Non-Metallic Mining: An Administrative Program and Natural Resources Analysis for Buffalo County, Wisconsin

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Abstract

Non-metallic mining has become a mandatory issue to be addressed by all counties, townships, and cities in Wisconsin. The initiation of this program began in the year 2000 and was designed to concentrate on pollution that was originating from non-metallic mining sites. The goal of the mandate was to set a series of guidelines, developed by the Regulatory Authority (Buffalo County), to which quarry operators must adhere. Guidelines are prepared to "reclaim" mined areas to return the land to a similar condition as prior to mining (Anonymous. A Guide to Developing Reclamation Plans for Nonmetallic Mining Sites in Wisconsin). As part of mining program requirements, Buffalo County is developing a series of resource modeling efforts in hopes of protecting natural resources. Such resource modeling involves stream protection (mines contributing point sources of sedimentation), identifying homes at risk of blasting repercussions (well collapse), slope analyses (runoff), traffic analyses (safety), and groundwater/geologic analyses. Furthermore, administrative methodologies are an important tool in governing the newly established program. Continual efforts are made at the county level to analyze proper program administration. Serving as a 'pilot program,' the non-metallic mining program offers Buffalo County the opportunity to develop an administrative GIS research/resource model that can be used for other programs and/or projects that will benefit from a comprehensive GIS – administrative approach to conserving natural resources and managing programs effectively.

Introduction

The work for this project began in June of 2001 as a portion of employment requirements for Buffalo County, Wisconsin. The data collection and administration topics contained herein, were part of an on-going data collection and program evaluation. As evident, this report will contain information collected since program implementation. Non-metallic mining was chosen for analyses because of its new forthcoming as an un-funded state mandate that is to be enforced by all counties, townships, cities, and municipalities in Wisconsin.

To model and/or research every intrinsic variable of this program would be profoundly difficult in part because of the many infinite program components as well as the fact that data is relatively new. However, this project will analyze two mechanisms vital to the non-metallic mining program: 1) Administrative Program Assessment and Evaluation and secondly, 2) Non-Metallic Mine Site Assessment - GIS Resource Analysis. In short, both mechanisms examine the principles and importance of utilizing program planning/evaluation with GIS resource modeling.

Program administration analyses were completed to better assess and evaluate the following from the non-metallic mining program:

1) Theoretical foundations of science methodologies in the social context of program development and evaluation.

2) Program data analysis and case study applications to accurately identify the strengths, needs, and goals appropriate for a developing program.

3) Formulate program recommendations in response to specific county needs.

4) Construct program evaluation plans that will render quality data for present and future resource conservation decision-making.

The second project element involved data collected from mine site inspection. The author developed criteria for assessing mine sites. Individualized (county) inspection criteria were developed to better serve the local needs of Buffalo County. Criteria were based on employee education and an understanding of the science behind the erosive potential of mine sites. Mine sites were ranked on a scale of 1–5. The rankings were based on 'severe conditions (1)' to 'little or no problems evident (5).' The collected information is directly related to the number of problems observed while visiting the site during mine inspection.

I. Evidence of Erosion or Sedimentation

1) Point Source of Sedimentation
2) Water Runoff Problems
3) Type of Drainage - External/Internal
4) Evidence of Drainage/Runoff to Neighboring Properties

II. Toxicity Potential Relating to the Site

5) Agricultural Runoff Reaching the Site
6) Hazardous Materials in/near the Site

III. Geologic/Physical Site Conditions

7) Geology of Site (Formation)
8) Approximate Slope (%) around Site
9) Presence of Fractures in Strata
10) Groundwater Pollution Potential
11) Proximity of Site to Stream(s)
12) Storage of Quarry Materials

IV. Wildlife Habitat Conditions

13) Habitat Diversification Around Site
14) Evidence of Habitat Degradation

V. Traffic Documentation

15) Traffic Observed on Road Networks that Intersect Mine Access Roads

For the simplicity of this model as well as to keep the project from becoming too large and burgeoning, only ten of the components were analyzed. The approach used to select those variables involved county needs of importance as well as the overall benefit to other county departments. Modeled variables included (by number): I. (1, 2, 3), II. (5, 6), III. (7, 8, 10, 11), and V. (15).

Methods

Administrative Program Assessment and Evaluation

The project planning/evaluation portion of this research was developed from assessing personnel activities and documenting case studies related to Buffalo County's non-metallic mining program.

One reason the administrative components were analyzed was due to the fact that no administrative assessment and/or evaluation had taken place at the county level or for that matter, at the statewide level. The program was evaluated on a local county level in hopes of determining if any program loopholes or inefficiencies were occurring during administration.

Assessment Narrative

An assessment narrative description of the non-metallic mining program was created from the date of June of 2001 (program inception) to June of 2002. The sole purpose of the assessment was to evaluate the effectiveness, planning, and direction of Buffalo County's non-metallic mining program. Another important element that the assessment identified was the short-term program goals and objectives. Questions that research attempted to answer were:

a. How can the Buffalo County Regulatory Authority utilize program flexibility to the greatest advantage to produce the greatest outcome possible?

b. What short-term goals and objectives can be used to reduce threatening opposition to the program?

c. Can we develop information about program requirements to benefit program goals and to model potential resource concerns?

d. What methods of outreach and I&E information will be required to garner public support for the program?

e. Will program revisions be required to maximize program efficiency?

Utilizing case studies and documentation reviews were among those methods used in the assessment. These methods were selected because an analysis could be completed without interrupting the operation and implementation phases of the program. This involved an analysis of financial statements (including permits, budgets, etc.), conversations, and communication documentation. Case studies provided a direct approach to understanding an operator's (mine operator) experience and what items are successful for program compliance and operator satisfaction.

Data sources involved in the assessment included a documentation review that identified both internal and external facets of the program. Internal facets of program administration encompass all documentation directly related to the program. Internal documentation included: administrative code, budgets, annual reports, letters, correspondence, time documentation, email/telephone conversations, and mine operator surveys. External facets included documentation that was not directly involved with the program, but could have some potential impact on program operation. Several issues identified as external documentation were mine literature, landowner letters, and related forms of I&E outreach. Individual case studies relating to each non-metallic mine operator were addressed to realize the experience each operator was incurring with the program.

The narrative also includes brief statements of summary descriptions and relevant community issues/ characteristics. The purpose of community context and relevant community issues are to describe a reason why proposed questions are important and what stakeholders and/or people the program may affect. In addition, descriptive statements incorporate information about the mission, history, and current programs of the organization (Buffalo County). A structural flow chart of the organization and the complete narrative document is provided in Appendix A.

SWOT Analysis

The final component of the narrative assessment was a SWOT (Strengths, Weaknesses, Opportunities, and Threats) analysis. Chiefly, the purpose of a SWOT analysis is to provide a framework for identifying issues having the most impact on the program (Anonymous. The Management Assistance Program for Nonprofits). Another advantage in utilizing SWOT analyses are to help isolate key issues and to also facilitate a strategic approach to administration. SWOT components are separated into four major categories. Strengths are classified positive aspects that are internal to the program. Weaknesses are negative aspects internal to the program. Opportunities are positive aspects that are independent and external to the program. Threats are negative and are largely independent and external to the program.

Program Goals and Objectives

Program goals and objectives were developed for the non-metallic mining program. Goals must exhibit conditions that are related to 1) the deliverables that will exist upon a desired outcome, 2) a time frame, and 3) resources and stakeholders involved in the goal to reach its desired result (Anonymous. The Management Assistance Program for Nonprofits).

Five major program goals were created. The program goals were clearly defined by the state and by Buffalo County. Please refer to Appendix B for a complete listing of program goals. Secondly, implementation goals were developed through the use of the SWOT analysis. By isolating major strengths and opportunities, goals were created to help facilitate the overall program goals. Third, development goals and objectives were created (also from the SWOT analysis) to help facilitate the implementation goals. Development goals and objectives were obtained largely to minimize program threats and weaknesses.

Non-Metallic Mine Site Assessment - GIS Resource Analysis

The second component to this project involved GIS modeling based on mine site inspection data. The purpose of the inspection assessment was to accumulate mine data that Buffalo County could accrue and use to develop an annual non-metallic mining GIS database that would serve as a means of resource modeling and protection. It is important to note that assessment information was only accumulated for one year (through 2001).

Inspection criteria were developed in part by the Buffalo County GIS, Land Conservation, and Zoning Department. Criteria were not born out of any existing protocol and/or other non-metallic mining programs. Buffalo County tailored inspection efforts to address the potential impacts that mining may have on county natural resources.

All relevant data to support the resource analysis portion of this project was accumulated from inspection data from which GIS themes were developed and attributes defined. A majority of the analyses were completed using this database. Stream, geologic, and water quality layers, etc. had been digitized and created from previous work, as well as from baseline data automated by the Wisconsin Department of Natural Resources (WDNR). GIS data used in this project were developed and were projected in Universal Transverse Mercator, North American Datum for the year 1983 (UTM NAD83).

Research accumulated during inspection had several predominant deliverables. Data captured for this phase of the project was used to derive models for groundwater susceptibility, assessments of drinking water wells related to quarry blasting, traffic hazard assessment, slope analyses, and external water runoff.

Groundwater Pollution Susceptibility

Historically, groundwater conditions have not been an issue of concern in Buffalo County. However, mining operations can produce hazardous chemicals from rock producing practices. Other hazardous elements such as fertilizers, manure, equipment fluids, and burnt debris have been found and/or disposed of in many county mine sites. What is the ultimate risk of groundwater pollution as a resultant factor of such practices? Local county geology, groundwater properties, and landuse factors are the major contributors when determining the extent of groundwater and its susceptibility to pollution. Buffalo County has more than 46 open and/or stripped mine sites that are composed of predominantly Ordovician limestone and dolomite as illustrated in Figure 1 (Brown, 1999).

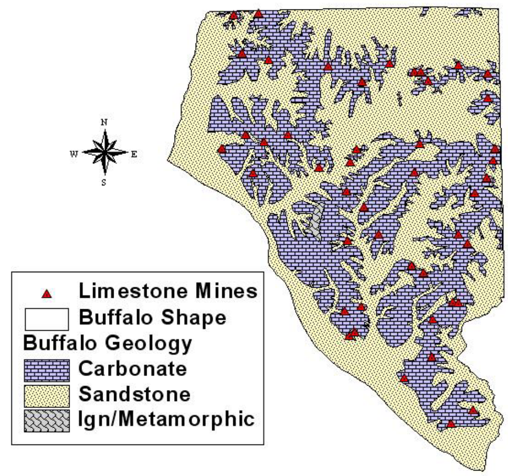

Figure 1. County geology and limestone mines.

Compositional properties of these rock types generally result in highly fractured strata attributed to blasting, chemical weathering, and mechanical weathering (frost wedging/freezing and thawing). Consequently, highly fractured strata provide a direct conduit for pollutants to enter groundwater environments.

Research and analysis for this project component involved several variables. A theme consisting of county mine sites was developed by first plotting mine sites identified with the use of county orthophotography. Attributes were added to this theme from inspection results as well as from WDNR classifications. The WDNR had previously denoted areas in Buffalo County that would potentially be at a higher risk of groundwater contamination because of factors described above. WDNR data sets were originally created in Wisconsin Transverse Mercator (WTM), which was highly incompatible with the current data set that is projected in UTM NAD83. Number codes were translated from the WDNR data set and were added to the mine theme in order to project the WDNR data into UTM NAD83. It should be noted that the author has not spoken to anyone who has been successful in either projecting data into or out of the WTM projection.

Site inspection codes were given to each mine site for groundwater susceptibility. A '5' was given for no risk, while a '1' was given for a high risk. The same code translation was used for the WDNR classification. The reason this was done was to identify any correlations that may have existed between WDNR data and county data. This approach was also used to investigate and warrant the validity of the mine inspection data to understand if it was remotely effective for modeling use. Number values were used for this model to develop a spatial analysis that illustrated an overall interpolation of Buffalo County's groundwater susceptibility potential related to mine sites. ArcView's Spatial Analyst was used to complete groundwater susceptibly interpolations for both sets of data. Interpolations were completed for both WDNR translated data and mine inspection data. Point data were interpolated using the Inverse Distance Weighted (IDW) analysis. This method assumes that local influence from each point diminishes with distance from each point.

Well Collapse/Failure Predictability

Another imperative concern relative to mining is well collapse, caused largely from detonation charges and the shock repercussions that are propelled through consolidated limestone/dolomite strata. Many problems common to well failure can be linked to uncased and/or improperly constructed wells. Buffalo County has forty-six (46) limestone/ dolomite mine sites. An analysis was completed to develop an understanding of well collapse potential. Homes were plotted with the use of UTM NAD83 orthophotography. Once homes were identified and plotted within several hundred feet of each limestone mine site, literature collected from the Department of Commerce suggested that homes located inside of a 1200' radius were more at risk for well collapse or well failure (Anonymous. Chapter Comm 7, Explosive Materials).

To model the predictability of well failure, limestone/dolomite mine sites were buffered at three intervals of 400' (high risk), 800' (moderate risk), and 1200' (low risk). The ArcView GeoProcessing Wizard was used to create the buffers in this analysis. Consequently, homes located within a buffered region were then given an attribute of either a high, moderate, or low risk depending upon their location within the buffered interval.

Sedimentation

In order to protect Buffalo County's stream corridors and riparian zones, inspection efforts also included sedimentation criteria. Sedimentation criteria were evaluated based upon observed factors such as external runoff, sediment load being carried from the site, and the apparent duration of sedimentation.

Stream networks were buffered in intervals of 100 feet up to 500 feet to create a depiction of what streams were possibly in danger from being impacted by sedimentation stemming from poorly managed mine sites. 500 foot buffers were the minimum as recommended by the University of Wisconsin Extension (Fritz, 1975). All buffers were created by the use of the Geo Processing Wizard. Another analytical approach used in the study was to find all mines within a specific distance from streams.

This method was accomplished by using the 'select by theme' operation under the Theme dropdown box in ArcView. The general intent with this practice was to determine distance relationships between mine sites and stream corridors.

For this analysis, mine sites were ranked according to a number scale. A value of '1' indicated a highly dangerous site in reference to sedimentation contribution, while a ranking of '5' indicated a low risk of sedimentation. Data collected from this analysis would prove useful in coordinating future efforts with mine operators to curb erosive conditions in the mine sites. Research for sedimentation potential, illustrated both streams with the greatest risk of sedimentation and identified mines with the greatest likelihood to contribute sediment load to streams.

Slope Analysis

The purposes of slope analyses for this project were twofold. The first objective was to determine general countywide patterns of slope gradients to locate which sites are at risk from water runoff and runoff into sites (possibly contributing to groundwater contamination potential). Procedures used in this analysis consisted of generating a TIN (Triangular Irregular Network) from a DEM (Digital Elevation Model) using Spatial Analyst for ArcView. Analysis objectives aimed to correlate slope results recorded from inspection data and compare them to the TIN data. The desired goal of contrasting data was to determine if inspection criteria were accurate enough to model. A TIN served useful in generating countywide slope percentages. Similarly, another component involved interpolating mine data collected during inspection. Information collected during mine inspection was based on a number qualification. A value of '1' indicated a mine had a high risk of agriculture or woodland water runoff entering the site and/or a high potential of water leaving the site. A value of '5' represented a site having little or no chance of collecting or discharging runoff.

The second objective of this analysis was to acquire an understanding of what the general landuse surrounding mine sites consisted of. Figure 2 exemplifies landuse and its importance in determining criteria for water/ chemical runoff into mine sites as well as for county Smart Growth planning objectives.

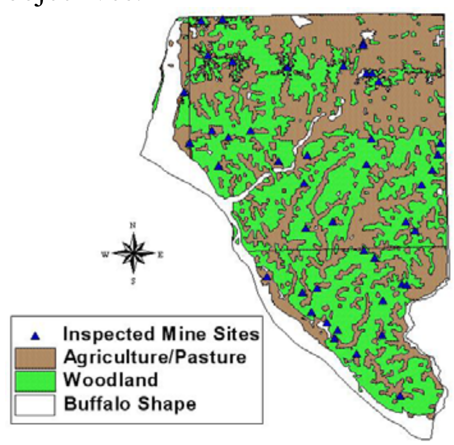

Figure 2. Landuse relative to non-metallic mining sites and slope analyses.

Traffic/Population Analysis

The purpose of traffic and population analyses were to ultimately determine safety factors involved with non-metallic mining. Reasoning for this analysis are strongly linked to the large number of trucking and transportation equipment moving into and out of quarry sites. Both mine operators and the county would find county demographics and traffic densities associated with non-metallic mining useful in coordinating activities.

Methods used in this analysis consisted of recording the number of vehicles observed while on inspection. Also, population values for each municipality and/or village in Buffalo County were recorded. Numbering criteria were assigned to each mine site based on the recorded number of vehicles. A value of '1' (high risk) indicated a high level of traffic, while a value of '5' (low risk) indicated a low level of traffic. Traffic values were based on the following traffic codification devised by the county:

- > 35 Vehicles/Hour = Ranking of 1
- 26-34 Vehicles/Hour = Ranking of 2
- 17-25 Vehicles/Hour = Ranking of 3
- 9-16 Vehicles/Hour = Ranking of 4
- 0-8 Vehicles/Hour = Ranking of 5

It is important to realize that the time of inspection and weather conditions influenced some of the data. Some mine sites were located a significant distance from public roads and in some cases could not be assessed. As a result, these mine sites were not given a numerical assessment value. The reader should also understand that several years of data accumulation would represent a better indication of overall county traffic patterns.

Population values were added to the municipalities theme. Numerical values were ranked from largest (1) to smallest population (21). To develop an overall population density, ArcView's Spatial Analyst was used to create an interpolation of the point locations that represented municipalities. The points were interpolated using the IDW selection. The results of population densities were then compared to that of the interpolated traffic rates around mine sites. The objectives were to determine which mine sites were located near populated regions of the county and to determine if municipalities had a direct impact on the rates of traffic near mine sites.

Active/Inactive Mine Comparison

The final component of the project involved pollution potential comparisons between active and inactive mine sites. The following inspection criteria were analyzed:

- Sedimentation
- External Water Runoff (leaving site)
- Agricultural Runoff (into site)
- Hazardous Material (found in site)
- Groundwater Pollution Potential
- Habitat Degradation
- Traffic Rates (near site)

The purpose of the statistical analysis was to make an inference about mine sites to discover if a relationship exists between active mines and inactive mine sites and their role in resource pollution potential. These inferences for this analysis were derived from inspection data. Active mine sites are sites in which mining activities are either occurring or are planned to occur for the calendar year. Inactive mine sites are sites that are also permitted, but are not scheduled for mine activity for the calendar year (Anonymous. Chapter NR135, Non-Metallic Mining).

Prior to any research, the rational hypothesis was that inactive mine sites have an equal likelihood to pollute/ degrade resources as active mine sites.

Ho: Inactive site pollution rankings = Active site pollution rankings

Ha: Inactive site pollution rankings ≠ Active site pollution rankings

To complete this analysis, inspected mine sites were separated into inactive and active classifications. After the two categories were created, the following statistical methods were used to determine if the hypothesis would hold valid:

- Mean of each category
- Sum of Squares for each category
- Standard Deviation for each category
- Pooled Variance
- Standard Error
- Variance-Ratio & 2 Sample T-Test

Results/Discussion

Administrative Program Assessment and Evaluation

Assessment Narrative

Results of the assessment narrative are completed and can be observed in Appendix A. Questions derived in the narrative assessment were largely facilitated by the SWOT analysis and will be discussed in the next section. The overall purpose of the narrative was to provide an outline of program intents.

SWOT Analysis

The SWOT analysis provides answers to the questions that were previously listed under Methods. Internal SWOT evaluations provided the following results.

The Buffalo County Zoning Department (Regulatory Authority) has good access to technological advancement and internal capacity programming that allows the program to be flexible in program administration. Some baseline data has been collected to help facilitate program direction. Presently, Buffalo County has a high level of operator compliance and satisfaction. The program has support from the county board and has qualified staff administering the program. The program has fostered excellent working relationships with mine operators, in spite of unscripted methodology and redundant paperwork for program administration. Insufficient information/data and dependence upon political (conflict) support make it hard to promote program benefits. In addition, there are no foundational or quantifiable standards for reclamation. Another major concern is program longevity. The program is slated to operate at rates to employ one part-time person; after a three-year period the program will likely become a smaller program. There is the potential that the program will not be perceived as important after the three year implementation efforts are met.

External SWOT evaluations yielded the following results. The program will demonstrate environmental protection and increased land value and tax benefits if adequate information is collected and incorporated into reclamation. Future evaluations and assessment information will benefit fiscal planning and budgeting. The program follows similar guidelines to other required permits and programs. This allows for a synergistic approach in program administration. Flexibility allows for endless reclamation opportunities. Many citizens are against the program because it has the potential for ending mining activity in sites once used for construction and limits material availability. There is not a great deal of information available to show the public the benefits of the program. Liability tends to be an outstanding issue for accidents and/or mishaps that may occur in and around the mine site.

The SWOT analysis also provided information relating to a small outline of program goals for continued SWOT development. The results are as follows:

1. Develop desirable research models derived from maximizing data and information collection.
2. Provide outreach and political support - meetings/surveys.
3. Maximize data from previous fiscal year budget.
4. Simplify paperwork redundancy by utilizing program flexibility to ensure performable reclamation standards and maintain operator and landowner contact during year.

Program Goals and Objectives

The results of program goals and objectives are a series of overall program goals followed by a number of implementation goals and development goals that were obtained from the SWOT analysis. The complete results of the program goals and objectives can be observed in Appendix B. Five major program goals were developed. Those goals are as follows:

1. Provide a statewide regulation framework for non-metallic mining reclamation.
2. Create a law for reclamation of active mine sites (does not regulate active mining processes or local zoning decision-making).
3. Fund program administrative expenses ($18,000/yr) (Un-funded state mandate).
4. Provide environmental protection for statewide resources.
5. Furnish technical support for operators (recommendations).

Implementation goals provided the following results relating to the non-metallic mining program.

1. Develop research to aid in program planning/resource modeling.
2. Continue building successful working relationships.
3. Develop internal networking between departments.
4. Maximize and utilize program flexibility for reclamation planning.
5. Analyze budgets yearly to reflect accurate expenses to properly facilitate program.
6. Improve public information outlet.

Lastly, development goals were also created with the use of the SWOT analysis. This approach provided facilitation goals to help foster the implementation goals.

1. Develop desirable research models.
2. Simplify paperwork redundancy.
3. Maximize data and information collection.
4. Provide outreach and support.
5. Maintain contact to landowners during inspection – reiterate program intents.
6. Maximize data from previous budget and inspection methodology.
7. Utilize flexibility to ensure performable reclamation standards.

Non-Metallic Mine Site Assessment - GIS Resource Analysis

Groundwater Pollution Susceptibility

Results of the groundwater pollution susceptibility analysis between the WDNR data and the non-metallic mine inspection data conveyed that most areas located near the western and southern portions of the county are at the highest risk to groundwater pollution via non-metallic mining operations. Reasons for the higher levels of susceptibility may include local geology, landuse, and variable water re-charge zones. Figures 3 and 4 show comparable interpolations of WDNR data and non-metallic mining data.

Well Collapse/Failure Predictability

Analysis results of the well collapse model indicated that three homes were within the moderate risk buffer of 400-800 feet. No homes/wells were within the high-risk buffer of under 400 feet. Six homes/wells were located within the lower risk buffer of 800-1200 feet. Figure 5 illustrates an example of homes constructed on limestone or dolomite strata that are subject to the risk of well damage caused by blast detonation charge repercussions.

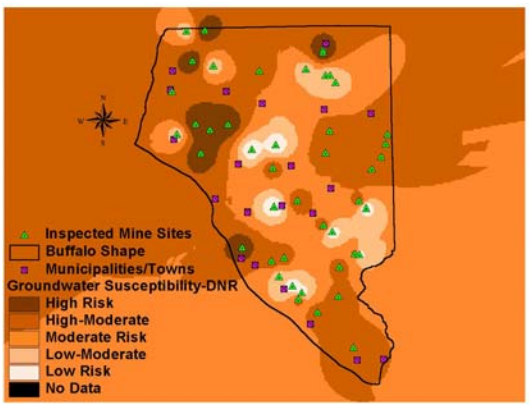

Figure 3. WDNR groundwater susceptibility data overlain with mine and municipality data.

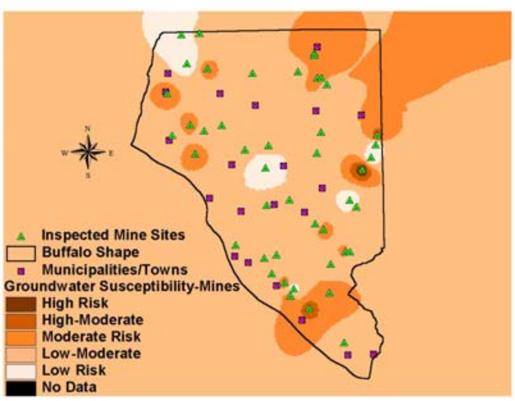

Figure 4. Non-metallic mine inspection groundwater susceptibility data. Note the comparable 'hotspot' locations with Figure 3.

Sedimentation

The goal was to determine which riparian/stream corridors had the greatest risk to be impacted by mine sites based upon their proximity and distance to the sites. The other component involved with the analysis integrated each mine site's current status of runoff and sedimentation to determine which sites needed to be prioritized to control runoff and sedimentation.

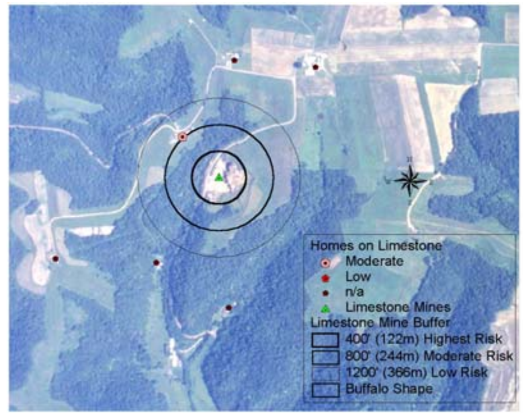

Figure 5. Well collapse example. A total of 9 wells are at risk due to blast repercussions. 3 wells-moderate risk area; 6 wells-low risk area.

Most problematic sites had uncontrolled water escaping from the site, coupled with open and/or scarred over-burden stock piles that would easily erode and move down-gradient from the site. As illustrated in Figures 6 and 7, four streams have the greatest potential to be impacted by sedimentation from nearby mine sites. These streams fell within 400 feet from an adjacent mine site that drains directly to the stream corridor.

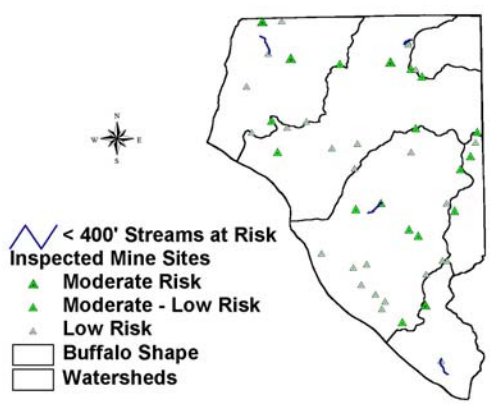

Figure 6. Four major streams at risk due to mine proximity. Sedimentation risks for mine sites are also illustrated.

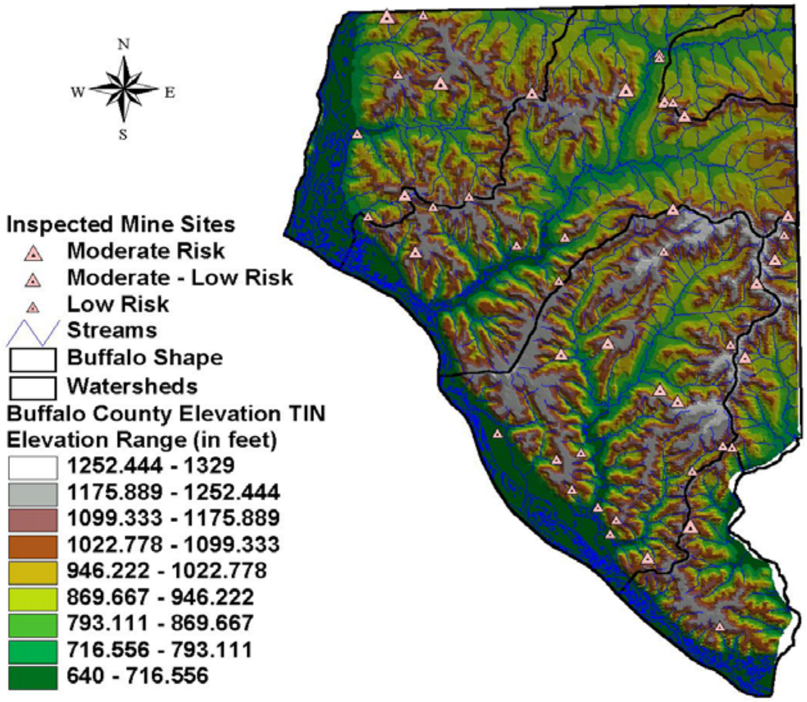

Figure 7. Stream corridors at risk due to neighboring non-metallic mine sites. Also shown is the risk potential for mine sites contributing sediment to streams.

Numeric results of Figure 7 are presented in Table 1, which shows the number of sites and each risk rating.

Risk Factor Rating For Mine Sites			
	High Risk	Moderate Risk	Low Risk
Number of Sites	4	15	26

Table 1. Sedimentation risk potential of Buffalo County non-metallic mine sites.

Slope Analysis

The results of the slope analysis clearly suggest the greatest slopes are found in the eastern portion of the county and also in the northwestern portion of the county that migrates in a northeast – southwest fashion. These results allow mine operators as well as the county to be more efficient in understanding where to plan for new mine site development. In addition, slope analyses allow runoff scenarios to be understood for agriculture as well as non-metallic mining. Figures 8 and 9 illustrate the results.

Traffic/Population Analysis

Spatial interpolations were used to complete this analysis. The interpolations consisted of comprehensive county population distributions as well as traffic patterns recorded during mine inspection. The initial goal was to analyze safety factors and also to determine if the more populous regions were contributing to the traffic rates near mine sites or if the traffic conditions observed were only arbitrary. Figures 10 and 11 depict the comparable relationships that exist between municipality populations and the traffic rates near mine sites.

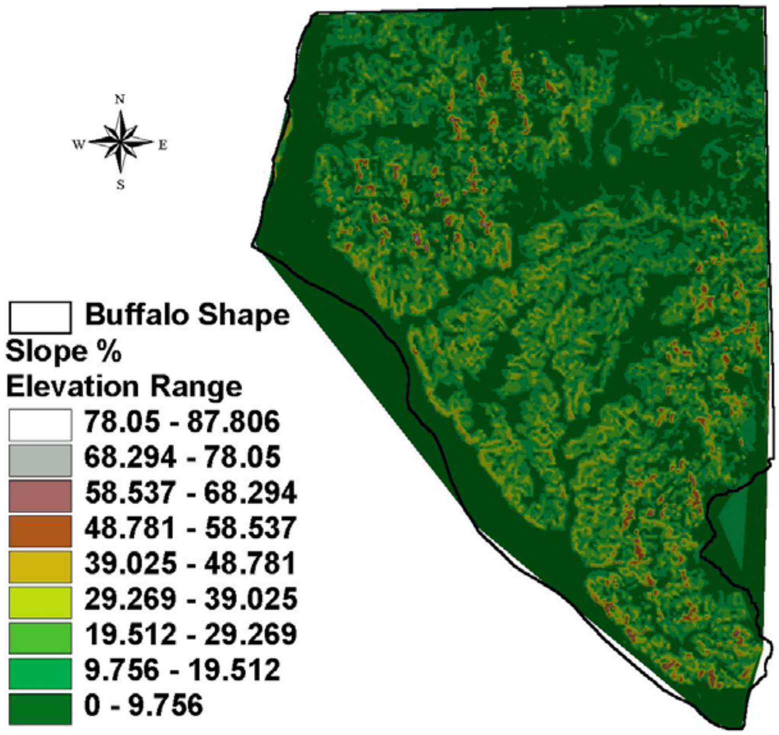

Figure 8. TIN derived data illustrating county slope percentages.

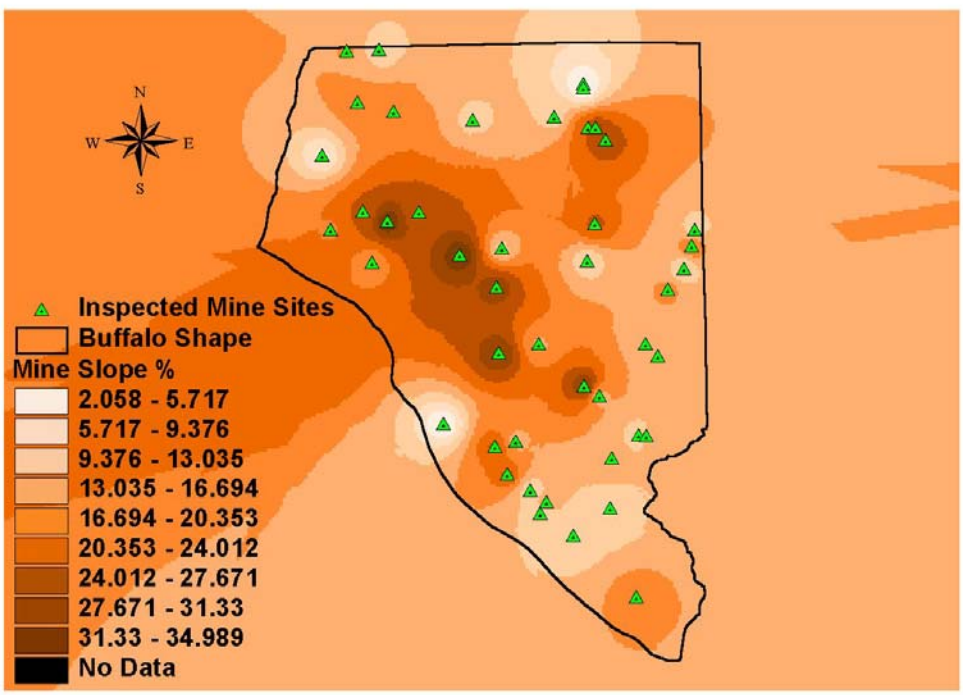

Figure 9. Countywide generalization of slope percentages from mine inspection data.

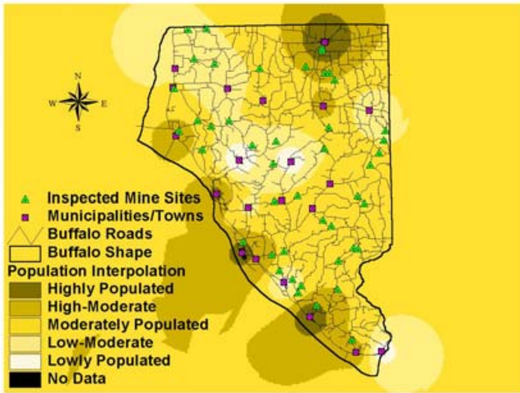

Figure 10. Buffalo County interpolated population distributions related to non-metallic mining. The greatest populations lie along the western and northern edges of the county.

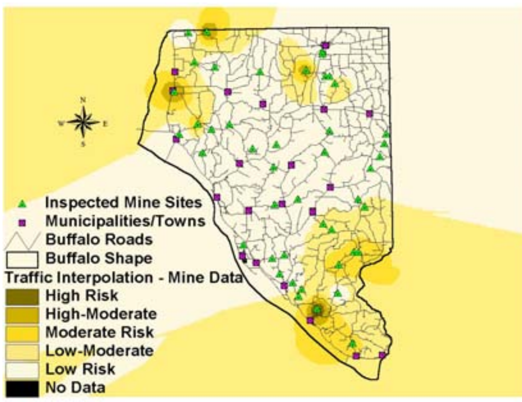

Figure 11. Traffic pattern interpolations that were captured during non-metallic mine inspection. Compare 'risk' areas to figure 10.

The conceptual goal to understand populations and their effects on traffic patterns did not offer a great deal of validity according to the analysis. In some areas, such as the southern portion of the county, traffic did have a small correlation to population, however, countywide analyses did not correlate.

Active/Inactive Mine Comparison

The initial intent of this analysis was to make any inferences regarding a statistical analysis to discover if a relationship existed between active mines and inactive mine sites and their role in resource pollution potential.

The original hypothesis suggested the following:

Ho: Inactive site pollution rankings = Active site pollution rankings

Ha: Inactive site pollution rankings ≠ Active site pollution rankings

To reiterate the research variables, the following criteria were compared between active and inactive mine sites:

- Sedimentation
- External Water Runoff (leaving site)
- Agricultural Runoff (into site)
- Hazardous Material (found in site)
- Groundwater Pollution Potential
- Habitat Degradation
- Traffic Rates (near site)

Each mine site was ranked according to the numerical protocol referred to herein. Aggregated values for each site were amassed to obtain an average rank of pollution potential. Table 2 illustrates the inspection averages.

Statistical analyses assisted in confirming the data consistency described above. According to the Variance-Ratio Test:

Ho: Data rankings are consistent between Inactive and Active mines

Ha: Data rankings are inconsistent between Inactive and Active mines

F(t) 0.05(2)18,25 = 2.29 (Zar, 1999).

F(c) = 1.259; If F(c) ≥ F(t): Reject Ho (Null hypothesis) and accept Ha. Variance-Ratio results suggested that the Null Hypothesis be accepted.

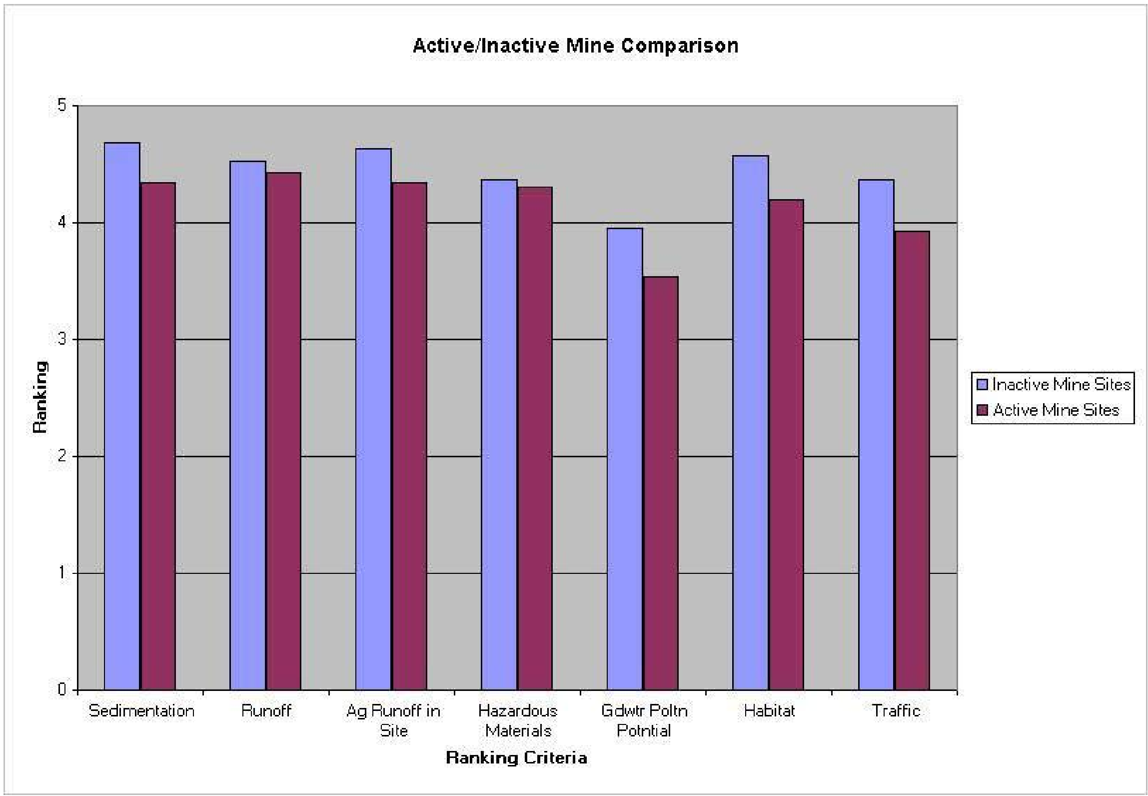

Table 2. Active/inactive mine comparison to determine if active sites have an equal potential to pollute as do inactive mine sites.

The Variance Ratio Test indicated that mine rankings were not highly variable and suggested that the data would be suitable for a two sample t-test analysis. The purpose of the t-test analysis was to infer whether a difference existed between active and inactive mine sites. The two-sample student t-test suggested the following:

T(c) = 2.048

T(t) 0.05(2), 43 = 2.017 (Zar, 1999).

Thus, if T(c) ≥ T(t): Reject Ho and accept Ha that there is a statistical possibility that active mines may pollute more than inactive mine sites. Upon completing the two sample student t-test, statistical analyses indicted that T(c) was, in fact, slightly greater than T(t). Consequently, Ho was rejected, and the hypothesis modified to show that active mine sites do, in effect, have a greater likelihood to pollute in comparison to inactive mine sites.

Conclusions

This project was designed to create a sheer synopsis of how GIS applications can be applied to program administration as well as the analysis components of a project and/or program. Throughout the project dialog, comments have been directed to the fact that the research conducted herein is not based on any existing protocol. This project model serves as a pilot example of how GIS can effectively measure and gauge the success of projects as well as to stimulate future ideas related to utilizing GIS functionality in managing projects.

Administrative Program Assessment and Evaluation

Administrative success of any program begins with a thorough analysis of program direction, stakeholders, and available resources. The sole purpose with an evaluation is to understand how closely the program is following the initial program intents and is it meeting the necessary outcomes. By identifying major program strengths, weaknesses, opportunities, and threats, program direction can be more effectively analyzed to build stronger implementation criteria and to mitigate uncertainties identified with weaknesses and threats. Program goals, followed by implementation and development goals supplement program direction to help achieve desired outcomes. In short, by utilizing the approach described herein, the manager will have clear decision-making information to improve program success.

Since its inception, the non-metallic mining program had very little administrative evaluation. Although lack of data and information made the program slightly more difficult to assess, the program is now operating more effectively and with better goals and objectives in place.

Non-Metallic Mine Site Assessment - GIS Resource Analysis

An interesting component of this project utilized an administrative assessment to gather information relating to improving program efficiency. GIS integration was used to help attain those goals. GIS has proven to enrich administrative goals and objectives.

The analytical GIS foundation of this project was merely constructed to help garner information that could be used to predict, analyze, and plan for county business. Project analyses helped to foster county personnel in understanding awareness factors and what counter-mechanisms could be employed to protect and enhance the natural resources of Buffalo County.

As with any resource model, it is only imperative to fully evaluate every feasible resource concern. Due to staffing and resource constraints, not every variable of non-metallic mining could be assessed. However, the county is eagerly looking forward to amassing more mining data through out the next several years in hopes of creating a much more thorough resource assessment model.

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