channels used in natural channel design are referred to as "dimensionless ratios." By determining basic parameters, i.e. size and slope, complete channel form can be defined. For example, pools naturally develop at periodic intervals for a given slope. The distance between pools is longer or shorter proportionate to a channel's width. So, by knowing the width of a channel, the pool spacing can also be determined using the relationship of pool spacing to channel width (known as the pool spacing ratio). The intent of this procedure is to produce channels that are stable, feasible, and that have a higher ecological integrity.

10.3 Stream Summary

Trapezoidal design was used in permits C-209, C-1305, and D-0019 to reconstruct the stream. The stream gradient of these three reconstructed streams range from 8.7 % to 19% (Table 10-1). These can be considered relatively steep channels designed to convey surface water to receiving streams without erosion of the channel. They are Class I ephemeral streams, and all three of these reconstructed streams are in equilibrium. Reclamation occurred at these three sites approximately 30 years ago. The greatest bio diversity exists at the C-209 site exhibiting exceptional tree growth within the channel and in the flood plain zone. The age of this site and the undeveloped land use are the two primary factors for successful tree growth. D-0019 also exhibits some tree growth, but the shape of the channel and placement of rock bank- to- bank in the flood plain zone may have been a detriment to more tree growth diversity and abundance. C- 1305 has very limited tree growth which may be attributed to the agricultural practices being conducted in the drainage area of this channel. C-1305 and C-209 exhibit characteristics of a two-stage channel following years of morphological processes.

B&N permits D-0958 and D-0807 were designed using natural channel design guidelines provided by ODNR, DMRM (Appendix C). The gradient at these two sites ranged from 1% to 1.5% and both are Class II intermittent streams (Table 10-1).

Table 10-1. Summary of the Stream Evaluation

Permit	Site type	HHEI score	HMFEI score	Stream type	Stream Classification	Stream Grade
C-0209	Reconstructed	32	N/A	Ephemeral	Class I	13%
C-0209	Biological	88	25	Perennial	Class III	N/A
D-0958	Reconstructed	47	28	Intermittent	Class III	1.5%
D-0958	Biological	64	25	Perennial	Class III	N/A
D-0807	Reconstructed SS # 1	35	16*	Intermittent	Class II	0.98%
D-0807	Biological	73	21	Perennial	Class III	N/A
C-1305	Reconstructed	28	N/A	Ephemeral	Class I	8.7%
C-1305	Biological	64	14	Perennial	Class II	N/A
D-0019	Reconstructed	24	N/A	Ephemeral	Class I	19%
D-0019	Biological	66	12	Perennial	Class II	N/A

*Located below physical measurements of stream segment

The reconstructed streams have a natural fluvial appearance, and average less than 10 years post reclamation. Numerous wetland and emerging tree species are thriving in the flood plain of the channel. These two reconstructed streams appear to be in a state of quasi-equilibrium. D-0958 is a remining site that reconnected this stream. The stream is improved, both chemically and biologically, including its aquatic community, by the elimination of sediment, heavy metals and acidity from the previously mined and unreclaimed headwaters.

With the exception of C-209, water quality in the down-stream samples of the reconstructed stream segments is close to pre-mining water quality. This is demonstrated by the low metal and sulfate concentrations. Additional photos of these sites is located in Appendix F.

10.4 Biological Summary

- Three of the five biological sites located downstream or adjacent to the reconstructed stream segments exhibit Class III bio diversity characteristics, while two exhibited Class II bio diversity characteristics.
- OEPA technical based water quality standards for coal mining sites are met at all sites. However, sulfates, a non- regulated water quality parameter, are relatively high at the C-209 biologic site.
- Downstream biological sites may be benefiting from reestablished groundwater tables in the mine spoil that provides a more consistent flow of water during drought conditions than unmined watersheds that may support there Class III bio diversity characteristics.

11 CURRENT REGULATORY ENVIRONMENT

Coal mine permitting has seen increased involvement by federal and state agencies as a result of recent court rulings, policies, and other regulatory interests including the Clean Water Act 401, 402, and 404 permits. An MOU between Federal and State regulators in 2009 in response to a surface mining technique referred to as "mountaintop mining," has modified the guidance to mine operators for obtaining mine permits. Specifically, the Corps and EPA, in conjunction with the Fish and Wildlife Service, issued guidance clarifying how impacts to streams should be evaluated. This included how to evaluate proposed mitigation projects to improve the ecological performance of mitigation implemented and to compensate for losses of waters of the United States authorized under Section 404 permits. Surface mining coal reserves requires the removal of overburden above the coal seam. Certain areas within proposed mining limits contain drainage areas that convey surface water via ephemeral or intermittent streams to the primary drainage system. Removal of the overburden will impact some of those drainage ways in the headwater areas of the watershed. Recent regulations and guidance require mine operators to either reconstruct impacted waterways on site and conduct other mitigation activities, or avoid affecting those areas.

The ACOE and OEPA have been working on engineering guidelines that will address mitigation and in lieu fee programs. In December of 2014 the Corps issued Guidelines for Stream Mitigation Banking and In-Lieu Fee Programs in Ohio, Version 1.0 (Guidelines). This document provides those interested in stream mitigation banking and in-lieu fee stream mitigation with a statewide guide developed by the Ohio Interagency Review Team (IRT). The IRT consists of the

following federal and state resource agencies: U.S. Army Corps of Engineers (Corps) Buffalo, Huntington, and Pittsburgh Districts, U.S. Environmental Protection Agency, U.S. Fish and Wildlife Service, U.S. Department of Agriculture's Natural Resource Conservation Service, Ohio Environmental Protection Agency, and Ohio Department of Natural Resources. These Guidelines may be modified by the Corps and the Ohio IRT based on public feedback and/or technical concerns. The Corps is also working on a rapid assessment of streams which has been completed in other states outside of Ohio. Each rapid assessment protocol needs to be tailored to each state's inherent differences.

ODNR, DMRM is the primary regulator of mining activities in Ohio. In July 2009, DMRM issued Procedure Directive Permitting 2009-01 that replaced earlier policy procedure directives on this subject. The subject of this Directive is " Stream Buffer Zone Variance Request with the stated purpose of providing guidance for operators to obtain a stream buffer zone variance. The Directive is based upon Ohio Administrative Code 1501: 13-9-04 (E), which prohibits disturbance of land for the purposes of conducting coal mining activities within 100 feet of perennial and intermittent stream. The rule provides the Chief with the authority to grant a variance to this prohibition upon the relying on certain findings. The findings must assure that the operators will not cause or contribute to the violation of applicable state or federal water quality standards and will not adversely affect the water quality and quantity or other environmental resources of the stream. In order for the Chief to grant a variance, the permittee must provide a written request that demonstrates the activity meets the intent of the rule. The topics to be covered in the Buffer Zone Variance Request include the following:

- Discussion of specific activities
- Discussion of why the activities are necessary

- Discussion of protection of water quality, quantity, and environmental resources
- Stream reconstruction or stream diversion and/or relocation
- Revegetation
- Markers of buffer areas
- Mapping

In addition to obtaining the DMRM buffer zone variance mine operators are also required to obtain a 404 permit from the ACOE and often times a 401 permit from the OEPA required under the Clean Water Act. The end result of obtaining all the required permits form the various regulatory authorities requires the mine operators to perform mitigation for impacted streams either on site or off site. Considering the multiple regulatory requirements, navigating through the regulatory programs can be problematic for a mine operator.

To address these concerns OEPA and DMRM established a 401 Mitigation Task Force. This is a multi-disciplined task force that includes representatives from the mining industry, the regulatory agencies involved in stream permitting and reconstruction, consultants, and academia.

One of the objectives of the task force is to begin the conversation of important issues pertinent to the regulatory agencies and the coal mine operators. One of those issues is " mitigation credits" both on site and off the permit. DMRM and OEPA are exploring these concepts and working on a MOU that will help clarify this approach. The regulatory agencies recognize that guidelines may differ between remining and virgin mining sites. The task force is developing a mission statement and will continue to meet in 2015. In the absence of stream rules, guidelines may be a more preferable method to address these issues.

12 CURRENT STREAM RECONSTRUCTION PRACTICES

12.1 D-2180 Ohio American Energy, Inc.(OAEI), Jefferson County

On March 25th 2015, a group that included staff from DMRM, OAEI, and OSU's consultant met to review current stream reconstruction practices conducted on this active permit. Several streams of various grades were observed (Figure 12-1, 12-2). Eric Barto, OAEI's on site manager of the stream reconstruction project, indicated that the company was using Rosgen's stream stabilization techniques (such as rock vanes and tree vanes to create a back pools, step pools, and ripples) to provide a suitable environment for recovery of the reconstructed streams (12-3 through 12-12) that were affected by their mining operation.

Figure 12-1. 2180 Site Location via Google Earth

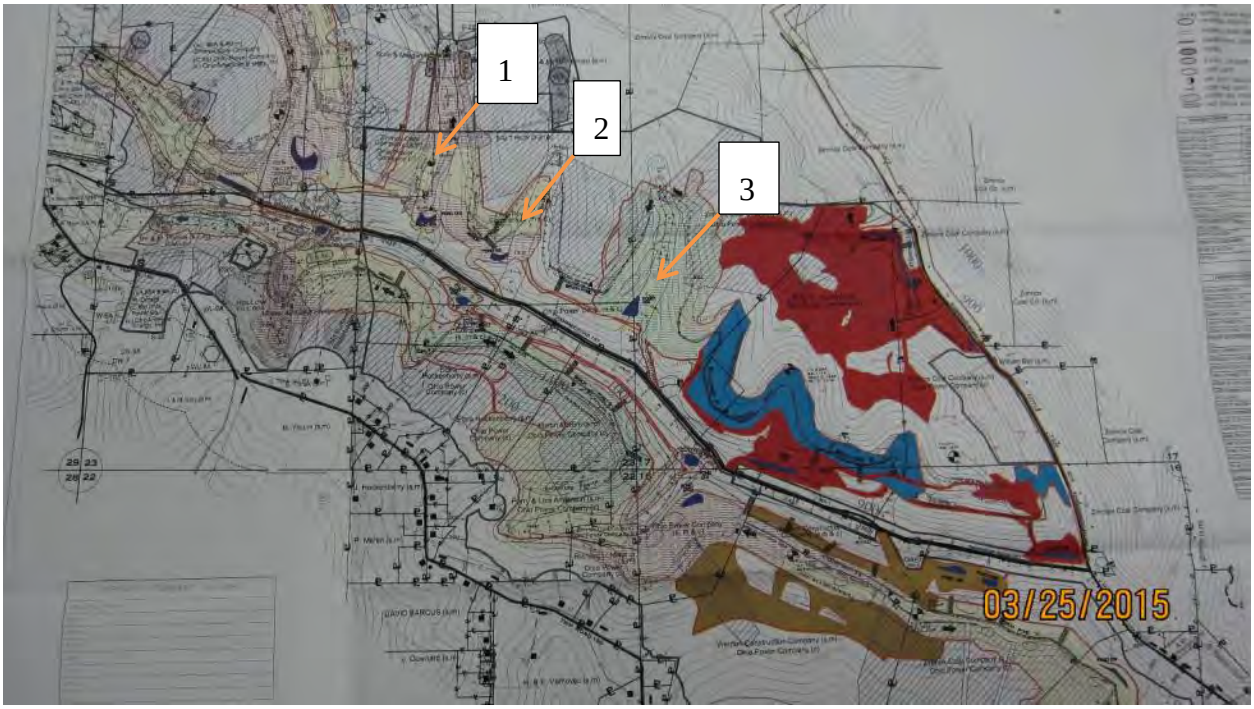

Figure 12-2. D- 2180 Application map with stream segment locations

Stream Segment # 1

Figure 12-3. D- 2180 SS#1 looking upstream with rock vanes

Figure 12-4. D-2180 DD#1 rock and log vanes

Figure 12-5. D-22180 SS #1 rock vanes and tree vanes

Figure 12-6. D-2180 SS# 1 rock vanes

Figure 12-7. D-2180 SS# 1 rock vane at head of stream

Stream Segment # 2

Figure 12-8. D-2180 SS# 2 rock vanes

Figure 12-9. D-2180 SS # 2 rock vane

Stream Segment # 3

Figure 12-10. D-2180 SS # 3 log dam

Figure 12-11. D-2180 SS # 3 step pools

Figure 12-12. D-2180 SS # 3 rock vanes

12.2 D-2266 Oxford Mining, Inc. Belmont County

On March 25, 2015 a group that included staff from DMRM and OSU's consultant reviewed stream reconstruction practices being conducted on this active permit (Figure 12-13). A perennial stream that was affected by mining was reconstructed using natural channel design and shown on the permit application map (Figure 12-14). Figures 12-15, 12-16, 12-17, 12-18, and 12-19 depict several views of the reconstructed stream that include upstream, midstream, downstream, and substrate views. According to DMRM Field Manager Mike Kosek, the company used a technique that included the re-compaction of resoiling material and suitable rock in a matrix to reconstruct the substrate bottom of the channel. The permit is still in active status and the reconstruction work on the stream is under review by the regulatory authorities, but appears to be in quasi-equilibrium.

Figure 12-13. D-2266 Site Location via Google Maps

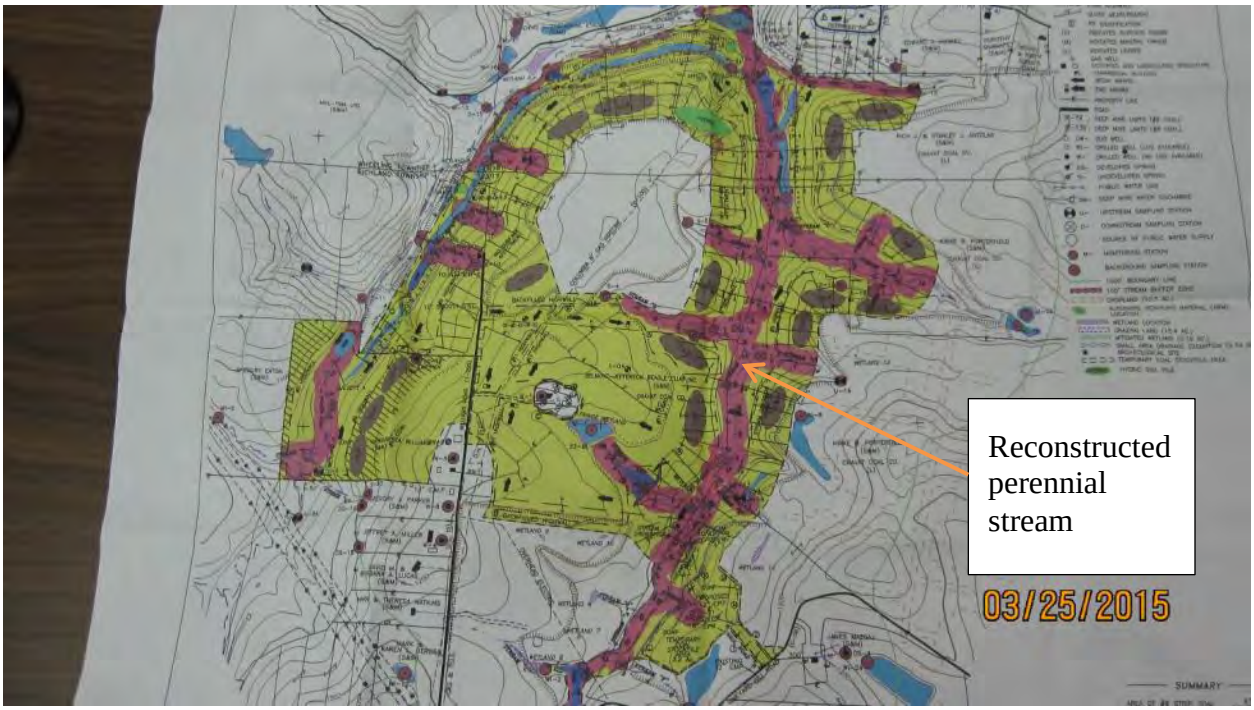

Figure 12-14. D-2266 Permit Map

Figure 12-15. D-2266 looking upstream

Figure 12-16. D-2266 midstream view

Figure 12-17. D-2266 substrate

Figure 12-18. D-2266 rock substrate view

Figure 12-19. D-2266 downstream view

13 CONCLUSIONS AND RECOMMENDATIONS

13.1 Conclusions

1. Channel Evolution Model indicates streams are generally in equilibrium until constructed and then move through stages of failing(degradation and widening), recovering(aggradation and widening), until reaching quasi-equilibrium(a stable channel similar to the pre-disturbance channel)[6]. Application of the model suggests the reconstructed stream segments located at C-0209, C-1305, D-0958, and D-0807 permits are in a state of quasi- equilibrium. Permit D-0019 remains in stage 2 “construction” as it appears relatively the same since it was constructed with no apparent morphological processes occurring(table 13-1) . This is primarily due to the construction technique utilized at this site. None of the reconstructed streams evaluated are failing.

Table 13-1. Stages of Channel Evolution

Stages of Channel Evolution (Simon, 1989a)

Stage		**Dominant Process**		**Geobotanical evidence**	
number	**name**	**fluvial**	**hillside**		**Permit**
I	Pre-modified	sediment transport; mild aggradation; basal erosion on outside bends; deposition on insided bends		Vegetated banks to low-flow line	
II	Constructed	trapezoidal cross section linear bank surfaces flow line lower relative to the top bank, vegetation removed			Wills Creek D-019
III	Degradation	basal erosion on banks	pop out failures	vegetation high relative to flow line, and may lean towards channel	
IV	Threshold	degradation: basal erosion on banks	slab, rotational , and pop-out failures		
V	Aggradation	development of meandering thalweg; initial deposition of alternate bars; reworking of failed material on lower banks	slab, rotational , and pop-out failures, low angle slides, previously failed material	titled and fallen riparian vegetation re-establishing vegetation on slough line	
VI	Re-establishment (quasi-equilibrium)	further development of meandering thalweg; further development of alternate bars; reworking of failed material on lower banks, some basal erosion on outside bends	low angle slides, some pop-out failures near flow line	reestablished vegetation extends up slough line and upper bank; deposition of material above root collars of slough line.	Ohio Power C-0209, Valley Mining C-1305, B&N Coal D-0958& D-0807

Remining site that reconnects streams improves water quality, both chemically and biologically, by the elimination of sediment, heavy metals and acidity from the previously mined and unreclaimed headwaters.

2. OEPA technical based water quality standards for coal mining sites are met at all sites.
3. Biological impacts are minimal as three of the five biological sites located downstream or adjacent to the reconstructed stream segments exhibit Class III bio diversity characteristics,

while two exhibited Class II bio diversity characteristics and these sites may be benefiting from reestablished groundwater tables in the mine spoil that provides a more consistent flow of water during drought conditions than unmined watersheds that may support their Class II and III bio diversity characteristics.

4. The Ohio Coal Industry appears to be improving their stream re-construction practices utilizing current technology in lower gradient streams at sites in Chapter 12.
5. The time frames for regulatory agencies to evaluate the success of a reconstructed stream may need to conducted in increments of decades and not years.

13.2 Recommendations

In addition to or in combination with other natural channel design approaches the coal industry should consider construction of two stage channels at mine sites where perennial type streams are to be reconstructed. Reconstructed streams observed appear to have two stage characteristics following morphological processes. This practice is gaining traction in the agriculture industry, and may have applicability in the mining sector (Figure 13-1).

Figure 13-1. Two Stage Channel Cross Section

A typical agriculture drainage channel is designed to have a single stage trapezoidal cross section. This channel design is great for efficient downstream water travel; however, with lacking flood plains the channel can experience side bank erosion and sediment buildup. Two stage channels are designed to activate the flood plain and minimize these occurrences. At the first stage, or main channel, a smaller bankfull width allows for water velocities high enough to reduce the amount of sediment deposition and promote transport. This sediment transport allows for heterogeneous sedimentation which increases biodiversity. The second stage allows for greater flood control in high storm event flows and an increased stability of the overall channel. For greater stability, the first stage of the channel will be lined with a rock material to counteract bank erosion. Also, two stage channels allow for nutrient removal to occur. With a large channel surface area, denitrification can occur more rapidly. This in turn results in a higher bio-assimilation, or plant growth, allowing for peak flow attenuation[12]. Figure 13-3 depicts a typical two stage channel cross section and an example of a two stage channel in an agricultural setting. It should be noted that agricultural drainage areas are very large and the industry is very active in redirecting and reconstructing drainage ways within actively farmed areas.

Two stage channels may be applicable for the mining industry for reconstruction of perennial streams, but may also be appropriate for intermittent stream reconstruction. In a mining environment the reconstruction of channel substrate could be comprised of a compacted rock/ soil matrix. The resoiling material provides a less permeable material as compared to mine spoil. Machine compaction of appropriate sized rock embedded with the clay composition in typical resoiling material would provide a more durable and less permeable substrate layer that mimics substrates found in nature. A cross section template of this configuration is termed a "Rock

Embedded Reconstructed Substrate"(Figure 13-2). The constructability and effectiveness of this type of substrate needs to be further evaluated.

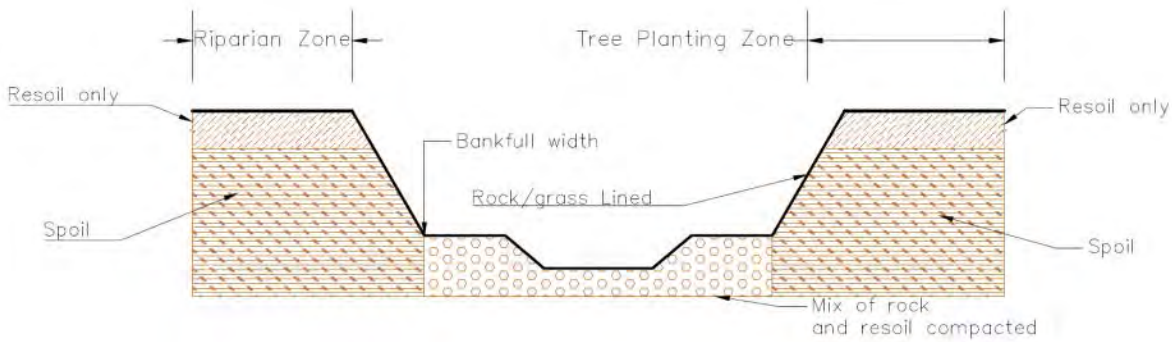

Figure 13-2. Rock Embedded Reconstructed Substrate

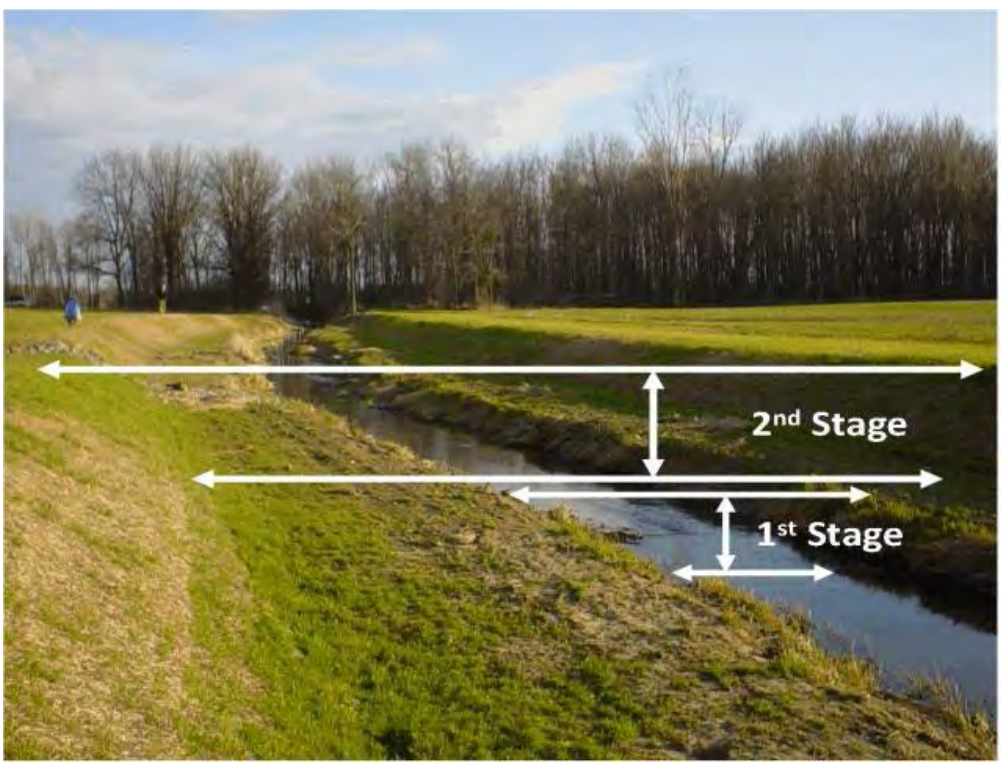

Figure 13-3. Example of Agricultural Two Stage Channel

6. For reconstructed channels, tree planting in the riparian corridor is important and required under current regulations. A reasonable survival rate count for tree plantings should be considered by regulators using studies conducted by the U.S. Forest Service. This is

important for tree plantings conducted in a mining environment; the mine operators are not actively managing these properties nor are they owners of the property, thus have little influence over post mining land use practices. For steeper reconstructed streams where rock channel protection is required, mine operators should be encouraged to plant tree seeds within the constructed rock placement area in the bottom of the channel where a source of water is more available to the seedlings/seeds; providing source of CPOM for biological communities as well as achieving a state of quasi- equilibrium..

7. Increase awareness of Ohio coal operators to follow DMRM guidelines for natural channel design should be encouraged. These guidelines should be updated periodically to review the current practices and update the guidelines, as appropriate. Since this is an evolving science and practice, providing a forum for open discussion on stream reconstruction practices and transfer technology would be beneficial.
8. DMRM and the other regulatory agencies should establish a practice of assessing reconstructed streams at 5 year intervals, post bond release, to build a viable data base that extends for decades.
9. DMRM should consider best management practices to include bank stabilization at the intersection of the reconstructed channel with the unaffected natural channel. This is particularly important for steeper channels greater than 4%. The energy flows produced in the reconstructed channel could be mitigated by a rock check dam at this intersection to prevent scouring of the natural channel bank (this was observed at one site in the field).
10. DMRM should provide additional incentives to coal mine operators who reconnect headwater streams through remining, and provide mitigation credits for the entire length of

stream that has been reconnected and reconstructed. The process of remining mitigates impacts from legacy mining, and the incentives should reflect that premise.

11. It would benefit the mining industry and the State of Ohio if “off-site” mitigation could include the reclamation of abandoned mined lands located near or adjacent to the mining operation.
12. The study evaluated a small set of reconstructed streams in the coal region. Further studies should be considered that include a wider swath of sites that includes perennial streams types and a more detailed assessment of the most current stream reconstruction approaches.

14 GLOSSARY

- *Bankfull Channel* – The portion of the channel that is most effective at maintaining itself.
- *Bankfull Cross – Sectional Area* – the channel area that corresponding to the bankfull flow. The bankfull cross-sectional area can be defined by the bankfull width and mean depth at bankfull dimensions.
- *Bankfull Width* – The surface width of the stream measured at the stage of the bankfull discharge.
- *Flood Prone Width* – The width associated with a value of twice the maximum depth at bankfull or in this procedure twice the maximum riffle depth.
- *Max Pool Depth* – The maximum depth of the channel at a pool. A pool is the deep and flat slope facet of the channel.
- *Natural Channel* – A channel that would exist naturally and has the ability, over time, to transport the flow and sediment of its watershed, without aggrading or degrading, while maintaining its dimensions, pattern and profile.
- *Weight of Evidence* – fact or proof that is conclusive on its own merit
- *Ephemeral Streams* – A stream that has flowing water only during and for a short duration after precipitation events. Ephemeral streambeds are located above the water table year-round, and groundwater is not a source of water for the stream. Runoff from precipitation is the primary source of water for stream flow.

- *Intermittent Streams* – A stream that has flowing water during certain times of the year, usually when ground water provides water for stream flow. During dry periods, intermittent streams may not have flowing water and runoff from precipitation is a supplemental source of water.

- *Interstitial Flow* – Continuously flowing streams occurring seasonally under the surface of the stream bed within the interstitial spaces of course substrate, or cracks in bedrock, also called "interrupted flow." Streams with interstitial flow have visually dry stream beds with isolated pools of water that are hydraulically connected by slowly moving water. At times of sustained drought, this type of stream may only have water flowing within the subsurface alluvium. The perennial flow is maintained by either deep groundwater recharge from the water table or from surface wetlands.

- *Perennial Streams* – A stream that has flowing water year-round during a typical year. The water table is located above the streambed for most of the year, and groundwater is the primary source of water for stream flow. Runoff from precipitation is a supplemental source of water.

- *Riparian Areas* – Lands adjacent to streams, rivers, lakes, and estuarine marine shorelines. Riparian areas provide a variety of ecological functions and services and help improve or maintain local water quality.

- *Stream reach*- a stream with a continuous channel bed up to 200 feet length, and for PHWH assessment may be shorter than 200 feet in situations where the tributaries have a junction with main stem of

PHWH streams or where features within the stream channel (either natural or artificial) warrant restricting the evaluation reach to a distance less than 200 feet of channel[1].

- *Watershed* – A land area that drains to a common waterway, such as a stream, lake, estuary, wetland, or ultimately the ocean.
- *Equilibrium* - a stream system that depends upon both the ability of the floodplain to dissipate the high energy flows and concentration of the energy of low, effectively creating a balance in sediment transport, storage, and supply[12].
- *Quasi-equilibrium*- in the Simon and Hupp evolution model a constructed channel will gradually reach a state quasi-equilibrium observed through predictable sequences that eventually leads to a stable channel similar to the pre-disturbance channel[6]

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