

Executive Summary

The Positive Impact of Water Augmentation Practices in Streams Affected by Longwall Mining

by

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PSM in Environmental Sciences
August 2021

Introduction

Underground coal mining has been prevalent in southwestern Pennsylvania since the late 1700s (*PA Mining History*, 2015). With the advent of longwall mining in the 1980s there has been detrimental ecological effects that can be seen on the surface. Hundreds of streams in Greene County have suffered flow loss in stretches of anywhere from one hundred to thousands of feet. These events have led state and government agencies such as the Pennsylvania Department of Environmental Protection to instate regulations concerning flow loss in tributaries and streams above longwall mines (*PA Mining History*, 2015). The company I interned for, CESO Inc., was contracted to investigate streams for flow loss and flow restoration.

Although the streams in the area have been negatively impacted to a high degree, stream restoration is a helpful environmental management strategy. The top priority of restoration in this area is to improve the water flow, with secondary goals including supporting overall environmental health and biodiversity. This entails the streams holding flow and conveying flow to larger streams instead of losing flow and even completely drying. The overall goal for the CESO team is to create a recovered stream, meaning it successfully holds stable flow and is closer to the stream's original natural state. CESO was not responsible and did not participate in any aquatic or plant studies.

Longwall mining, used in underground coal mines, is a full extraction mining method. The roof of the coal seam is temporarily supported while the full thickness of the coal seam is extracted. The coal is mined out of sections called panels, panels are usually 1,500 feet wide and 10,000 feet long. When extraction is complete, the roof is allowed to 'cave-in'. This causes fracturing of the strata above the coal seam, and generally results in damages on the surface. The fracturing of the strata from this mine subsidence can cause drainage of ground water from aquifers and streams as well as causing diversions of surface water flow. The mine that was the subject of my research has a total of 42 panels. However, the section where we were investigating and monitoring the mitigation of streams was located above 4 panels.

The ecosystem of the impacted streams is mostly temperate forests, with some urban landscape, and farmland as well. The focal point of the project lies within the ecosystems of the streams that are dry due to the mine subsidence. Instead of flowing, perennial streams, they have transformed into ephemeral and intermittent tributaries. This means these streams no longer flow year-round and will have flow only during Springtime or during rain events. These transformations have directly impacted local flora, fauna, and wetlands in the watershed. Although this has negatively affected the entire local habitat it has had the most severe impact on aquatic species such as the local fish and macro-invertebrates. The mine subsidence has disrupted the biota that used to thrive in these habitats; freshwater crustaceans, fish species, and those that rely on them, can no longer be sustained by this dying ecosystem. The water

augmentation and grouting process will help restore and stabilize stream flow so the water will once again flow perennially with conveyance from the headwaters to the confluence. Eventually the ecosystem will be revitalized with local vegetation and aquatic species returning to their natural habitats.

Scientific Summary

The role CESO performed in the water augmentation project is investigating and observing the augmentation water pressure, stream flow, and flow loss. The purpose of the project was to restore flow and recover streams affected by mine subsidence. The water augmentation system is comprised of water pumps, tanks, and lines to increase flow at the headwaters and midpoints of streams experiencing significant flow loss. A separate company was hired to install this system. Before I started the internship, most of the systems were already in place at the project site and background GPS and GIS data had been acquired. This data was used to build a map in ArcGIS to represent where the streams and augmentation systems were located in regard to the mining panels. During my work with CESO I was able to assist in collecting GPS data for new streams and systems that were installed. This allowed me to gain valuable GIS experience and knowledge of the area.

Throughout the summer and fall CESO was investigating these streams and augmentation systems at this particular site area in Greene County. These investigations were required by the mining company to make sure there was flow in the streams and locate any dry areas. Any area that could be observed to have significant flow loss would be important for the mitigation team. Daily reports were crucial to keep track of what streams and where there was good flow, no flow, and what gallon per minute the augmentation pumps were flowing. Periodically the CESO environmental team would take flow measurements at each station (100ft apart) in every stream that lies over the longwall panel of interest. The more we are able to investigate and collect the data the quicker we are able to create an analysis of sensitive areas in the streams. To ensure the accuracy of these measurements, we use two collapsible rulers and a flow meter. Using the two rulers allows the team to use the cross-sectional area method to determine the discharge rate at several points along the reach.

After sufficient flow data had been collected, the CESO engineering team and the mining company mitigation engineers would devise which streams would be mitigated. This is one of the last steps and most integral parts of this remediation process to restore the flow loss is grouting the stream bed. Grouting requires drilling under the stream bed and pumping grout into the voids in the strata in an attempt to seal off the stream bed. Unfortunately, I did not have much experience with the drilling and pumping crews on site. My focus was to map the sections that had been grouted and investigate stream flow post-grouting. These observations of the streams post-grouting were part of the last step in the augmentation investigation and allowed our team to determine if the streams had recovered. In the final stages we would take additional stream flow measurements and collect data that would validate the stream remediation efforts. This method is not a perfect science and different streams will recover over shorter or longer periods of time.

The results of the augmentation process and grouting helped me in achieving my internship project goal. The goal of the augmentation process is to restore streams as close to their natural flow volumes. The research answer that I sought to provide was a qualitative answer regarding positive impacts of water augmentation and mitigation practices. This theory can be compared to streams located over mined longwall panels that have not gone through the augmentation

process. The GIS mapping that I performed during the course of my internship demonstrated that augmented streams improved over the internship period.

Throughout the months of combined investigation, data collection, augmentation, and grouting the team at CESO was able to make initial judgments regarding recovery status in the project area. In total there were 8 different streams that had active water augmentation systems resulting in 25,608 feet or 4.85 miles of streams. During my internship 4 out of these 8 streams were able to be mitigated with the grouting technique. The team determined that 11,162 feet or 2.1 miles were mitigated (Figure 1). Post-drilling, the environmental team was able to conduct investigations and take several flow measurements, giving the engineers sufficient data to run flow analyses. These analyses allowed the engineers to make an initial conclusion that the mitigation was successful, and the streams were no longer experiencing any significant flow loss and were maintaining healthy base flow. Future observations will still need to be performed by CESO, but the initial results are positive.

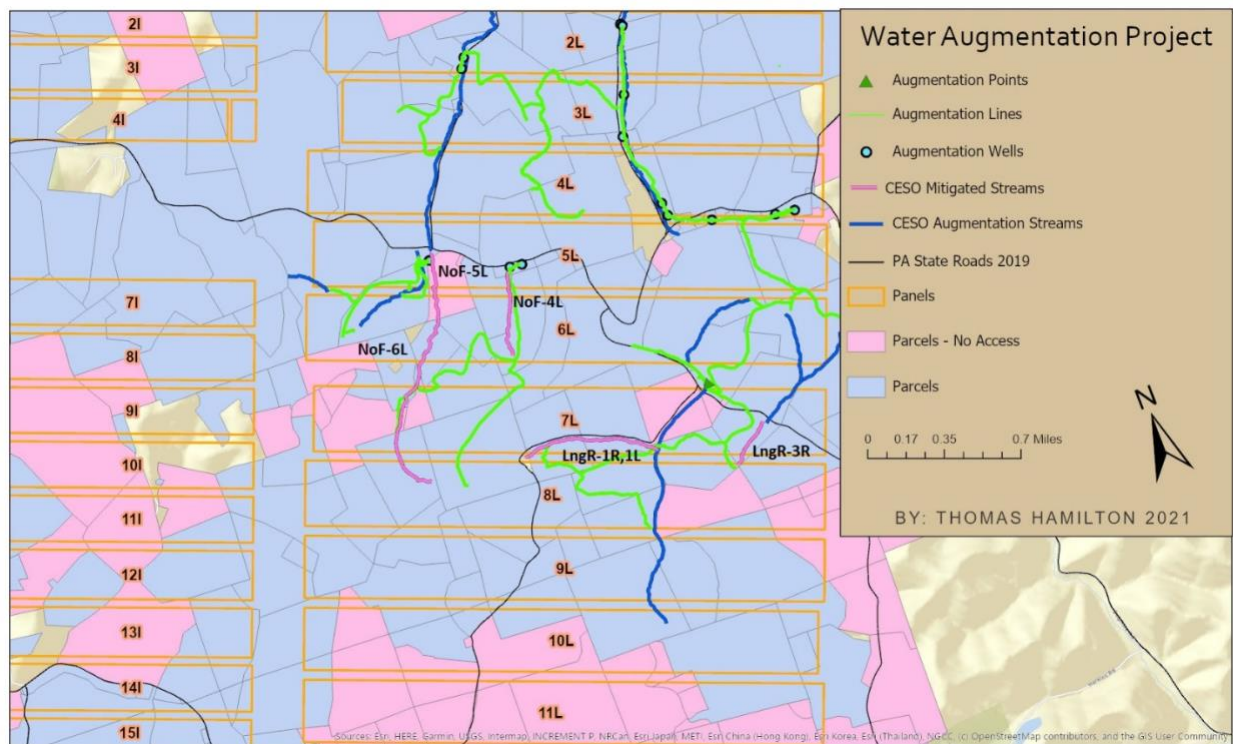


Figure 1. ArcGIS map showing the augmentation project area including augmentation systems, investigated streams, mitigated, streams, mine panels, and parcel access.

Business Summary

CESO Inc. which stands for Civil Engineers of Southwestern Ohio was started in 1987 by David Oakes in Dayton, Ohio. CESO started out as a civil engineering firm and slowly expanded into other markets such as surveying. The second office opened by CESO Inc. is located in Columbus, Ohio. The focus of this office is also civil engineering and surveying. In the early and mid-2000s other offices were also opened in Arizona, Arkansas, Tennessee, Florida, North Carolina, Michigan, Ohio and in Pittsburgh, Pennsylvania. The Pittsburgh office is where I was located during the internship. The Pittsburgh office was established in 2007 and while it has a large team of engineers, it was the first office to have an environmental team (CESO Inc,

(2021). As CESO expanded with these offices, they also launched new services alongside engineering, surveying, and environmental. These services include architecture, landscape architecture, and interior design. With these services CESO serves markets such as retail, distribution and warehouse, hospitality, residential, mixed-used development, healthcare, and energy.

The long-term goals of CESO are comprised of serving others with quality professional services and to help support their mission statement and core values. Their core values encompass humility, trust, loyalty, and respect. The mission statement of CESO is inspired by their client's success by serving them with integrity and commitment (CESO Inc, (2021)). This allows their culture to support local values and build strong communities. These values build a foundation which supports the company's priority long term goals of being a comprehensive firm offering start-to-finish capabilities.

CESO's underlying goals and high-quality work has allowed them to evolve and grow exponentially. When CESO was originally formed they were purely a civil engineering firm offering mostly site development services. These services included traffic studies, site design, utility main extensions, and stormwater management design, among others (CESO Inc, (2021)). By having this niche, it allowed them to slowly build a strong portfolio and loyal customer base. The engineering services they provided however were only a part of what the whole project usually needed and extra work such as surveying or environmental permitting would be carried about by other firms CESO made a transformation where they were able to shift the paradigm of the company and open themselves to more markets and provide a greater variety of services.

This variety of services is what allowed CESO to pitch themselves to the mining company and gain the company the contract for working on the augmentation project. CESO has completed other projects with this mining company that were similar in scope to the one that was the focus of my internship. The target stream identification, investigation, and plan development for augmentation contracted to CESO are required by law and do not produce revenue for the mining company. The stream restoration work must be done in order for the mining company to maintain its permits and stay in compliance with the law. Ultimately, if violations are not corrected, the mining company could have their permit revoked and their mining operations would be ceased until reparations are made. The work completed during my internship was one part of one condition of a large and complex permit that could have ripple effects throughout the company's work plan.

CESO was contracted to perform investigations, collect data, and oversee the grouting crews. They did not pay for, or install any of the tanks, augmentation lines, or pumps. The mining company paid a separate company to construct these systems and perform maintenance while the systems are operating. As the augmentation systems and grouting materials were not CESO's financial burden, I will attempt to disclose any costs CESO may have incurred. The main costs that the Pittsburgh office would acquire throughout the augmentation project would revolve around staffing and any gas or car maintenance which was rare during my tenure. The mitigation performed during the internship project lasted nearly six months. Therefore, half of salary or six months of salary will be used in the equation. The table presents the employee's time spent on the project multiplied by half of their salary to find the cost to employee each person (Figure 2). To gain this data I used Glassdoor.com. Below is a table outlining the estimated costs CESO would have incurred from staff during the Greene County augmentation project.

Position	Time Spent on Project	Half of Salary	Cost Per Person
Intern	1/3	\$17,680	\$5,834
Field Biologist	1/3	\$26,000	\$8,580
Environmental Project Manager	1/3	\$35,000	\$11,550
Engineering Project Manager	1/5	\$50,000	\$10,000
Environmental Manager	1/10	\$50,000	\$5,000
		Total Cost:	\$45,964

Figure 2. Table representing staffing costs paid by the mining company for the augmentation project throughout the internship project.

Conclusion

Being able to participate in a project as substantial as the longwall mine augmentation project in Greene County was an incredibly educational experience. While completing my necessary internship goals for Oregon State University for the Professional Science Masters’ degree in Environmental Sciences, I was able to contribute significantly to the team at CESO. It was a unique experience to see a project of this magnitude transform and change through its lifecycle. Each step of this process including the investigation, data collection, and mitigation observations were integral in understanding how water augmentation practices can have a positive impact in these streams affected by longwall mining.

Working on a detailed environmental restoration from start to finish was a unique work experience. The mining company was able to benefit from having CESO perform a professional job with responsible investigations, quality data collection, and oversight of the effects of grouting. The environmental teams efficient work helped build the client-customer relationship and trust of the team when making decisions. With the mining company recognizing the team’s effectiveness and professionalism, CESO has been able to attract attention from other local companies. They have also obtained a future contract from this same company to continue to investigate streams to mitigate above other mine panels. During the 6-months of augmentation and mitigation work that I observed, the team was able to determine substantial restoration gains. These results help to solidify the working relationship between the two teams from CESO, environmental and engineering, working on the project.

The goals of my internship research and the water augmentation project I worked on provided a wide array of benefits for myself, the mining company, CESO, and the local environment. CESO’s mission statement helps to illustrate that the company’s vision is to find purpose through serving others. This allows for the CESO team to be inspired by their client’s success and to make a positive difference in the community. This project encapsulated these values as the whole process helped the client follow through with their goals of mitigation of these damaged streams and helping to restore the local ecosystem. The internship served as a unique and valuable learning experience that I will continue to value and feel a sense of accomplishment. Although the augmentation and mitigation work is far from being completed in

the Southwestern Pennsylvania area, I feel relieved knowing the local mining companies have CESO at their side.

References:

ACT 54. (2018). Retrieved 1 June 2021, from <https://www.dep.pa.gov/Business/Land/Mining/BureauofDistrictMining/Act54/Pages/default.aspx>

Cavity / bulk / mine fill grouting | Keller Group plc. (2021). Retrieved 6 June 2021, from <https://www.keller.com/expertise/techniques/cavity-bulk-mine-fill-grouting>

CESO Salaries. (2021). Retrieved 5 June 2021, from <https://www.glassdoor.com/Salary/CESO-Salaries-E1141515.htm>

Home - CESO Inc. (2021). Retrieved 5 June 2021, from <https://www.cesoinc.com/>

How Streamflow is Measured. (2021). Retrieved 17 August 2021, from https://www.usgs.gov/special-topic/water-science-school/science/how-streamflow-measured?qt-science_center_objects=0#qt-science_center_objects

Michalski, S. (2011). Coal-Mining Techniques and Coal Fires. *Coal And Peat Fires: A Global Perspective*, 29-46. doi: 10.1016/b978-0-444-52858-2.00002-5

PA Mining History. (2015). Retrieved 1 June 2021, from <https://www.dep.pa.gov/Business/Land/Mining/Pages/PA-Mining-History.aspx>

SECTION VIII: A Follow-Up on the Effects of Mine Subsidence on Streams during the 3rd Act 54 Assessment. (2013). Retrieved 1 June 2021, from https://files.dep.state.pa.us/Mining/BureauOfMiningPrograms/BMPPortalFiles/Act%2054/08_Se c8_FINAL.pdf

Tips on Investigating Stream Dewatering from Underground Mines. (2013). Retrieved 1 June 2021, from https://www.arcc.osmre.gov/about/techDisciplines/hydrology/docs/techGuidance/2013/tsd-wggb-Tips_on_Investigating_Stream_Dewatering.pdf

Underground Coal Mining Methods and Engineering Dust Controls. (2018). *Monitoring And Sampling Approaches To Assess Underground Coal Mine Dust Exposures*, 142-150. doi: 10.17226/25111