Frac-Sand Mining in Winneshiek County: A Comprehensive Impact Study

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Executive Summary

Background

The following report provides an economic impact assessment pertaining to scenarios of industrial frac-sand mining expansion into Winneshiek County, Iowa. As portions of Winneshiek County's geology have a potential for future mining, Winneshiek County officials have expressed interest in frac-sand mining's impacts. The primary goal of this analysis is to measure, in both qualitative and quantitative terms, the positive and negative effects that frac-sand mining would impose on Winneshiek County's citizenry. A secondary goal of this analysis is to provide information about the magnitude of these potential impacts, so that Winneshiek County officials and citizens can make informed policy decisions regarding regulation of the industry. The major impacts analyzed include frac-sand mining's potential influence on Winneshiek County's jobs; residential, agricultural and industrial property values and taxes; transportation network; ambient air quality; and tourism industry.

Methods of Analysis

The methods of analysis employed in this report are varied. An input-output analysis was conducted to determine the number of direct, indirect, and induced jobs and labor income that can be expected from a range of mining sizes and intensities. This type of analysis consideres interrelated industrial demand and how spending in one industry can affect similar attributes in supporting industries. A hedonic model was applied to three hypothetical mine locations to estimate frac-sand mining's impact on property values and annual property tax revenues. The purpose of the hedonic model is to account for the effects of mining's negative externalities in the decline of property value based on proximity to a quarry.

In order to estimate the impact of frac-sand mining on Winneshiek County's transportation infrastructure with respect to loss of road lifespan, the total amount of Equivalent Single Axle Load (ESALs) were projected over Big Canoe Road. This road would function as one of the primary county roads used for hauling sand to the Calmar rail hub. A baseline ESAL count of current traffic was established in addition to projections of future ESAL counts given the number of trucks required to haul away estimated mining output. The estimated number of truck trips and mining output were also used to calculate increases in mobile and point-source emissions. A range of pollutants derived from the 2008 National Emissions Inventory (NEI) were used as a baseline to project an expected percentage increase in particulate emissions.

Impacts to county tourism were analyzed by looking at the yearly percent changes in direct visitor spending that occurred over a ten-year period in Wisconsin counties. The analysis compared the spending that occured in counties that host many frac-sand mines and counties that do not have any mines. Since much of Winneshiek County's tourism is grounded in outdoor recreation, mining's impacts to the county's bluff landscapes and popular fisheries was also researched.

Findings

Results of our input-output analysis showed that a single mine is estimated to yield between 6 and 13 mining jobs and between 5 and 30 trucking jobs. Direct output created by these jobs is estimated to range between $960,000 and $2.1 million. Average mine worker earnings is estimated at $53,075 annually. Indirect jobs created by mining are estimated to be between 2.4 and 10.1 jobs producing between $310,000 and $1.10 million in output. Induced jobs that are created in the county as a result of mining are estimated to fall between 2.8 and 10.7 jobs. The total number of direct, indirect, and induced jobs created by mining in Winneshiek County are estimated to be between 16.2 and 63.8 jobs, yielding between $737,000 and $2.8 million in labor income. An estimated 57 percent of the new jobs will be filled by local residents.

After applying a hedonic model, we estimate that the total loss in property values ranges from $841,356 to $1.4 million for a single mine. A three-mine scenario would produce property losses of over $3.6 million. Annual lost property tax revenue from residential and agricultural properties would range between $10,038 and $17,061 from a single mine. Property tax contributions from frac-sand mines are estimated to be between $5,483 for a $5,000 per parcel acre value 50-acre mine, and $125,596 for a $15,000 per parcel acre value 350-acre mine.

On average, output from a medium-sized mine will result in a loss of lifespan between 8 and 14 years to Big Canoe Road. The associated cost with this loss of lifetime, based on the actual construction costs from 2008 and adjusted for inflation, equates to $456,971 for an average mine and was predicted to consume between 24 percent and 74 percent of the remaining lifetime of the road.

Mining and processing both contribute to point source emissions. Blasting and wet drilling at an average mine is estimated to produce between 10.24 and 31.91 tons of PM10 annually. These emissions would constitute 0.29 percent of 2008 county PM10 emissions. PM2.5 emissions from the mine are estimated to be between 2.05 and 6.38 tons annually, about 0.31 percent of 2008 PM2.5 emissions in the county. Total processing center emissions are expected to fall between 0.38 percent and 0.54 percent of the 2008 county total. Mobile emissions that occur along one county-contained haul route are estimated to produce between 0.03 percent and 0.10 percent of total 2008 county emissions.

In comparing direct visitor spending within heavily mined counties versus non-mining counties in Wisconsin, it does not appear that mining is associated with declining tourism. However, as fishing and outdoor recreation are vital components of Winneshiek County's tourism industry, it should be noted that some of the Iowa's most popular fishing destinations are located in the county's highest probability mining zones. The mines should be set back at least one-half of a mile from waterways in order to reduce the potential for over-sedimentation. Results of a 3-D sight-line analysis for two scenarios demonstrate that mining activity would not be visible to recreationalists at the county's more popular fishing destinations.

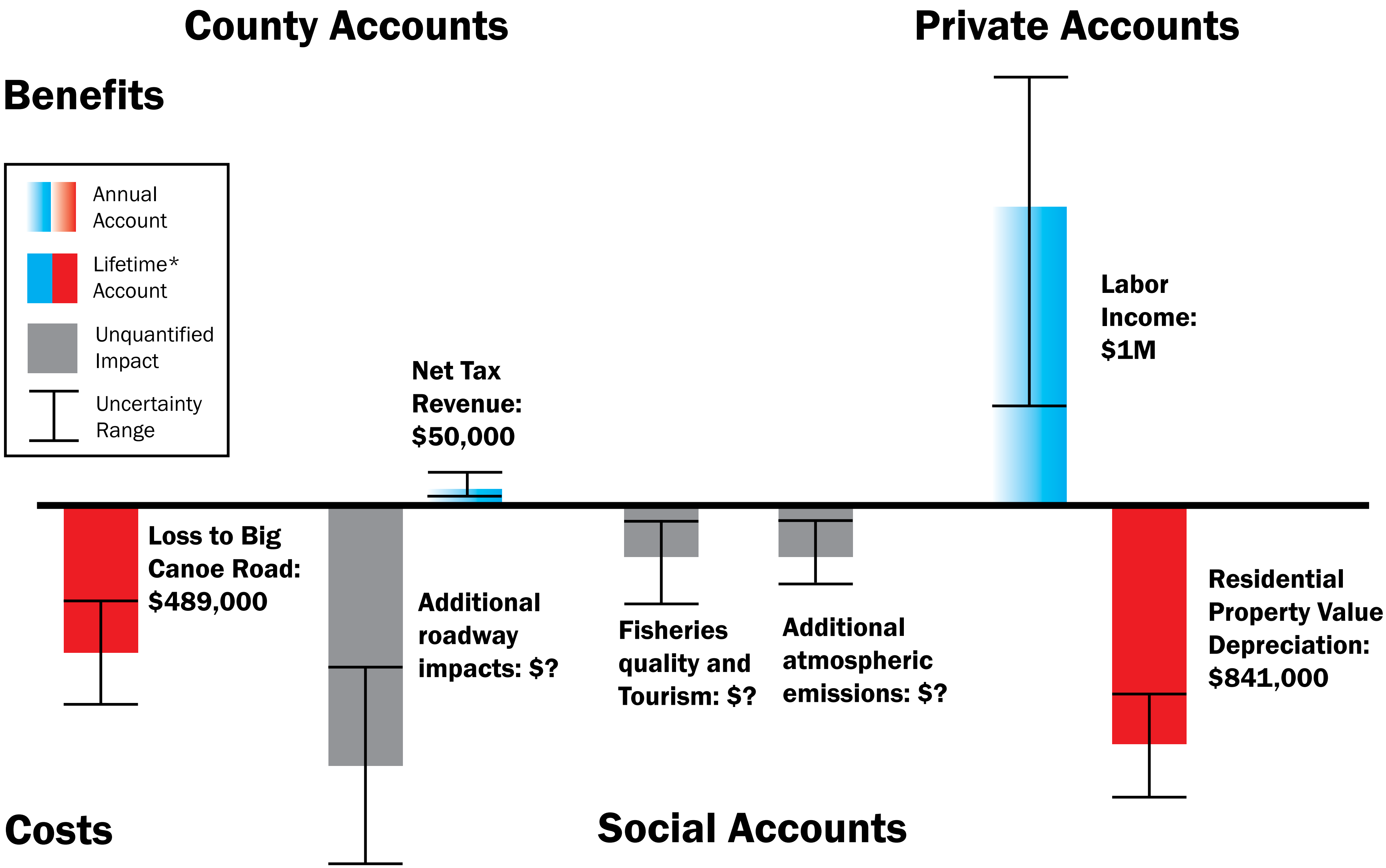
Conclusions

This report finds that frac-sand mining in Winneshiek County would deliver both positive and negative impacts. With a higher intensity of mining, the potential exists for a fair amount of job growth, county output, and direct labor income. Benefits in the form of induced job growth are less appealing. Questions also remain with respect to whether job growth would be sourced locally.

Significant losses to values of properties located within 3 miles of a mine are expected with medium or large mines. Revenue gains and shortcomings from property taxes of both residential and industrial mining properties are expected to be minimal. Impacts to roads through dispersed loading from increased truck traffic will be substantial and without regulation, the associated costs would be absorbed by the County.

A small increase in atmospheric emissions is expected, but we anticipate this will have a negligible impact on the health and welfare of county residents. However, residents and businesses located adjacent to point sources and along major haul routes could be impacted to a greater degree. Dramatic losses to Winneshiek County's tourism industry as a result of mining are not expected, but precautions should be made to preserve the current state of popular county fishing sites.

Summary of projected economic impacts



Summary of report findings

Chapter 1 — Introduction

Under the auspices of the Iowa Initiative for Sustainable Communities, this report has been prepared as part of a capstone project for the School of Urban and Regional Planning Master's Degree program at The University of Iowa. Through the Iowa Initiative for Sustainable Communities, students and faculty from The University of Iowa departments of Urban and Regional Planning, Law, Engineering, and Public Health conducted a comprehensive study for Winneshiek County as it prepares for possible mining.

As the frac-sand mining industry has seen rapid growth in the northern portions of the Driftless Area, the potential for industry expansion in Northeast Iowa remains viable. At the request of the Winneshiek County Board of Supervisors, we have prepared the following economic impact assessment of the potential positive and negative impacts that would be associated with frac-sand mining in Winneshiek County. While there is some existing literature that currently outlines frac-sand mining's impacts, there is an absence of research documenting frac-sand mining's impacts in a comprehensive quantitative fashion. It is our intent that this report will provide the necessary analytical framework for County officials to make informed decisions regarding potential future regulation of the frac-sand mining industry.

Acknowledgements

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Chapter 2 - Frac Sand Primer

2.1 Geology of Northeast Iowa

The Midwest is known for its expansive farmlands that produce agricultural goods for national and global export. Yet below its fertile soils lies a commodity that has burst onto the market, bringing with it fortunes and controversy alike. That commodity is sand, a key input to the hydraulic fracturing process that has triggered skyrocketing levels of domestic natural gas production. To understand why this particular type of sand is so sought after, one must first understand its geological origins.

The geology of Northeast Iowa is part of the Driftless Area that covers much of Minnesota, Wisconsin, and parts of Illinois. Throughout the Paleozoic Era, this region was alternately covered by water as sea levels rose and fell. As the sea ebbed and flowed, masses of sand were deposited, picked up, sorted, and re-deposited in vast swatches along the shoreline. These deposits are distinctive in that they were laid down in long, thin sheets, whose layers are usually less than 150 feet thick. In these strata a unique and valuable grade of sand is found. The layers that are most important to the natural gas industry are the St. Peter, Jordan, and Wonewoc sandstone formations.

The oldest formation of the three is the Wonewoc, followed by the Jordan, both of which were deposited between 490 and 550 million years ago during the Late Cambrian Period. The St. Peter formation is slightly younger, having been deposited an estimated 450 to 490 million years ago during the Early Ordovician Period. The rock formations in the upper Iowa River Watershed encompasses parts of Winneshiek County.[1] Due to the physical processes by which each layer was deposited and weathered over time, the Wonewoc and Jordan formations contain mainly medium to coarse grained sand, while the St. Peter has a larger concentration of fine-grained particles. The differences in particle size, as well as the purity of the grains, comes into play when being considered for sands use in the natural gas extraction industry.[2] Sandstone in Winneshiek County comes almost exclusively from the St. Peter formation. This formation is composed primarily of 40 to70 grade sand.

2.2 Hydraulic Fracturing

To understand the types of sand needed for hydraulic fracturing it is necessary to first understand the process itself. To meet energy demands in the U.S. and globally, natural gas industries have invested heavily in new extraction techniques. Natural gas deposits are contained in sedimentary rock formations, and can be classified as conventional or unconventional.[3] Conventional gas is found in highly permeable reservoirs, meaning gas can readily travel through interconnected pores and is extractable by standard drilling techniques. In gas-rich formations, such as shale and some sandstones, the pores which contain the gas are not interconnected[4], so gas cannot flow easily to the wellbore.[5] Shale plays, or areas where there are known or possible gas deposits, are located in many parts of the U.S. The largest plays are located in the Northeast, Gulf Coast, and Southwest (see

1 Libra, R. D. (2011, September). Geologic Mapping for Water Quality Projects in the upper Iowa River Watershed. Iowa Department of Natural Resources. Retrieved from http://s-iihr34.iihr.uiowa.edu/publications/uploads/TIS-54.pdf

2 David F. Kramer, P. (2013, January 24). Frac Sand Mining in SE Minnesota. Minnesota County Engineers Association.

3 Chong, J., & Simikian, M. (2014, January 30). Shale Gas In Canada: Resource Potential, Current Production and Economic Implications. Parliamentary Information and Research Service. Retrieved from http://www.parl.gc.ca/Content/LOP/ResearchPublications/2014-08-e.pdf

4 A "wellbore" is a hole that is drilled to aid in the exploration and recovery of natural gas resources; it is the actual hole that forms the well.

5 Basic of Shale Gas. (n.d.). Retrieved November 22, 2014, from Shale Gas Information Platform: http://www.shale-gas-information-platform.org/areas/basics-of-shale-gas.html

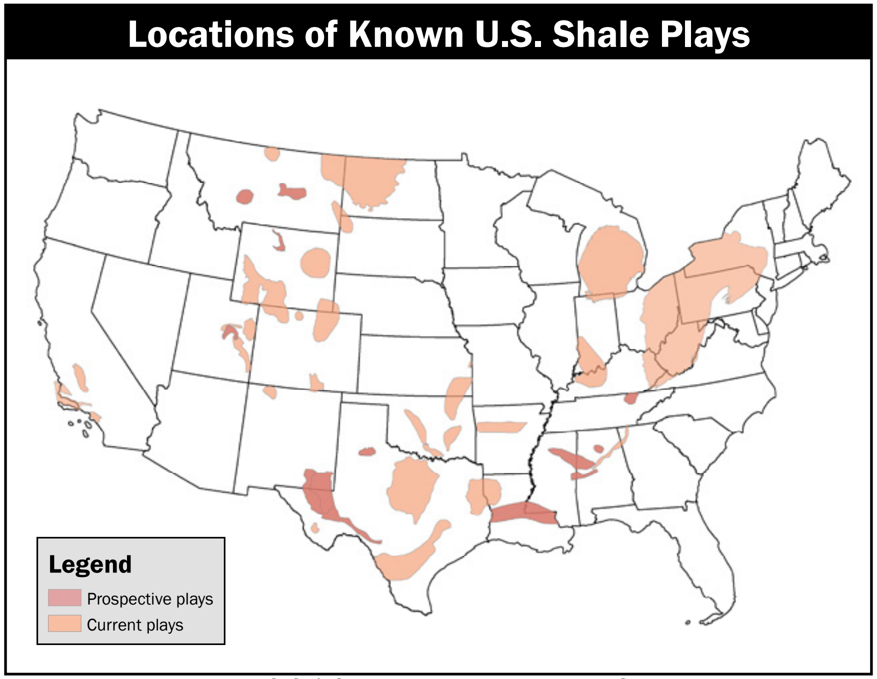

Figure 2.2.1 Shale plays in the United States

Figure 2.2.1).[6] In order to tap these unconventional deposits, decades-old fracturing techniques were combined with standard drilling operations in the late 1990s, culminating in what we now refer to as hydraulic fracturing. Hydraulic fracturing, in its most basic form, consists of drilling vertical and horizontal wells into known source rock within the plays, and then pumping a mixture of water and chemicals at high pressure into those rock formations. To keep fractures from closing under enormous pressures proppants are included in the slurry.[7] Figure 2.3.1 shows a rendering of how the sand enters the fractures to hold them open during gas removal. Three types of proppants are common: natural sands (referred to as frac sands), resin-coated natural sands, and man-made proppants.[8] This report will focus on natural sand, which can be extracted from the Jordan, Wonewoc, and St. Peter formations.

2.3 The Sand

Good sand proppants must meet certain physical and chemical standards. A good proppant is highly pure, strong, and has round, spherical grains. Purity refers to the chemical composition of the grains themselves, which must be 99 percent quartz. Quartz is a form of crystalline silica (SiO2) that occurs naturally in sedimentary rocks such as sandstone.[9] Silica is chemically

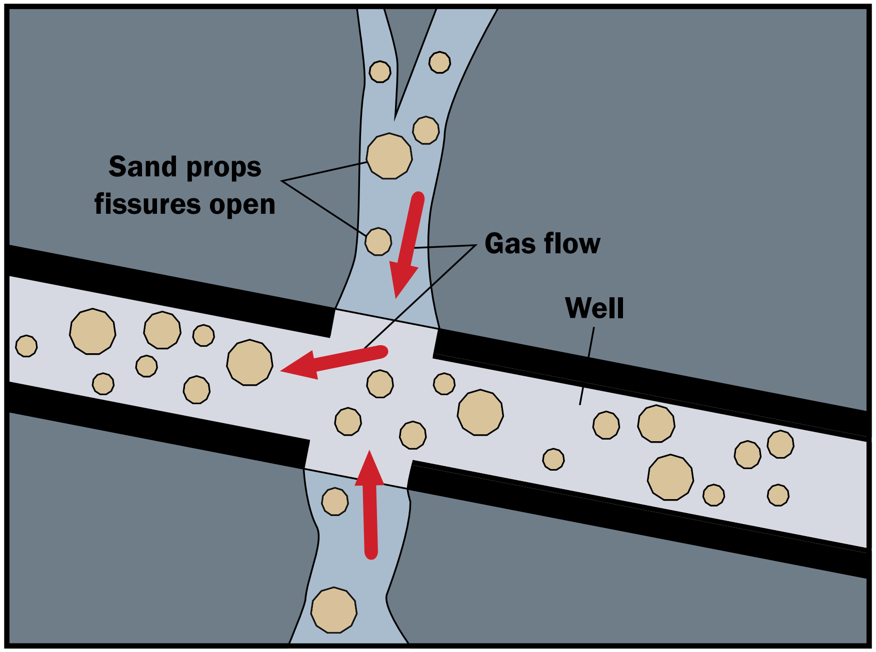

Figure 2.3.1 Sand props fissures open to allow gas to flow freely to the well bore

6 Other Inputs. (n.d.). (United States Department of Commerce) Retrieved November 22, 2014, from Assess Costs Everywhere: http://acetool.commerce.gov/other-inputs

7 Fitzgerald, T. (2013). Frackonomics: Some Economics of Hydraulic Fracturing. Case Western Reserve Law Review, 63(4).

8 Deshaw, B. (2013, December). Frac Sand in Demand; The New Cash Mineral. Bakken Oil Business Journal. Retrieved from http://bakkenjournal.uberflip.com/i/221484/56

9 Branch of Industrial Minerals. (1992). Crystalline Silica Primer. U.S. Department of the interior & U.S. Bureau of Mines. Retrieved from http://minerals.usgs.gov/minerals/pubs/commodity/silica/780292.pdf

Figure 2.3.2 Tool used for sieve analysis

inert, meaning it does not react with other chemicals in the slurry mixture.[10]

Grains must be round and spherical to allow gas to flow past. Sphericity refers to the shape of the overall particle – how close a particle is to a sphere – while roundness is a measure of the sharpness of the corners on the grain.[11] To visualize how sand works as a proppant, think of marbles in a jar. When the marbles are different sizes or have jagged edges, they become lodged against one another or against the walls of the jar, thus leaving less room for a substance to move through.[12] When grains are round and uniform in size they allow a substance to more easily flow through the larger spaces and be recovered.[13]

Grains must also be crush resistant to withstand extreme pressures deep underground. Considered a Class E sand by the American Petroleum Institute, silica sand can withstand pressures between 2000 and 6000 psi without breaking down and producing excessive fines, which clog pore spaces and stop the flow of gas. At this strength, Class E sands can be used in wells more than 8,000 feet deep.[14] Size also determines the overall crushability of the grains, as larger grains have higher associated strengths.

Fracking fluid requires a consistently sized material to ensure fracture permeability. Because there is a tradeoff between strength and permeability, industry buyers look for a grain size

10 McLaws, I.J. (1971). Uses and Specifications of Silica Sand. Report 71-4. Research Council of Alberta

11 Rupke, A., & Boden, T. (2013, July). Frac Sand Potential on Selected SITLA Lands. Utah Geological Survey.

12 Deshaw, B. (2013).

13 Mclaws, I.J. (1971).

14 Herron, S. (2006). Industrial Sand and Sandstone. Industrial Minerals & Rocks. Retrieved from http://www.segemar.gov.ar/bibliotecaintemin/LIBROSDIGITALES/Industrialminerals&rocks7ed/pdffiles/papers/060.pdf

that best suits their operation.[15] The most sought after and commonly used grains fall into what is referred to as the 20/40 fraction. Processors use sieve analysis to separate grains by size (see Figure 2.3.2). This entails sifting a material though a series of differently sized meshes.[16] The sieve number (20, 30, 40, etc.) corresponds to the number of openings in one inch of screen; a 20 mesh has 20 openings in one linear inch. 20 sieve mesh openings are approximately 0.84 mm (0.0331 in), while 40 mesh sieves are 0.42 mm (0.0165 in). In the most desirable frac sand, 90 percent of the particles will pass through the 20 mesh but stop at the 40 mesh (hence the 20/40 designation). Particles in this size range are considered to be coarse to medium grained. 30/50 size sand is also in high demand for certain fracking processes, while 40/70 can be used, but is in less demand overall due to its larger proportion of fine sands.

2.4 Frac-sand Mining and Processing

The process of extracting industrial sand from the ground shares many similarities with standard construction aggregate mining practices that have a long history in the United States. Industrial sand and construction aggregate differ mainly in their physical characteristics, end use, and market share of the total U.S. mineral supply. In 2000, crushed stone and aggregate made up 75 percent of the total mineral market, while the industrial minerals share was 12 percent.[17] Industrial sand is used not only in oil and gas recovery, but other industries including glassmaking, metal production, and ceramics. The literature examines some of the differences of construction aggregate mining versus industrial sand extraction, with varying economic focuses. Table 2.4.1 provides a helpful overview. Some notable differences are: deposit and sales volumes tend to be larger for sand operations; costs are determined by processing and distance to customer; and the market for the material tends to be out of state.[18]

Aggregate Mining Comparison		
	Construction Aggregates	**Industrial Sand**
Location determined by	Geology	Geology
Deposit size	Small to Large	Tend to be Larger
Employees	Local People	Local People
Size of Capital Investment	Low	Higher
Size of Sales Volume	Small to Large	Tend to be Larger
Operating Cost Determined by	Site Conditions	Processing Costs
Cost of Transportation	Distance to Job	Distance to Customer
Price of Product	Low	High
Customer Base	Local	Select Base
Market Location	Within State and less than 50 miles from site	Out of State and transportation more than 100 miles
Cost Impact	Cost directly impacts Local Economy	Cost directly impacts National Economy

Table 2.4.1 Comparison between the construction and the industrial sand market

The processes of selecting, reviewing, regulating, and permitting a frac-sand operation follow a series of normative steps to maximize production and minimize impacts to the surrounding environment. Before mining can begin, companies must first identify possible locations of economically viable frac sand and perform on-site resource exploration to determine the quality

15 Ruoke, I.J. (1971).

16 Integrated Publishing. (n.d.). Equipment Operator Advanced Manual. Retrieved November 22, 2014, from http://enginemechanics.tpub.com/14080/css/14080_127.htm

17 Wagner, L. A. (2002, February). Materials in the Economy - Material Flows, Scarcity, and the Environment. U.S. Geological Survey Circular.

18 Milestone Materials & Mathy Construction. (2012, May 24). Aggregate Mining vs. Industrial Sand Mining. Retrieved from http://monroe.uwex.edu/files/2012/02/Milestone-Monroe-WTA-Presentation-5.24.12.pdf

of the formation itself. Next, engineering and environmental reviews must be drafted, reviewed, and approved, while any local and state permitting applications must be filed and approved.[19] Once these steps are completed, mining operations begin with the removal of topsoil and overburden, followed by blasting, extraction, processing, stockpiling, loading, and hauling of the sand.

Processing is defined as anything that is done after extraction to prepare the raw material for its final use, which may include wet and dry processing. In wet processing, the sand is cleaned and initially sized. Dry processing involves the drying and final sizing of coarse sand.[20] Whether or not processing takes place at the extraction site depends on multiple factors, including local regulations and proximity to transportation networks. Lastly, a mine reclamation plan is standard requirement. Many local regulatory agencies limit the amount of acreage for active mining, regardless of the total available mining area. For example, if a company wishes to mine 100 acres, it may be limited to extraction and processing on 50 acres at a time. Often, reclamation of the first 50 acres must be completed before the remainder can be mined.

2.5 National Energy Outlook: Demand for Frac Sand

Sand has become an industry standard for use as a proppant, and as such, frac sand mining has grown in step with the expanding market for natural gas. However, the demand for natural gas has seen periods of growth and decline owing to varying estimations of the amount of recoverable gas, as well as market competition with coal and oil. The total volume of U.S. reserves that is economically recoverable is the subject of much debate. The Energy Information Agency (EIA) uses the term “technically recoverable” to describe the amount of proven and unproven reserves of all types of natural gas. This designation is misleading as it includes three categories of gas: probable (reserves), possible (contingent resources), and speculative (prospective).[21] Probable reserves are those that are known by the industry, and able to be extracted economically. Possible resources are those that are known, but cannot be economically extracted using today’s technology. Speculative or prospective resources are those that are thought to exist but have not been discovered.[22] The EIA estimates that there is about 2,000 trillion cubic feet (tcf) of technically recoverable gas available to producers. At current extraction rates, many political and industry leaders estimate 100 years of gas supply. The controversy lies in the fact that the estimate of 2,000 tcf of gas includes all three categories, whereas including probable reserves and contingent resources produces a much shorter timeline. The lowest estimates project only 11 to 35 years’ worth of natural gas. Uncertain projections of the volume of U.S. natural gas reserves makes it difficult to predict long-term industry stability. The outlook for the frac sand industry is likewise uncertain.

Similarly, the prices of natural gas, coal, and oil all influence the other‘s respective demands, and correspond to the fluctuating demand for frac sand. Natural gas is primarily used in the energy production sector, and when gas prices rise, many utilities turn to coal as a cheaper form of fuel. But as existing and new wells are constructed to tap into previously un-extractable reserves,

19 Aiken, J. (2012). Exploring Environmental Impacts Related to Frac Sand Mining and Processing - Minnesota Focus. Barr Engineering Company.

20 Victory Nickel Inc. (n.d.). Frac Sand at Minago. Retrieved from http://www.victorynickel.ca/projects/minago/frac_sand/index.php?&content_id=12

21 Engdahl, F. W. (2013, March 13). The Fracked-up USA Shale Gas Bubble. Global Research. Retrieved from http://www.globalresearch.ca/the-fracked-up-usa-shale-gas-bubble/5326504

22 CDM Smith & The Tioga Group. (2013, May 15). Shale Gas Outlook for Great Lakes and Ohio River Basin States: Production, Production Facilities, Products, and Methods of Delivery. U.S. Army Corps of Engineers.

the expanded supply can cause gas prices to fall. Extraction in harder-to-access formations may become cost-prohibitive. These industry fluctuations have led to varying demand for frac-sand producers, leaving operations sitting with stockpiled material, while others continue to produce to capacity for buyers. Overall, however, the frac-sand industry has grown steadily in the last few years, with production going from 6.13 million tons in 2007 to 26.63 million tons in 2012. Long-term estimates point to continued growth, with demands reaching upwards of 45 million tons by 2017.[23] Some forecasters attribute the growth to increased demand for natural gas and expanding export markets, while others attribute it to fracking operations using more and more sand per well as they try to maximize output. Currently, 20 percent of all gas wells are using larger-than-normal volumes of frac-sand. This percentage is expected to increase to almost 80 percent of all known wells in the near future.[24]

23 Victory Nickel Inc. (n.d.).

24 Vulcan, T. (2014, September 3). Fracking Makes Sand the New Hot Commodity; What You Need to Know. Retrieved from http://www.hardassetsinvestor.com/features/6207-fracking-makes-sand-the-new-hot-commodity-what-you-need-to-know.html

Chapter 3 – Snapshot of Local Regulations

Two Northeast Iowa counties, Clayton and Allamakee, took divergent regulatory paths. Clayton County set very relaxed, non-specific mining requirements and Allamakee County adopted stricter regulations that involve a detailed application process and multiple assessments specifically tailored for frac-sand mining. While considering how to best regulate frac-sand mining, the Winneshiek County Board of Supervisors established a moratorium on frac-sand mining permits.[1] The 12-month moratorium began in January 2013, and was extended for six months in December, 2014. The moratorium will expire in June 2015.[2] Whether Winneshiek imposes strict or lax regulations may affect mining in nearby counties.

Clayton County has a long tradition of mining. Since 1950, Pattison Sand Mining Company has operated both open-pit and underground mines. Clayton County's zoning ordinance allows the Board of Adjustment to decide how and when to permit frac-sand mining with only the guidance that all mining is permissible:

Subject to section 6.15-2 [special exception permits] and other requirements contained herein, the Board of Adjustment may permit the following: " ... Underground mines, quarries, sand and gravel pits, sawmills and related facilities required for obtaining, processing, storing and transporting minerals and raw materials."[3]

The zoning ordinance does not mention mining other than the excerpt quoted above. With no specific frac-sand mining regulations or heightened mining requirements like in Allamakee County, Clayton could receive more frac-sand mining operations compared to other Iowa counties depending on nearby counties' policies and regulations.

Allamakee County recently opened its borders to the frac-sand industry, but with much tighter regulations than Clayton. These regulations took effect July 1, 2014, and prohibit: mining or processing with any chemicals unless expressly permitted with a conditional use permit; hydraulic dredging; reuse or "placement of previously mined, processed and contaminated sand"; locating "within any portion of the Bluffland Protection District, within 1,000 feet of any identified Karst features, or within one mile of the viewshed of any stream, river, recreation trail or scenic byway."[4] Additionally, Allamakee County requires periodic inspections by the zoning authority, and the permit application process is involved.[5] This process includes public notice requirements; a survey of all wildlife habitats on the property; an archaeological and cultural resources assessment (for example, ancient burial grounds); a geologic and karst survey of the mining property and all land within 1,000 feet; and a map and narrative of all proposed operations among other requirements.[6]

The regulatory stances of Allamakee and Clayton counties are structured to affect potential site location on a regional scale, as well as inform Winneshiek County policies. A possible effect of Allamakee's stricter regulations compared to Clayton, is to steer mining companies to Clayton and possibly to Winneshiek depending the type of regulations adopted in the future by Winneshiek.

1 Winneshiek County Resolution 15-18; Winneshiek County Board Minutes September 29, 2014.

2 Winneshiek County Resolution 15-18; Winneshiek County Board Minutes September 29, 2014.

3 Clayton County Zoning Regulations, amendments (2011). *Clayton County, Iowa*. Retrieved from: http://www.claytoncountyia.gov/information/ordinances/720-zoning-regulations.html.

4 Allamakee County Zoning Ordinance, Mining Amendment (2014). *Allamakee County, Iowa*.

5 Allamakee Mining Ordinance.

6 Allamakee Mining Ordinance.

Chapter 4 - Winneshiek County Economy

4.1 The Regional and Local Economy

Understanding the regional economy is essential before assessing the impacts of frac-sand mining. Winneshiek County is the most populous county of the four most northeast, Iowa counties: Allamakee, Clayton, Fayette, and Winneshiek County. Of these four counties, Winneshiek County also had the highest median household income at $52,827 in 2012.[1] According to American Community Survey 5-year estimates, there were 21,033 people living in the county in 2012.[2] Notably, Winneshiek County contains the City of Decorah (population: 8,097 in 2012) and Luther College (enrollment 2,340 in spring 2013[3]). This chapter will first examine economic trends in the county, including employment totals, business establishments, unemployment rate, and wages levels. Following is a discussion of the current county workforce focused on the inflow and outflow of local workers. Finally, the chapter contains a review of the value of different industries to the Winneshiek County economy using direct output from industries and adjusted values to account for the final users of goods and services.

Since 2004, Winneshiek County has experienced similar economic trends as many other rural Iowa counties. Like the majority of the nation, the county experienced employment loss between 2006 and 2010. Between 2010 and 2013, the county employment grew, but total employment has not returned to the 2004 level. According to the Quarterly Census of Employment and Wages (QCEW), Winneshiek County had 10,457 paid employees in 2004. That number dipped to 9,926 employees in 2010, a low for the 10-year period between 2004 and 2013. By 2013, there were 10,177 total paid employees in the county.[4]

We indexed the data to 2004 numbers to compare employment trends between the State of Iowa and Winneshiek County. Winneshiek's jobs trends were similar to the state's trends during the 10-year period between 2004 and 2013. However, during times of growth, Iowa's economy grew at a faster rate than Winneshiek County's economy. Additionally, during times of contraction, the rate of decline was greater for Winneshiek County than for the state. According to the QCEW, which is maintained by the Bureau of Labor Statistics, Iowa's economy grew between 2004 and 2008, while Winneshiek's economy remained relatively stagnant. The state reached 105 percent of the 2004 total jobs in 2008. Both the county and the state

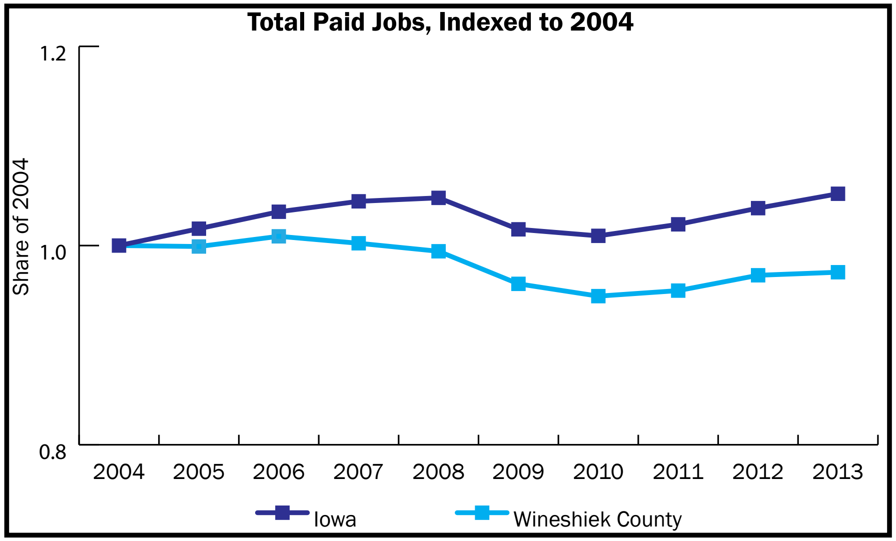

Figure 4.1.1 Paid Employees in Iowa and Winneshiek County, as a share of 2004.

1 U.S. Census Bureau; American Community Survey, 2012 American Community Survey 5-Year Estimates.

2 U.S. Census Bureau; American Community Survey, 2012 American Community Survey 5-Year Estimates.

3 Luther College (n.d). 2012-13 Student Enrollment. Retrieved from https://www.luther.edu/ir/enrollment/2012-13/

4 U.S. Bureau of Labor Statistics; Quarterly Census of Employment and Wages.

economies saw a large drop in 2009 when the recession hit Iowa. By 2010, Winneshiek County's total paid employees declined to 95 percent of total jobs in 2004. Iowa's total paid employees decreased to 101 percent of the 2004 level in 2010.[5] From 2010 to 2013, total county paid employees grew by 193 jobs. Despite this job growth, 2013 total employees remained at 97 percent of the 2004 level. In contrast, the state reached a 10-year high at over 105 percent of 2004 totals in 2013. Figure 4.1.1 shows a comparison of paid employees in Iowa and Winneshiek County indexed to their respective 2004 levels.

In addition to employment changes, the structure of the county's workforce and establishment base has shifted since 2004. As the number of Winneshiek County jobs declined, the number of establishments in the county has consistently increased since 2004. Thus, the average size of businesses is shrinking in the county. In 2013, there were 108 percent of the number of total establishments in the county in 2004. The 3 percent decline in jobs since 2004 was met with an 8 percent increase in the number of business establishments. The number of paid employees and number of establishments increased at the same rate through 2006, both reaching 101 percent of 2004 numbers. Starting in 2007, the two variables diverged; the number of employees began to decline, while the number of establishments continued increase. Establishment totals grew each year, except 2011, when it declined by four establishments (see Figure 4.1.2).[6]

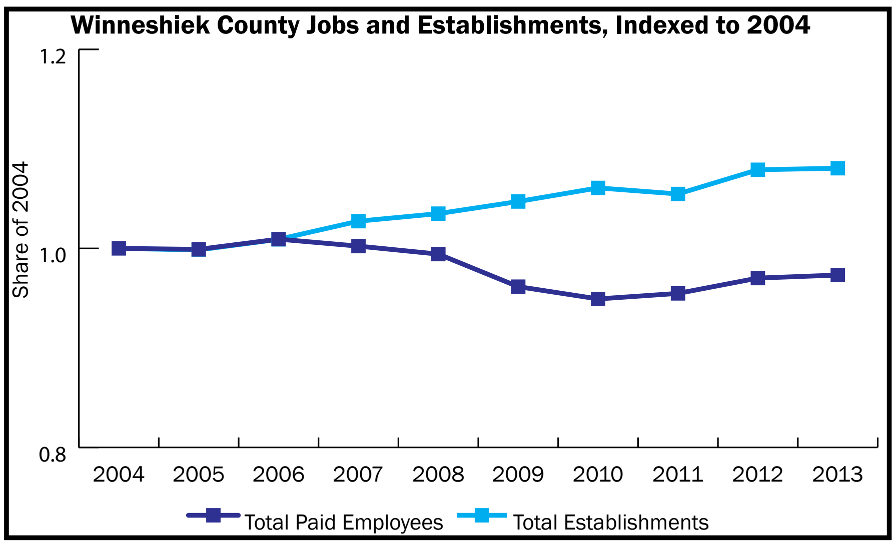

Figure 4.1.2 Winneshiek County Jobs and Establishments, indexed to 2004

Since 2004, Winneshiek County's annual average unemployment rate has been lower than Iowa's in every year except 2008. As the total paid employees' data indicates, the average annual unemployment rate jumped fairly dramatically in Winneshiek County and Iowa in 2009, with both rates increasing from just above 4 percent to 6.1 percent for the county and 6.3 percent for the state. Since 2009, the annual average unemployment rate has consistently declined for both the state and county, reaching lows of 4.6 percent and 4.5 percent in 2013 for Iowa and Winneshiek County, respectively. By expanding the analysis to the quarterly average unemployment rate, within-year trends can be analyzed (see Figure 4.1.3). Despite annual averages showing lower unemployment in Winneshiek County than in the state, the county's quarterly unemployment rate has fluctuated more rapidly than the state's has. There are unemployment spikes in the first quarter of each year at both the county and state level, but the county's spikes have been higher than the state's. Quarterly average unemployment in Winneshiek County peaked at 8.3 percent in the first quarter of 2009, while the state unemployment peaked twice, in the first quarters of 2009 and

5 U.S. Bureau of Labor Statistics; Quarterly Census of Employment and Wages.

6 U.S. Bureau of Labor Statistics; Quarterly Census of Employment and Wages.

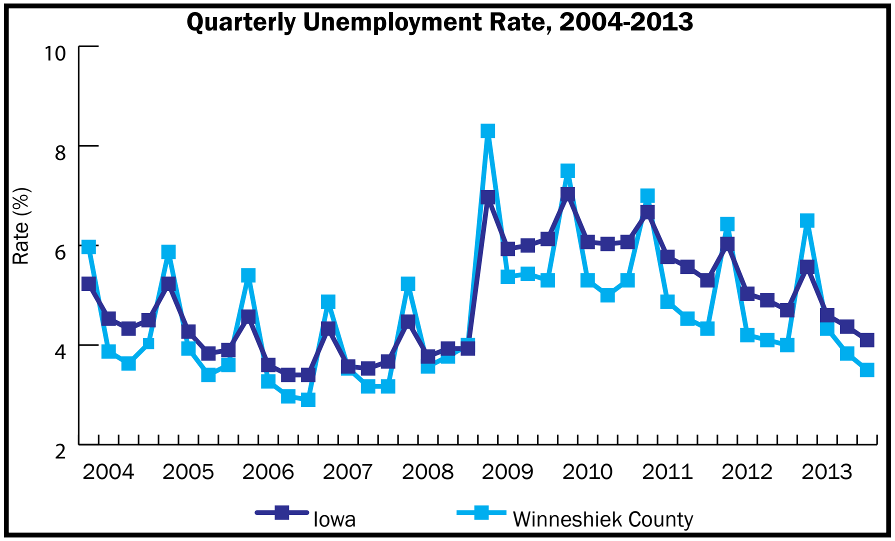

Figure 4.1.3 Average Quarterly Unemployment Rate, 2004-2013

2010.[7]

Since 2004, Winneshiek County has maintained average wage at levels approximately $5,000 less than Iowa's average wages. Wage growth rate has been similar for both the state and the county, averaging 2.79 percent for Iowa and 2.63 percent for Winneshiek County annually from 2004 to 2013. Despite the nominal growth, real purchasing power has not changed much in the last 10 years; Winneshiek County mean wage earners can only purchase slightly more now than they were able to in 2004. Using the Consumer Price Index estimated from the Bureau of Labor Statistics to adjust wages for inflation, the mean purchasing power only increased by 3.85 percent in Iowa and 2.4 percent in Winneshiek County in the ten-year period between 2004 and 2013. Average real wages declined in the county in 2005, 2007, and 2011, while they increased by less than 1 percent in all other years except 2006.[8]

7 U.S. Bureau of Labor Statistics: Quarterly Census of Employment and Wages

8 U.S. Bureau of Labor Statistics: Quarterly Census of Employment and Wages

Regional jobs are filled by local residents and in-commuters. In-commuters can come from any of the surrounding Iowa counties, including Howard, Chickasaw, Fayette, Clayton, and Allamakee Counties or from across the state border in Minnesota. Knowing the structure of the local economy is necessary to determine the portion of economic impacts that are captured by that economy. During the five-year period from 2007 to 2011, the proportion of Winneshiek County jobs that were filled by Winneshiek County residents remained fairly stable, ranging from 56.6 percent in 2011 and 2008 to 59.2 percent in 2010. The five-year average was 57.5 percent. Thus, the five-year average proportion of the jobs in the county that were filled by out-of-county residents (in-commuters) was 42.5 percent. Additionally, all employed Winneshiek County residents either have a job within the county or they out-commute for work. Between 2007 and 2011, the percent of Winneshiek County residents who out-commute for work varied from 41.1 percent in 2007 to 42.7 percent in 2008. The 5-year average was 42.1 percent.[9] On average, 57.1 percent of employed county residents had a job within the county

Winneshiek County Workforce Inflow and Outflow		
	Count	Percent
Work in Winneshiek County	9,628	100
Work in Winneshiek County, live elsewhere	4,052	43.4
Work and live in Winneshiek County	5,276	56.6
Live in Winneshiek County and employed	9,167	100
Live in Winneshiek County, work elsewhere	3,891	42.4
Live and work in Winneshiek County	5,276	57.6

Table 4.1.1 Winneshiek County Workforce Commuting

9 U.S. Census Bureau; On the Map.

between 2007 and 2011. Table 4.1.1 shows a summary of the commuting statistics for Winneshiek County.

4.2 Industrial Structure

There are a few different ways to examine the value of industry to any economy. Using 2014 IMPLAN Winneshiek County input-output tables, this analysis will first examine the direct output and value added from 13 general industries including agriculture, mining, construction, and manufacturing. It will then analyze inter-industrial demand and adjust values to account for the final demand of goods. IMPLAN is a company that compiles economic data for the United States for economic impact modeling. It is widely accepted as the one of the best data sources for completing this type of analysis. Both methods of analysis provide useful numbers that value industries in the local economy. Industry analysis will focus mainly on total value added as the measure of worth to the Winneshiek County economy. Total value added is another way to represent gross domestic product (GDP), or total income in the economy. It shows the amount of economic value that is created within the county by each industry. Summing all industrial output and value added shows that Winneshiek County had approximately $1.758 billion in total output and $870 million in total value added in 2014.

In direct terms, the industry “all other services” contributes the largest value added to the Winneshiek County economy. All other services includes industries such as private health care providers and private education, and thus incudes Luther College. Services contribute $117 million in total value added, which is 19 percent of the total value added for the county economy. The wholesale and retail trade industry contributes 13.7 percent of the total value added. The next three largest industries are finance, insurance, and real estate; all governments; and all agriculture, at 13.5 percent, 12.6 percent and 12.5 percent, respectively. Manufacturing, which is generally a key base exporter, is 10.3 percent, and construction makes up 6 percent of total value added.

Adjusting these values to account for final demand can give a better measure of industrial value to a local economy. The amount of goods or services produced and sold by any industry is determined by the demand for those good and services by all users. Those users include buyers who purchase the good for final use within the economy, those who purchase it as an input into a production process within the economy, and those who demand it from outside the economy.[10] Exporting goods outside the economy or selling to local consumers for consumption is production for final demand, because the seller or exporter is the last party to add value to the good within Winneshiek County. Selling a good or service to another local company for use in production is not production for final demand. Adjusting for final demand shifts the fraction of the economy that is attributed to each industry providing more weight if an industry is producing for final demand. If a company sells its products to the final consumer, or to another company outside the local economy, then the value added that was created within Winneshiek County earlier in the production process is dependent on the company that sells to the final demanders. If an industry demands many goods from other local industries as inputs into production for final demand, the fraction of the economy that is attributed to that industry will increase, while other fractions will shrink. The adjustment for final demand provides better estimates of each industry’s true value to Winneshiek County’s economy.

10 Hastings, S. E., & Brucker, S. M. (1991). An Introduction to Regional Input-Output Analysis. Microcomputor-based Input-Output Modeling. Westfiew Press

Industries that produce primarily for export are classified as base industries, which drive economic growth. The value of a basic industry to the regional economy generally increases after the final demand adjustment.

Transformation of county data, as seen in Table 4.2.1, shows that Winneshiek County's economy is driven primarily by the agriculture and manufacturing industries, both of which are industries that produce primarily for export. Agriculture's contribution to total value added becomes 18 percent of the local GDP, or $157 million. Therefore, 18 percent of the Winneshiek County economy is linked to agricultural sales for final demand within the Winneshiek County economy. Additionally, manufacturing becomes a much more important part of the local economy after the transformation. It accounts for 15 percent of the county economy, or $130 million. The contribution of construction (6 percent under the direct method, 9 percent after transformation) and government (13 percent under the direct method, 15 percent after transformation) also increase. The value of the Finance, Insurance, and Real Estate industry declines after transformation. Many of the services from this industry are used as inputs for other business, such as insurance for a manufacturing plant. By transforming industry data to account for sales from production for final demand, the agriculture and manufacturing industries become more important than was shown by the direct method while industries such as utilities and services lose value.

Value Added by Industry in Winneshiek County

Industry	Direct Industrial Activity Summary		Final Demand Input Output Summary	
	Total Value Added (millions $)	Percent of Total	Total Value Added (millions $)	Percent of Total
All agriculture	109.00	12.52	157.32	18.07
All mining	5.59	0.64	7.65	0.88
All utilities (elect., gas, water, sewer)	14.70	1.69	8.09	0.93
Construction	52.13	5.99	79.72	9.16
Manufacturing	89.63	10.30	130.58	15.00
Wholesale & retail trade	119.09	13.68	55.63	6.39
Transportation & warehousing	19.98	2.30		2.04
All information (digital and print)	17.79	2.04	12.01	1.38
Finance, Insurance, & Real Estate	117.77	13.53	19.75	2.27
Professional, scientific, & tech. services	31.97	3.67	13.96	1.60
Business services	16.08	1.85	12.11	1.39
All other services	166.69	19.15	106.18	12.20
All governments	110.20	12.66	129.63	14.89
Households	0.00	0.00	120.24	13.81
Total	870.62	100.00	870.62	100.00

Table 4.2.1 Value added by industry in Winneshiek County

Chapter 5 – Model Parameter Development

5.1 Section Overview and Acknowledgment

To estimate the impacts that frac-sand mining will create in Winneshiek County, we must first establish a set of parameters to build our models. Those parameters include highest probability locations for mining operations, the volume of sand that will be extracted from mines of varying sizes, the number of trucks trips that will be used to haul the product, and the haul routes that those trucks will use. This section defines the parameters that are used throughout our analysis and outlines the methods we have utilized to estimate them.

To help develop mine siting criteria, a group of graduate students from the Geoinformatics for Environmental and Energy Modeling and Prediction (GEEMaP) team modeled locational attributes to predict what factors might impact location of silica sand mines in Winneshiek County. We worked closely with one member of the GEEMaP group, Austen Smith, who refined the model for its final application. This section describes the methodology used by Smith and the GEEMaP team to identify probable mining locations in Winneshiek County. Their spatial predictions are used to evaluate all spatially-dependent impacts of mining.

5.2 Objective

The economic benefits modeled in the second section of this report are a-spatial. That is, a worker may live and spend at any location within the county, and impacts to the regional county economy are assumed to be constant. On the other hand, most of the economic costs associated with frac-sand mining are spatially dependent. Mine locations must be predicted before any attempt to estimate impacts to water quality, residential values, or the surrounding transportation network. Thus, a primary objective for the frac-sand study was to predict the most suitable locations for mining.

5.3 Statistical analysis of mine location

The recent growth of the frac-sand mining industry in Wisconsin provides an existing sample size from which to perform Bayesian spatial logistic regression. This model was utilized to derive criterion weights for a series of site prediction factors, including depth to sandstone, thickness of sandstone, and proximity to the transportation networks. Depth to bedrock determines the cost of overburden removal. In general, firms do not explore deposits that are more than 50 feet below the surface. The thickness of the sandstone stratum itself determines the volume of available resource. Finally, the transportation of frac-sand is costly. Firms minimize costs by locating near serviceable roads and rail. By analyzing trends from Wisconsin data, GEEMaP generated a series of iterative models to assess the relative importance of these four factors to industry. The derived criterion coefficients are given in the table below. Based on these coefficients informed by modeling Wisconsin, the final criterion weights were selected.

Mine Location Factor Weighting	
Variable	**Weight**
Thickness of St. Peter	0.35
Depth to St. Peter	0.3
Distance to Rails	0.2
Distance to Roads	0.15

Table 5.3.1 Mine locational factor weights as derived by GEEMaP

5.4 Interpolation technique

Sampling is conducted at point locations, but interpolation is possible because many geologic formations exhibit high spatial autocorrelation. That is, points that are close neighbors have similar values, while distant points exhibit higher variability. The Iowa Geological Survey's GeoSam database provides subsurface data that was collected during the drilling of wells and other excavation projects. By interpolating these points for the St. Peter formation, sandstone geology can be estimated with reasonable accuracy across the county.

To minimize degradation of the interpolated surface at the county border, sample points were clipped to a 10-kilometer buffer. The interpolated layer was generated from 368 sample points using ordinary Kriging. The mining industry has used Kriging extensively for decades to assess volumes of mineral and petroleum reserves.[1] This method applies an inverse distance weighting scheme to compute values in the interpolated layer. Sample points that are near to an estimated point are more heavily weighted than those that are farther away.

Interpolation of the lower elevation was fairly straightforward. In some instances, subsurface data was collected from wells that do not fully penetrate the St. Peter formation. To achieve the best estimate for the lower elevation of the formation, these points were removed from the sample.

Interpolation of the upper elevation was more complex. Sensitivity analysis of the results of an initial model revealed unexpected variations in the top elevation of the St. Peter formation. This variability is caused by the inclusion of sample points that have experienced significant erosion relative to the

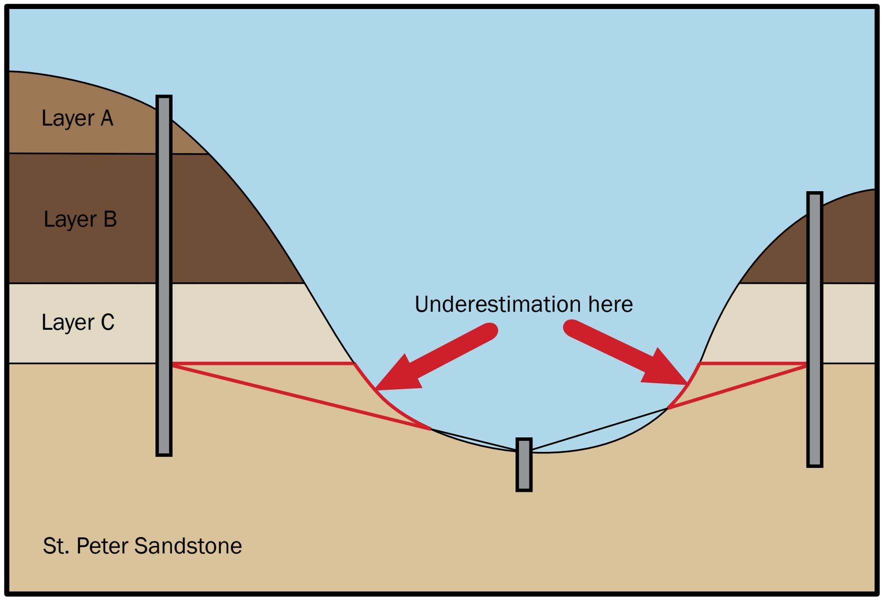

Figure 5.4.1 First interpolation resulted in underestimation

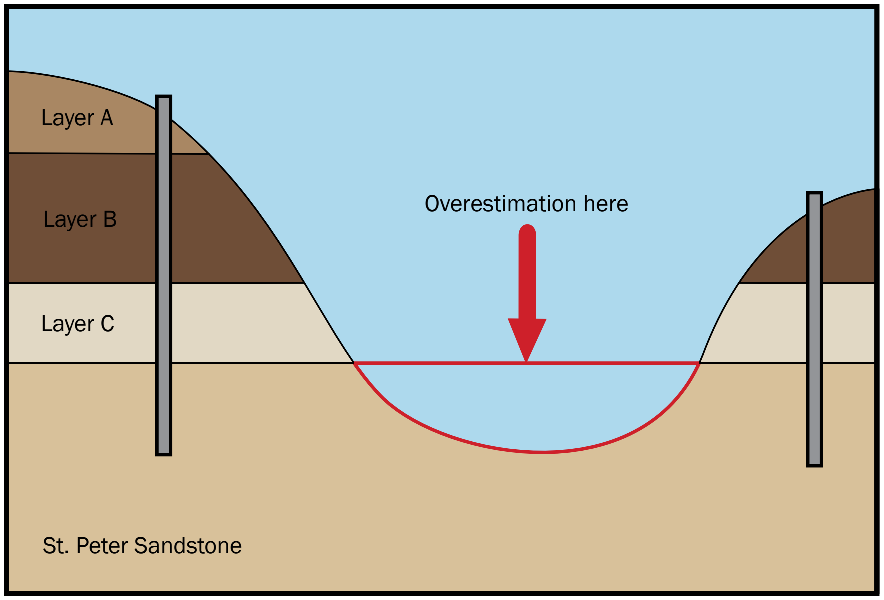

Figure 5.4.2 Second interpolation with overestimation with added control

1 Warnes, Jeremy. A sensitivity analysis for Universal Kriging. Journal of Mathematical Geology; Vol 18 No 7, 1986

surrounding area, leaving the St. Peter formation as the strata immediately below the surface.[2] The interpolation that results from the inclusion of these points tends to underestimate the upper elevation of the St. Peter for the surrounding area (see figure 5.4.1). To correct this issue, the model was reformulated to exclude such points from the sample, and to utilize only points for which the St. Peter formation was not the topmost strata. This interpolation captures the true trend of the St. Peter formation, but overestimates for locations at which the upper elevation of the St. Peter exceeds the elevation of the surface (see figure 5.4.2). Overestimations were reconciled by computing the difference between the new interpolated values and actual surface elevation, for which topographical imagery provides highly accurate data.

A final thickness layer was derived by computing the difference between the upper and lower elevations of the St. Peter. Similarly, depth to bedrock was calculated by computing the difference between surface elevation and upper elevation of St. Peter.

The Kriging process interpolated raster files for depth and thickness at 30-meter resolution. Each raster grid cell is 900 square meters, and is associated with one value for depth and one value for thickness. Both values were normalized to a scale of 0.00-1.00, where a value of 0.00 represents the condition least favorable for mining and a value of 1.00 represents the condition most favorable for mining. Summing these values for every grid cell yields a predictive layer that accounts for depth to the St. Peter formation and thickness of the formation, the two geologic attributes that primarily influence locational choice for the firm.

2 Smith, Austen. Where is the sand? Using geospatial point data to approximate3D subsurface geology (date of presentation)

Initially, depth and thickness attributes were integrated with two additional raster layers that accounted for proximity to the distribution network, including major roads (highways) and railroads. Ultimately, however, the roads and rails predictive layers were not factored into the model adopted for this report, for several reasons.

First, the transportation network exerts more influence over a large study area, where there is a high degree of variability in distance to roads and rail. Including these attributes makes sense for the statewide model for Wisconsin. In our case, however, the Winneshiek County mining zone is small enough – about 150 square miles – to limit potential haul routes. The two available railroads are proximal and essentially equidistant from the sand deposit in the county's northeast corner.

Additionally, the transportation weights were derived using a straight-line distance method, but did not account for time along an actual travel network. When straight-line distance does not represent the actual road network, it can reflect routes that do not exist.

Finally, minable sand volume in Winneshiek County is small in comparison to deposits elsewhere in the Driftless Region. With only so many location choices, depth to bedrock and thickness of the St. Peter formation should outweigh other considerations.

With this in mind, the model was adapted to include only the predictive layers for depth and thickness. The original weights of 0.35 for thickness and 0.30 for depth were normalized over a 100-point scale, yielding new weights of 0.54 and 0.46, respectively. Figure 5.4.3 shows the final predictive layer that was used to develop three locational scenarios used throughout the next section of the report.

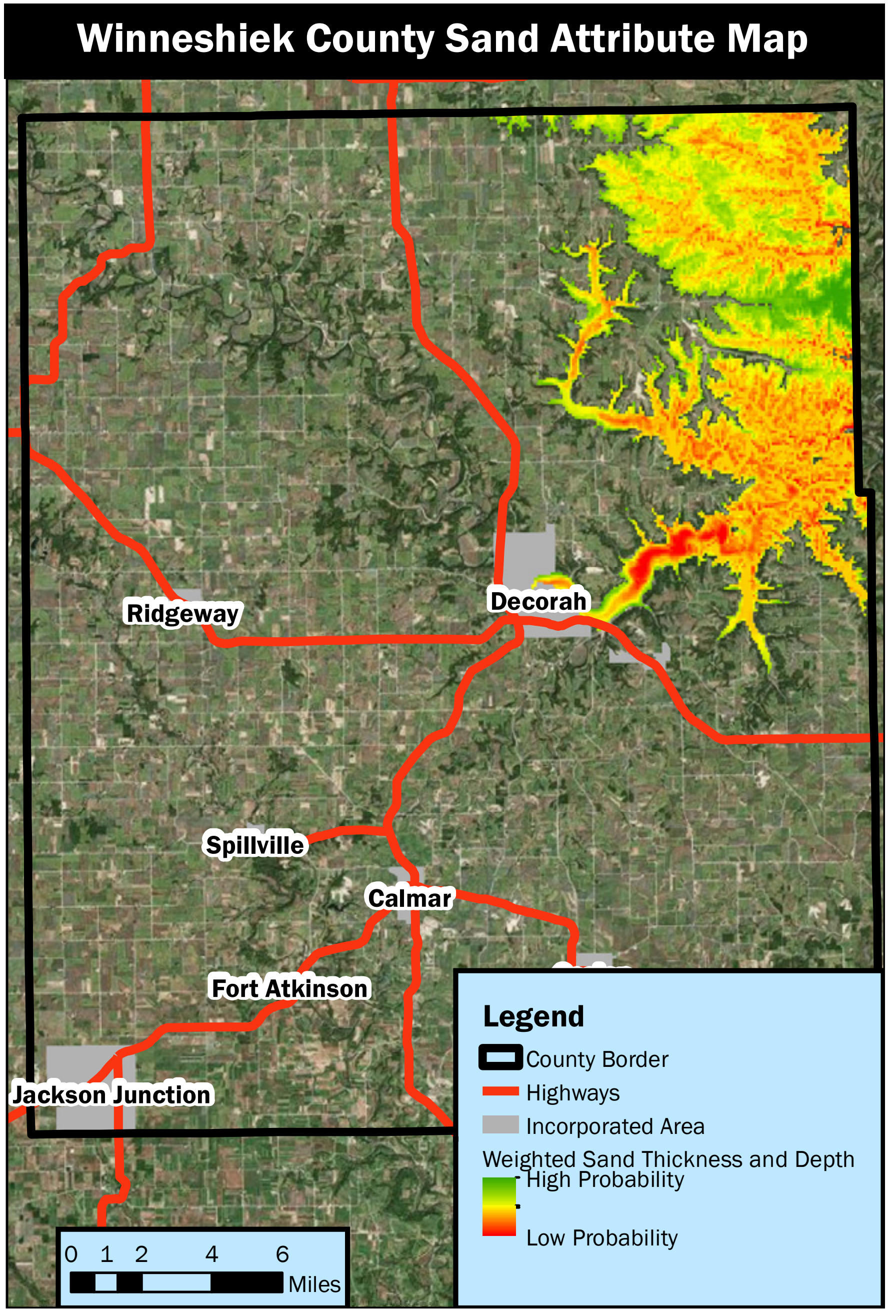

Figure 5.4.3 Sand depth and thinckness weighted map

5.5 Hypothetical Mine Locations

In order to measure impacts on the transportation and to public health through emissions, we identified likely mine locations and sand destinations. We used the new criterion weights for depth to sand and thickness of the sand deposit to site a hypothetical mine with highest thickness and lowest depth. (Site 1) A second mine (Site 2) was selected to model the impacts of a mine located closer to Decorah. A third mine location (Site 3) was used to verify some of the impacts measured based on Site 1.

5.6 Haul Routes

Once we identified the most likely rural mine location and one location closer to Decorah, we selected haul routes to estimate road impacts and mobile emissions. Two routes link Site 1 to New Albin in Allamakee County, and one uses only Winneshiek County roads, ending in Calmar.

- Route 1 moves north through Allamakee County and follows the Iowa-Minnesota border to New Albin
- Route 2 follows the Upper Iowa River across Allamakee County to New Albin
- Route 3 goes to west to Highway 52, then takes the highway south to Calmar

5.7 Mine Output

In order to estimate transportation impacts and air quality impacts, we first estimated the quantity of sand the would be removed from the three hypothetical mines. To do so, we examined Wisconsin mine output data for 17 different mines. Data on production output is available for a variety of mines throughout Wisconsin, but data about currently operating

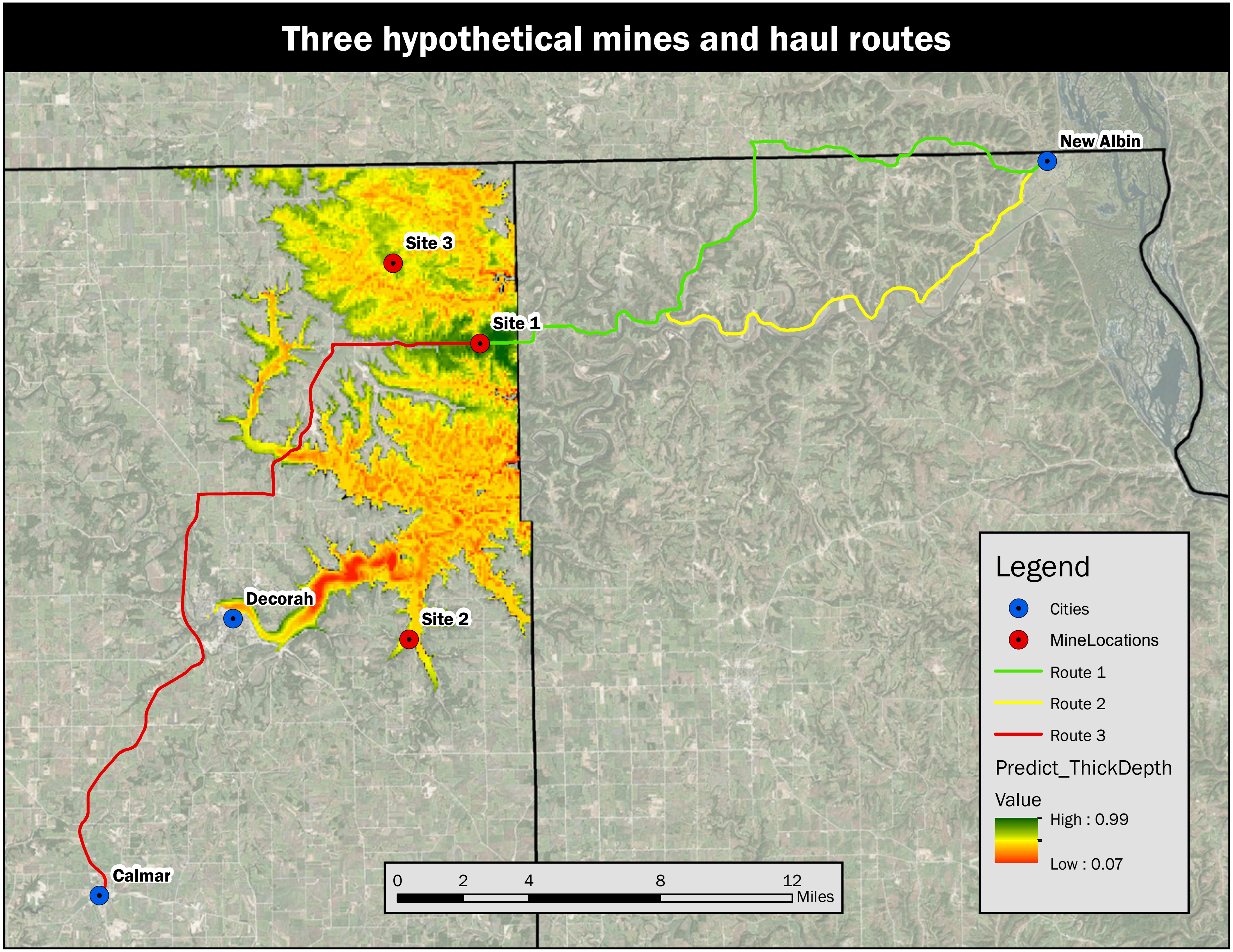

Figure 5.6.1 Hypothetical mine sites and three identified haul routes

mines is often missing or incomplete. Since mines vary in size depending on season and operational intensity, we used output per parcel acre to standardize estimates for potential mine output. Table 5.7.1 presents the mines, their parcel acres, and their predicted outputs.

After removing a couple of outliers and points with incomplete data from the Wisconsin data, we estimated output per parcel acre for varying levels of mining intensity. We used the mean value for output plus/minus one standard deviation to arrive at an average, low, and high estimate for output. The average mine (Table 5.7.1) produces 2,770 tons of sand per parcel acre annually, a low output mine produces 1,346 tons of sand per parcel acre annually, and a high output mine produces 4,194 tons of sand per parcel acre annually.

To estimate single mine output, we focused on potential mine size. Once again, we used estimates for a small, medium, and large mine. Using GIS, we examined parent parcels to determine a reasonable mine parcel size. Using the size of parcels in the mining area, we predicted that a large mine would be located on a parcel that is about 350 acres. Using the same methodology, we assume that a small mine will locate on a 50-acre parcel. Finally, we used the average of the two mine sizes to estimate the average mine size, which is 200 parcel acres. Using the different output intensities and mine sizes, we estimate that a small mine can be expected to produce between 67,313 and 209,696 tons of sand annually (Table 5.7.1). An average sized mine can be expected to produce between 138,505 and 969,532 tons of sand annually and a large mine can be expected to produce between 471,192 and 1.467 million tons annually. These large ranges increase uncertainty in our estimates.

Annual Mine Output Estimates			
Magnitude of Output	Mine Size		
	Small	Medium	Large
Low	67,313	269,253	471,192
Average	138,505	554,018	969,532
High	209,696	838,784	1,467,871

Table 5.7.1 Mine output estimates based on Wisconsin mine data

5.8 Truck Trips

Finally, we estimated the number of truck trips that would be necessary to transport all the sand to a rail hub. As has been discussed throughout this document, because there is no rail in the area where mines are most likely to locate, we assume that all sand must be transported by truck before it is loaded on rail. Based on discussions with construction company managers and mine owners, we determined that the sand will be transported in trucks that have a 25-ton payload. Using that payload, we estimated the number of annual truck trips that are necessary to transport the varying levels of sand mined. Based on our output projections and our payload, we estimate that between 7 and 22 daily loaded truck trips are necessary for a small mine, between 30 and 92 daily loaded trips are necessary for a medium sized

Loaded Truck Trips						
Magnitude of Output	Mine Size					
	Small		Medium		Large	
	Annual	Daily	Annual	Daily	Annual	Daily
Low	2,693	7	10,770	30	18,848	52
Average	5,540	15	22,161	61	38,781	106
High	8,388	23	33,551	92	58,715	161

Table 5.8.1 Round trip truck trips necessary to transport the estimated sand output

mine, and between 52 and 161 daily loaded trips are necessary for a large mine. The same number of unloaded truck trips will return to the mine.

Chapter 6 - Economic Benefits

6.1 Introduction

Traditional economic base theory focuses on export activity as the primary determinant of a region's economic growth.[1] This theory states that the production of goods for export drives local demand for locally produced goods, which supports jobs and creates wealth in non-basic industries. Non-basic industries do not produce for export. Thus, they can be said to redistribute rather than generate regional wealth. Non-basic industries would not exist but for basic industries. Therefore, true economic impact requires a change in the economic base. The majority of frac sand is mined and processed in Wisconsin and Minnesota and shipped by rail to be used as an input to oil operations in North Dakota, Pennsylvania, and Texas. Frac sand mined in Iowa would also be sold to oil companies operating in those regions. Because this is an export activity, this transaction constitutes an economic impact. Initial construction would also constitute an economic impact, albeit a temporary one, if the investment comes from an outside source and the project utilizes local labor.

Base multipliers relate a change in the number of basic jobs or level of productivity in basic industries to an impact in the non-basic sector. Similarly, the Input-Output method relates the producers of a good or service to all of the users of that product by assigning multipliers to each industry. Additional jobs and output at a mine or processing facility generate indirect demand for input goods and services, thus creating jobs in other sectors. Workers in those sectors, in turn, induce additional impact as they spend money on goods and services.[2] We used an Input-Output table for Winneshiek County that was generated from IMPLAN economic data, which contains multipliers for more than 400 national industries. However, frac sand mining is a new industry. Because Winneshiek County has no frac-sand mining currently, no multipliers were available, and we generated our own.

This chapter contains two sections. In the first section, Methods, we describe the process of developing a set of multipliers for the frac-sand industry. We establish a range of potential direct earnings and jobs impacts for the Input-Output model, and discuss how those impacts are scaled based on regional workforce residency. We project a range of mine sizes based on trends in Wisconsin, as well as what seems reasonable given local constraints. The Methods section concludes with a summary of hypothetical mining scenarios, the benefits of which are modeled in the Analysis section that follows.

6.2 Background Information

One of the leading factors behind frac-sand mining's accelerated growth throughout the Driftless Area is the industry's ability to create a number of well-paying jobs. These jobs can be attributed both to the direct activity associated with mining, as well as to complementary industry and local community services needed to support the daily activities of both the mines and the newly transplanted workers. Many rural Midwestern counties are still recovering from the shock of industrial recession. When factoring in supporting industrial activity, frac-sand mining can produce tangible direct and indirect benefits.

While mining is often perceived as an unstable industry, there is an increasing amount of evidence which suggests that mining

1 Krikelas, A. (2010, March). Why Regions Grow. Regional Impact Models. Retrieved from http://rri.wvu.edu/WebBook/Schaffer/index.html

2 Hastings, S. E., & Brucker, S. M. (1991).

has a positive impact on employment and income growth rates.[3] Steven Deller and Andrew Schrieber surmise that mining's jobs, most of which are considered well-paying, can ultimately lead to lower levels of poverty. Complementary correlation analysis shows that in addition to lower levels of poverty, higher concentrations of mining can lead to reduced levels of income inequality. Deller and Schrieber also find little evidence that remote rural counties experience population decline or stagnation as a result of increased dependency on mining. The magnitude of growth stemming from mining operations can also be contingent on the degree to which mining ownership is local. Deller and Schrieber find that mines run by local firms, and which thus generate local profit, tend to result in greater economic impacts and higher levels of local growth.

Like many other large-scale industrial operations, benefits accrued from land acquisition are isolated, but substantial. According to Thomas Pearson's study on frac-sand mining in Wisconsin, most farmers are paid well above market value for sale or lease of their land.[4] The Federal Reserve Bank of Minneapolis recently reported that a Texas-based oil and gas firm bought a potential frac-sand mining site in Red Wing, Minnesota, for over $16,000 per acre. This figure represents a substantial increase over the region's typical valuation per acre at $9,100 to $12,000 per acre.[5] In addition to lofty sale acquisition prices, many farmers and land owners are paid royalties on their lands after sale or leasing. Industry averages show royalties can range from $1.50 to $3.00 per ton for frac-sand hauled away from the property. High demand for precious real estate is a result of market valuation of frac sand as a commodity. Frac sand may sell for $45 to $80 per ton before shipping, which is twice the cost of sand production.[2] Values increase up to $300 per ton when transportation costs are included. For a 50-100 acre mine, this can result in hundreds of thousands of dollars per year in royalties for the selling or leasing party.

Given the extensive scope of mining operations, new facilities construction and maintenance acts as a major source of newly created jobs. A recent analysis on the economic impact of frac-sand mining in Wood County, Wisconsin, estimates the impacts of permanent jobs, worker earnings, and county revenues over the first 10 years of construction and operational mining in the county.[6] When factoring in direct, indirect, and induced jobs resulting from facilities construction of both a frac-sand mine and processing center, the study estimates that 616 new jobs would be created. These new jobs yield over $33.3 million in new earnings for county workers. By the third year of mine operation, the study estimates over 700 new permanent jobs (or an additional 84 jobs) and a county earnings yield of $42.8 million. After eight years of operation, over 930 new, permanent jobs and $58.7 million are projected. Additional inputs to county revenue are projected at $1.5 million to $2.6 million per year.

An additional study performed by *Workforce Connections* on the frac-sand mining industry in West-Central Wisconsin, reported the average regional hourly earnings and projected the impacts of several job-related multipliers on the region's welfare.[7] In 2011, regional mining industry wages ranged from $11.87 per hour for laborers and material movers to $22.81 per hour for operational engineers and construction equipment operators.

3 Deller, S., & Duley, C. (2014). The Economic of Sand Mining in Buffalo County. Madison, WI. University of Wisconsin-Madison Extension, Department of Agriculture and Applied Economics.

4 Pearson, T. (2012). Frac-Sand Mining in Wisconsin: Understanding Emerging Conflicts and Community Organization. Journal of Culture and Agriculture. Menominee, WI. University of Wisconsin-Stout.

5 WErnau, Julie. (2014). "Mining for Fracking Sand Drives Some Illinois Farmers from Land."

6 The Economic Impact of Frac Sand Mining, A Look at Jobs and Earnings in Wood County, Wisconsin. (2013). Moscow, ID. Economic Modeling Specialists.

7 Frac-Sand Mining Industry Report

Assuming a standard annual workload of 1,788 hours per year, the resulting gross annual salaries would range between $21,000 and $41,000 per worker per year. [8] These wages would align with statewide averages for labor and construction work.[9]

The *Workforce Connections* study also projects sales, jobs, and earnings multipliers for the region. The study estimates the sales multiplier for the region at 1.37, meaning that for each dollar made in sand mining sales, the sales in the county will have an additional increase of $0.37.[4] The jobs multiplier is estimated at 2.79. The resulting estimation for each regional job created in the sand mining industry is nearly three total jobs (or 1.79 additional jobs) inserted into the regional economy.[4] The primary consequence of this multiplier is that regardless of where mining takes place in the region, the local number of jobs is projected to increase nearly threefold. The *Workforce Connections* study estimated earnings multipliers of 1.48.[4] Similar to sales, the assumption with this multiplier is that for each dollar gained in sand mining earnings, the regional economy would benefit by increased earnings of $0.48. In terms of net permanent job growth, leading support industries projected to benefit from the presence of mining include government, retail, and health care.

6.3 Methods

Developing the Multipliers

With the help of Dave Swenson, Associate Scientist in the Department of Economics at Iowa State University, we created a set of Winneshiek County multipliers for the frac-sand mining industry. Using county Input-Output tables, we transformed our tables to reflect final demand. Transforming for final demand creates a production recipe for each industry in the county. This recipe shows the inputs that each industry purchases from other industries in Winneshiek County. Using estimated wage and estimated number of employees per establishment, we were able to modify social accounts to have employment, labor income, and ownership structure reflect that of the frac-sand mining industry. To develop the multiplier, we assumed the average mine would employ 23 workers[10] at an average salary of $46,152.[11] From there, we created tables of multipliers that provide indirect and induced impacts for $1 million of mining output. As our inputs reflected wage and employee estimates, and because mine production output is difficult to predict, all output data in our analysis are rough estimations. However, total output is not reflective of economic value. Jobs, labor income, and value added—in this case, gross regional product—are better measures of economic impact. To quantify impacts from trucking, we used trucking multipliers for Winneshiek County that were provided from IMPLAN.

Mining and Processing Defined

To measure the indirect and induced economic impacts – as well as external costs and benefits – of any impact, one must determine the scale of the direct impact itself. This includes estimating total jobs and earnings associated with all phases of mining: construction of the processing plant, if there is one, as well as excavating, extraction, crushing, wet and dry processing, and trucking. For our purposes, we define "mining" to include all excavation (clearing and grubbing) and extraction activities. We define "processing" to include all activities related to crushing, sorting, on-site trucking, and wet and dry processing activities.

8 OEC. StatsExtracts. Average Annual Hours Actually Worked per Worker. Retrieved from http://stats.oecd.org/ index.aspx?DataSetCode=ANHRS

9 Bureau of Labor Statistics. May 2013 State Occupational Employment. Retrieved from http://www.bls.gov/oes /current /oes_ia.htm#47-0000

10 County Business Patterns, 2012, Industrial Sand Mining in Wisconsin.

11 The derivation of this value is explained in the Mining Jobs section.

Both mining and processing inputs take the same frac-sand industry multiplier, but we make the distinction to clarify scenarios in which an operation contains one or more mining units as well as a processing unit, as this creates additional jobs and earnings impact. Furthermore, the construction of a wet and dry processing facility creates additional economic impact. We define “construction” as the construction of a physical processing facility. We project low and high estimates for mining, processing, and trucking, and then sum those impacts to model low and peak production scenarios for one mine. Chapter 6 provides estimates for trucking distance from mine to processing center/ transfer station.

Mining Jobs

We estimate that one mine will employ 6-13 workers. The low estimate is based on multiple conversations with regional mining companies and observation of the Skyline gravel quarry in Winneshiek County. Additionally, the operator of an open-pit mine in southeast Minnesota, who requested anonymity, indicated that his operation employed 5-6 miners. Six workers can be thought of as the smallest unit that can perform blasting, excavating, and extracting activities. At peak productivity, a large mine may require two units, or 13 workers. While some mining jobs must be seasonally adjusted, excavation may continue throughout the year, as there are often limits to the amount of overburden that can be removed at one time.[12]

Using Quarterly Workforce Indicators (QWI) from the Bureau of Labor Statistics (BLS), we downloaded data for the industry “Nonmetallic Mineral Mining and Quarrying” (industry code 2133) for the State of Wisconsin and major mining counties. The frac-sand market took off in 2009, with mining wages increasing accordingly. Figure 6.3.1 presents data from 2006 to 2012, capturing the growth in nominal average earnings in Nonmetallic Mineral Mining and Quarrying for seven Wisconsin counties. This industry aggregates frac-sand mining wages and earnings for other nonmetallic mining industries. Figure 6.3.1 excludes data for mining counties with hidden data or irregular income patterns. The average mining wage in Jackson County, for example, was $141,333 in 2011 and $143,832 in 2012, more than $90,000 above the seven-county average. A difference of this magnitude may be due to the residency of one or more mine executives within the county.

In 2012, the seven-county average salary was $47,761. This number informed our estimations of Iowa frac-sand mining, an industry that does not currently exist in the state.[13] To estimate the wages that Iowa frac-sand miners would receive, we used County Business Pattern data from 2012 for Iowa, Wisconsin, and the nation. We adjusted national Industrial Sand Mining wages by two factors to make the estimates. First, we adjusted for being a frac-sand miner versus “other” industrial sand miners. Second, we made an adjustment for being a miner in Iowa versus a miner in Wisconsin.

The first step in the adjustment was to make a comparison between Wisconsin and U.S. wages using the Industrial Sand Mining industry (NAICS code 212322). We assume that the majority of sand that is industrially mined in Wisconsin is frac sand, and that Wisconsin data for Industrial Sand Mining is therefore representative of the frac-sand mining industry. The average wage for that industry in Wisconsin was $53,587, while the national average was $49,781.The difference between the

12 Jordan Sands. (n.d.). Zoning Request Applications. Mankato, Minnesota. Retrieved from http://www.mankato-mn.gov/upload/contents/366/Jordan%20Sands%20Application.pdf

13 Clayton County’s Pattison operation is a frac-sand mine, but it differs from most Wisconsin operations in that the under-ground operation was constructed long before the frac-sand boom.

two is assumed to capture the difference between the wages for frac-sand miners and wages for industrial sand miners who mine sand for other uses. Dividing the Wisconsin average by the national average with Wisconsin excluded shows that the average Wisconsin frac-sand miner earns 110 percent of the average industrial sand miner in the United States.

We next took the Sand, Gravel, Clay, and Ceramic and Refractory Minerals Mining and Quarrying industry (NAICS code 21232) and determined the adjustment for being a miner in Iowa versus the national average. A Sand and Gravel miner in Iowa earns an average of $46,640 annually, while the national average is $49,174. As performed above, we divided Iowa wages by the national wage with Iowa excluded to show that an Iowa miner earns 85 percent of national wage on average. Combining these two scalars, a frac-sand miner in Iowa would earn 94 percent of

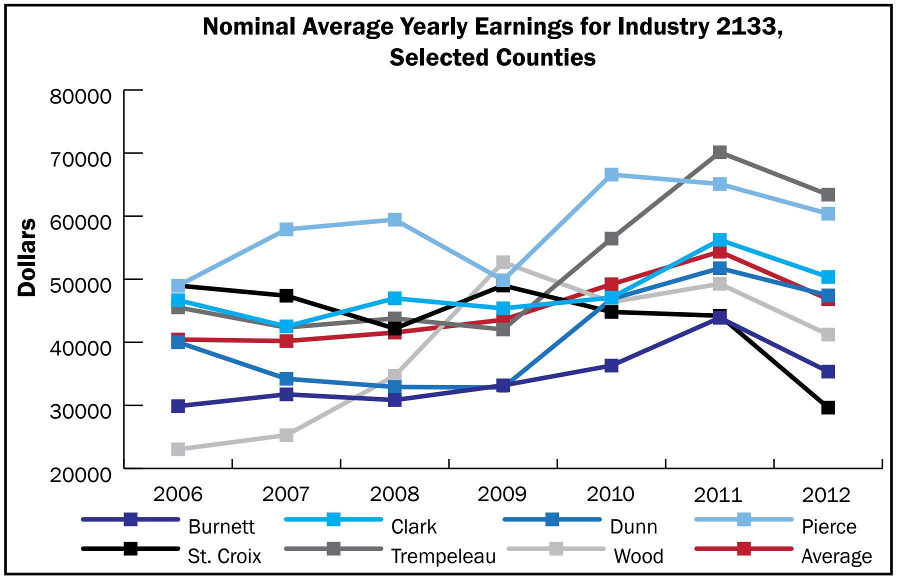

Figure 6.3.1 Mining earnings by county, selected Wisconsin Counties (Source: Bureau of Labor Statistics)

national Industrial Sand Mining, or $46,152 annually. This figure is close to the seven-county average presented above, but is appropriately smaller. We use this average earnings figure for all mining and processing jobs.

Processing Jobs

Wet and dry processing facilities are constructed in 6-8 months, generating economic impact in the construction sector. For these construction jobs, we use the Winneshiek County multiplier for the "construction of new non-residential manufacturing structures." For the day-to-day operation of the plant, we project 7-15 jobs[14]. The low and high processing estimates seem reasonable given our initial mining estimates: more product requires more processing jobs. Furthermore, the sum of our high estimates for mining and processing is 28 jobs, which is consistent with numbers cited in the Environmental Assessment Worksheet for Great Plains Sand (now Shakopee Sands, LLC), a facility in Scott County, Minnesota, that includes approximately 100 mined acres and a 28-acre processing facility.[15] That operator projected 32 combined jobs for mining, processing, and shipping (spring/summer/fall) and 12 total jobs during the winter. Because there is rail on site, no jobs are projected for offsite truck transport. The entire mining operation slows during the winter, because wet processing cannot occur at sub-freezing temperatures. Figure 6.3.2 shows quarterly employment fluctuations for the State of Wisconsin. We use our frac-sand mining multiplier for all processing jobs, which encapsulates crushers, wet washers, dry washers, mechanics, and on-site

14 Initial numbers based on estimates provided to us during informal interview of job Foreman who works for a local quarrying operation. He wishes to remain anonymous due to political nature of the Frac sand debate.

15 EAW obtained from Scott County website: http://www.co.scott.mn.us/ParksLibraryEnv/Environment/EnvReview/greatplainsminingeaw/Documents/Great_Plains_Sand_EAW_no_links.pdf

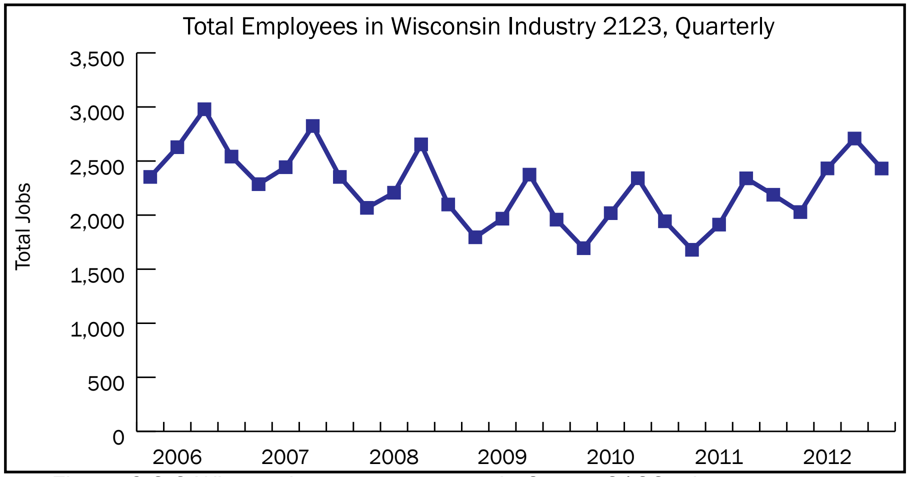

Figure 6.3.2 Wisconsin total employees in Sector 2123, shown quarterly

trucking jobs. Because our multipliers for the frac-sand industry were derived from multipliers for similar extraction industries, we assume that they capture seasonal employment changes. Therefore, we do not scale model outputs to account for the effect of reduced labor income during the fourth quarter.

Trucking

The Rein Quarry, located in Fillmore County, Minnesota, is our best analog for estimating the number of long-haul truck trips for a large Winneshiek County mine with or without processing facility. In its Environmental Assessment Worksheet, the operator projected 120 loads (240 total trips) a day to the offsite processing center and back during periods of peak operation. The company also estimated that 30 trucks would be required to complete trips during peak production. Thus, we set 30 trucking jobs as our high trucking estimate. We project a conservatively low estimate of five trucks/job, because the tonnage of sand produced, as well as transport distance, decline for smaller mines. (It is not viable for small operations to truck long

Mine and Processing Job Parameters

	Mining	Processing	Trucking	Total
Low	6	7	5	18
High	13	15	30	58

Table 6.3.1 Low and high direct job estimates

distances.) In 2012, the average trucking salary was $44,202 in Winneshiek County.[16] Table 6.3.1 summarizes our projections of low and high impacts for mining, trucking, and processing. Because we model various combinations of mine and processing, analyses may not reflect the numbers in the Total column. Figure 6.3.3 shows the location of mineable sandstone in Winneshiek County in relation to three processing sites located in Winona, Minnesota; New Albin, Iowa; and at the Pattison Mine in Clayton County.

County Revenue and Local Jobs

In addition to jobs and new labor income, the County may reap revenue benefits as new workers, who demand public services, enter the tax base. The income that some of the new workers earn will increase revenues for the local government. The county will receive increased revenues from additional income only if that income stays within the county. Like the rest of the Winneshiek County workforce, some of the people who fill the mining, trucking, or processing jobs will be residents of surrounding counties. To estimate the percentage of the new jobs that are filled by Winneshiek County residents, we used U.S. Census data from On the Map to determine where the workforce lives. The most recent On the Map data is from 2011. That year, 56.6 percent of Winneshiek County jobs were filled by residents of the county. Additionally, 57.6 percent of employed Winneshiek

16 Bureau of Labor Statistics

County residents worked within the county.[17] We took the average of the two values to estimate that 57.1 percent of the jobs created directly, indirectly, and through induced means will be filled by Winneshiek County residents.

Once we estimate the number of jobs and total earnings that accrue to the County, we can estimate the County's potential revenue benefits using actual County expenditures from fiscal year 2012 to 2013.[18] Using the County's budget breakdown, we examine own-source receipts to determine the amount of County revenue that is generated by local incomes. [19] Comparing this figure to Total Personal Income (TPI) for the County,[20] we can estimate the amount of public services demanded as a fraction of TPI. We multiplied those percentages by the total labor income of local resident jobs created by mining to estimate additional county receipts.

We assume that all Winneshiek residents consume a standard set of public services. Thus, we can make an estimation to determine if the increase to county receipts results in a net gain or a net loss to county revenue. This analysis assumes that residents whose personal income is equal to the county's per capita personal income of $41,471 are taxed in proportion to the amount of county services that they use.[21] However, workers who earn more than the per capita personal income pay for a greater portion of services than they consume, while those who earn less pay for a smaller portion than they consume. By comparing average annual earnings for new jobs to per capita personal

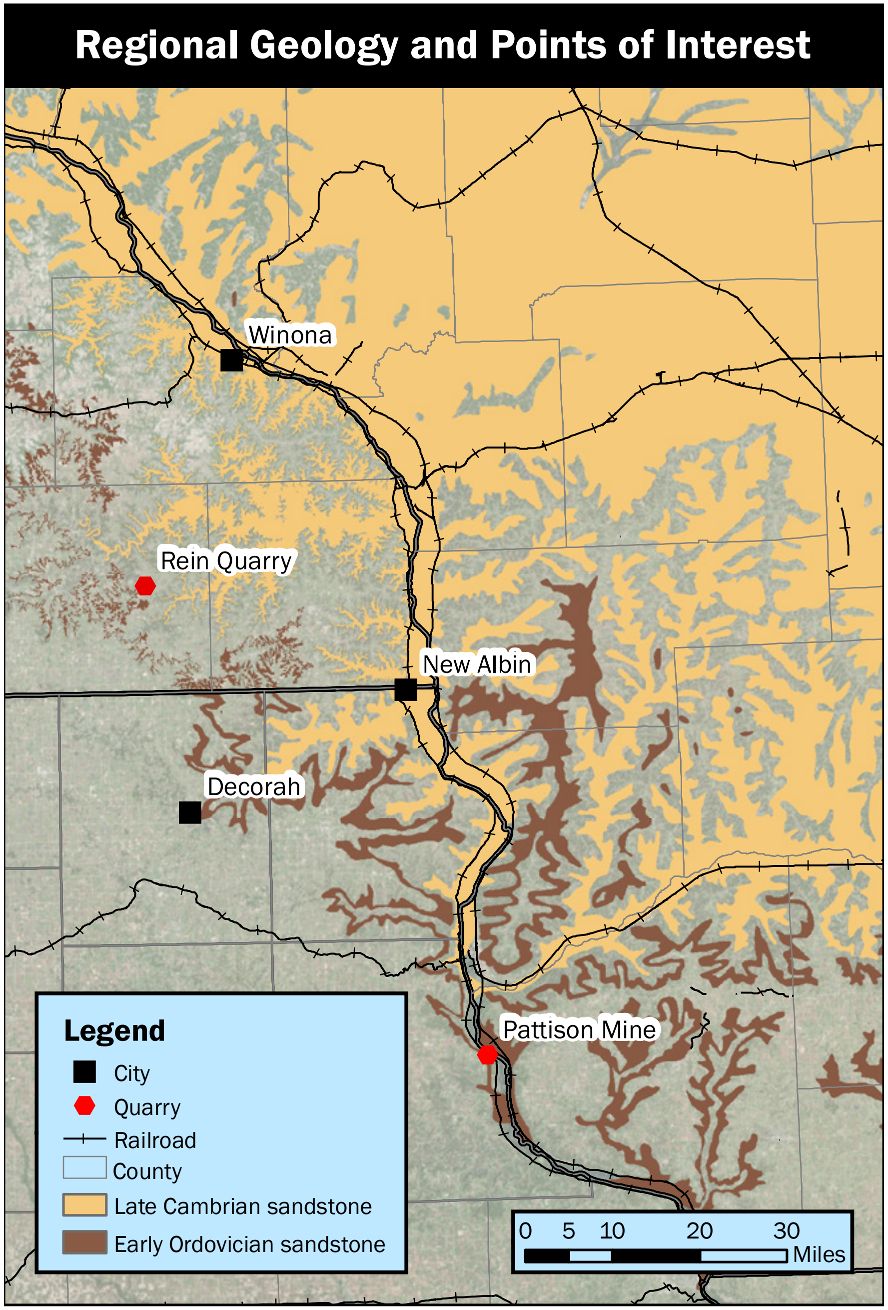

Figure 6.3.3 Regional geology and points of interest

17 U.S. Census Bureau; On the Map.
18 Actual county spending is available from the Iowa Department of Management.
19 Using the County's budget breakdown, own-source receipts include revenue generated from "taxes levied on property"; "other city taxes"; "licenses and permits"; "charges for fees and service"; and "miscellaneous". Table 5.4.10 on Page 44 gives a detailed breakdown.
20 Available from Bureau of Labor Statistics
21 U.S. Department of Commerce; Bureau of Economic Analysis

income, we can estimate what fraction of new county receipts is a net gain or net loss relative to average revenue demanded.

Primary Data Analysis and Wisconsin Trends

Spatial data from the Wisconsin DNR was downloaded from arcgis.com and was used to analyze trends in mine location and size. This dataset, which is from 2012, indicates the activity status of each mining facility as operating, permitted or as having been applied for. Facilities may include mine, processing, or shipment center, or some combination of the three.

Wisconsin data was compared with an interactive map from the Wisconsin DNR's website that was updated in July 2014, but which provides less information than the original dataset.[22] This map was used to update the operation status of each mine. For example, the permit for a 1,390-acre processing facility in Buffalo County, which had been applied for by January 2012, was still pending in 2014. With few exceptions, all operations were mining Cambrian-Era sandstone, which includes both the Wonewoc and Jordan formations, but not the St. Peter.

The parcel area of Wisconsin's 30 operating mining facilities in 2012 ranged from 11 to 420 acres. Due to this variation, and because mine surface area is not necessarily correlated with actual mined area, we elected to set employment parameters in terms of jobs per mining establishment rather than jobs per acre. However, there are other reasons to project parcel acreage. First, parcel acreage determines how a mine is assessed and taxed, as well as how much acreage may be removed from agricultural production.[23] Moreover, parcel acreage sets the theoretical limit to which an operator can mine without acquiring additional land. While the actual excavated acreage of one mine may be only a fraction of total parcel area, it is parcel area—along with the agreement established in the conditional use permit—that dictates the possibility of future expansion.

Scenarios

We will estimate total jobs, earnings, and revenue benefits for four scenarios, running our low and high job inputs for each. First, we will estimate the benefits that accrue to Winneshiek County for one mine, including trucking but without processing. This will provide a baseline estimate for a range of impacts associated with one mine, which will be linearly increased to show impacts for scenarios with more mines. The single-mine scenario demonstrates what might occur if the County were to ban chemical processing, regulate water withdrawals, or otherwise limit processing such that it was not economically feasible for a facility to locate in the county. Next, we estimate a range of impacts for a single processing center. Then, we model the benefits of one mine and one processing center. If there were no processing restrictions, it would be most efficient to process on site. Therefore, we assume the processing facility is located on a shared mining parcel or is otherwise sited close enough to the mine such that no additional trucking impacts accrue beyond those we already consider. We will also model benefits for three mines and one processing facility, as well as for five mines and two processing facilities. The following chapter focuses on the analysis of benefits for each scenario.

22 Wisconsin DNR. (2014, July 9). Locations of industrial sand mines and processing plants in Wisconsin. Retrieved from http://dnr.wi.gov/topic/Mines/ISMMap.html

23 Alstad, J. (2014, November 10).

6.4 Scenario Analysis

Estimating the potential impacts of frac-sand mining requires first estimating the job and labor benefits from one mine. Because jobs and labor income are assumed to scale linearly as the number of mines grows, making an estimate of the benefits of one mine and one processing center is the first step in measuring the expected benefits from frac-sand mining at different intensities. For each level of mining intensity we outline the direct, indirect, and induced benefits from mining based on low and high direct job estimates. Because private industrial output is difficult to predict and because it is a poor measure of value to an economy, the main focus of this analysis will be based upon jobs and labor income. All numbers in this section (Chapter 5.4) are derived from IMPLAN input-output tables, unless otherwise cited. In the following analysis, the term direct refers to impacts from the mine or processing center, indirect are impacts that are created as a result of the new industry demanding goods as inputs, induced are impacts from spending that happens from the new labor income, and total impacts are all three aggregated.

Mine Job Impacts

As previously discussed, we assume the low-end employee estimates for a single mine will be six workers in the mine and five workers for trucking and the high-end estimates are 13 miner jobs and 30 trucking jobs. This section will first examine the direct mining and trucking jobs and the labor income that those jobs will be paid. Following, it examines the indirect and induced jobs that would be created as a result. It is important to note that all of the impacts scale proportionately with one another. As an example, if the direct jobs are on the high end of our range, other impacts, such as labor income and indirect jobs, will also be on the high end of the estimated range.

On the low end, the six direct miner jobs are expected to produce $960,000 in direct output. Of that direct output, $318,000 is expected to be labor income. On the high end, we expect the 13 miner jobs to produce approximately $2.08 million in direct output, including $690,000 in direct labor income. On both the high end and the low end, we expect each miner to make approximately $53,075 annually.

We project a range of five to 30 trucking jobs. Those direct jobs are expected to earn, on average, $47,265 annually. They are expected to produce between $673,000 and $4.04 million in total output, which includes between $236,000 and $1.42 million in direct labor income.

Both direct mining and trucking jobs would create indirect jobs in other industries. We project a range of 2.37 to 10.1 indirect jobs. Those jobs are expected to produce between $310,000 and $1.10 million in total output. Of that output, between $92,000 and $367,000 is expected to be labor income. For the low-end estimates, the indirect jobs are expected to make about $38,840 annually, and for the high-end estimates, the indirect jobs are expected to be paid $36,347 annually.

Finally, the additional income that enters the economy will create additional, induced jobs. We expect that between 2.8 and 10.7 induced jobs will be created from mining and trucking. Those jobs will produce between $281,000 and $1.074 million in total output. We expect that labor income for the induced jobs will be between $90,000 and $343,000. In general, induced jobs are of lower quality than direct and indirect jobs. That holds true here, as the average annual earnings for the induced jobs is expected to be approximately $32,000.

To estimate the impact from the entire mine, including both mining and transport of the sand by truck, all benefits must be aggregated. The total jobs created from one mine can be expected to be between 16.2 and 63.8 jobs, earning between $737,000 and $2.818 million in total labor income. Total output from a single mine is expected to range between $2.226 million and $8.296 million.

While all of the jobs would be located in Winneshiek County, they would not all be filled by county residents. In 2011, 57.1 percent of Winneshiek County jobs were filled by Winneshiek County residents. Assuming the labor force that fills these jobs is consistent for other sectors, we scale proportionately to estimate, on the low end, that 9.2 of 16.2 total expected jobs attributable to the single mine would be filled by Winneshiek County residents. On the high end, 36.4 jobs are expected to be filled by Winneshiek County residents, earning a total labor income of $1.6 million. See Table 6.4.1 for single-mine impacts.

Single Mine Job Impacts

	Intensity	Jobs	Output ($)	Labor Income ($)	Average Annual Labor Earnings ($)
Direct Mine	Low	6	961,980	318,450	53,075
	High	13	2.084 M	689974	53,075
Direct Trucking	Low	5	672,964	236,325	47,265
	High	30	4.038 M	1.148 M	47,265
Indirect	Low	2.4	310,023	92,087	38,840
	High	10.1	1.010 M	367,082	36,347
Induced	Low	2.8	280,711	89,701	32,158
	High	10.7	1.074 M	343,162	32,147
Total Impact	Low	16.2	2.226 M	736,562	45,579
	High	63.8	8.296 M	2.818 M	44,190

Table 6.4.1 Direct mine, direct trucking, indirect, induced, and total job impacts from a single mine

Processing Center Job Impacts

For a single processing center, we are assuming that the company will employ between seven and 15 workers. We utilized our frac-sand industry multipliers to estimate the job impact from a single processing center. Direct processing jobs $53,075 annually, the same amount as direct mining jobs. Winneshiek County can expect that one processing center will bring between 1.3 and 2.7 jobs. The total labor income that is expected to be paid to those employees ranges from $56,000 to $121,000, and averages approximately $44,000 annually per job. Finally, a single processing center can be expected to produce between 1.8 and 4.0 induced jobs. We expect those jobs to be paid about $32,000 annually.

Again, we must sum the direct, indirect, and induced jobs to see the total impact from a single mine. Therefore, we expect that a single processing center will create between 10.1 and 21.6 total jobs in the Winneshiek County economy. Those jobs will produce between $1.539 million and $3.229 million in total output. The total labor income can be expected to be between $487,000 and $1.044 million. According to our commuting estimates, 57 percent of the new jobs will be filled by local residents. On the high end, 12.4 of the 21.6 total jobs are expected to be filled by Winneshiek County residents. That means that $596,000 in labor income would stay in Winneshiek County.(See Table 6.4.2 for summary.) For our low estimate, 5.8 of the 10.1 jobs are expected to be filled by Winneshiek County residents, while the remaining 4.3 will be filled by out-of-county commuters. In this scenario, the total labor income that would be captured by Winneshiek County residents is $278,000.

Single Processing Center Job Impacts					
	Intensity	Jobs	Output ($)	Labor Income ($)	Average Annual Labor Earnings ($)
Direct Processing	Low	7	1.122 M	371,525	53,075
	High	15	2.405 M	796,125	53,075
Indirect	Low	1	231,373	56,437	44,940
	High	3	495,800	120,937	44,940
Induced	Low	2	185,739	59,361	32,178
	High	4	398,012	127,202	32,178
Total Impact	Low	10	1.539 M	487,323	48,247
	High	22	3.299 M	1.044 M	48,247

Table 6.4.2 Direct processing, indirect, induced, and total job impacts from a single processing center

Indirect and Induced Jobs from the Frac-Sand Mining Industry

Many different industries will see some benefit from frac-sand mining. Some will sell goods or services that will be used as inputs to mining operations, while others will have increased demand through the extra spending created through the new labor income. The indirect impacts from the mining operation itself will be located primarily in the following industries: support activities for mining; mining and quarrying stone; monetary authorities and depository credit intermediation activities; transport by truck; architectural, engineering, and related services; and natural gas distribution. While other industries will be impacted, each of the industries listed above should have an increase of greater than $3,000 in labor income for every $1 million in output from the frac-sand mining industry. Additionally, the induced impacts from frac-sand mining will be located primarily in the following industries: food and drink establishments; wholesale trade businesses; nursing and residential care facilities; retail stores motor vehicle and parts, general merchandise, and food and beverage services; and private junior colleges, colleges, universities, and professional schools. Each of these industries can expect an increase to labor income that is greater than $2,000 for every $1 million of direct output in the frac-sand industry. For a comparison, $1 million in direct mining output is expected to provide 6.2 jobs for frac-sand mining or processing.

Multiple Mines

To capture a range of impacts, we scale the number of mines up to five, and provide analysis for the four scenarios that were discussed above. This analysis will also include the average of the high and low estimates to provide a middle value for the estimated impacts of each level of mining intensity. The benefits from mining grow linearly. Thus, estimating the impacts from additional mines requires multiplying the impacts discussed above by the total number of mines. We have created graphs to illustrate the growth of benefits as the number of mines increases to five. Using our low and high estimates, the total number of employees that can be expected with three mines should be between 71 and 191. The average estimate is 131 jobs. The labor income can be expected to be between $3 million and $8 million. Additionally, with five mines, we expect 118 to 319 jobs. The average estimate is 219 total jobs. The total labor income associated with five mines should be expected to land between $5 million and $14 million. Figures 6.4.1 and 6.4.2 summarize mining and trucking total jobs and labor income over increasing numbers of mines.

The impact ranges from each of our scenarios is shown in Table 6.4.3. As discussed in the methods section, our four scenarios are: a single mine; a single mine with a processing center; three mines and one processing center; and five mines and two processing centers. As we have already discussed in detail our

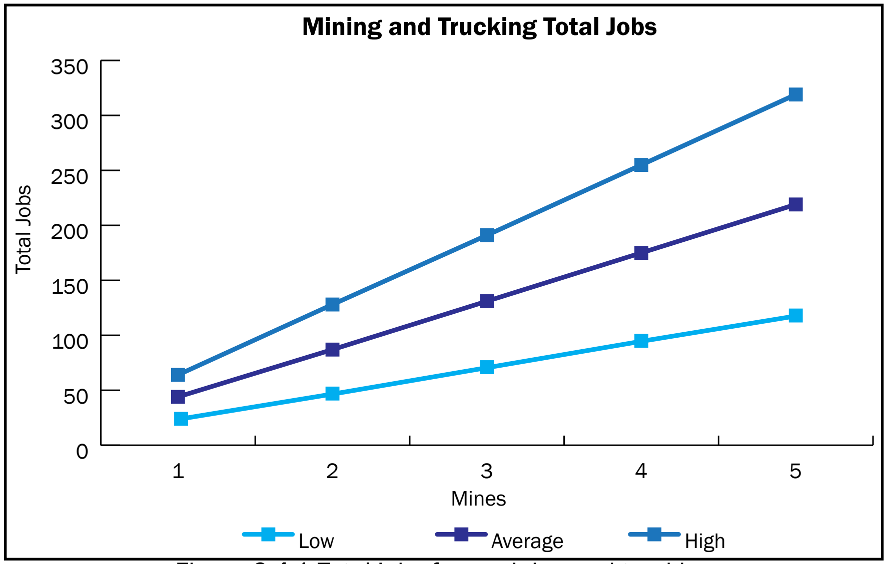

Figure 6.4.1 Total jobs from mining and trucking

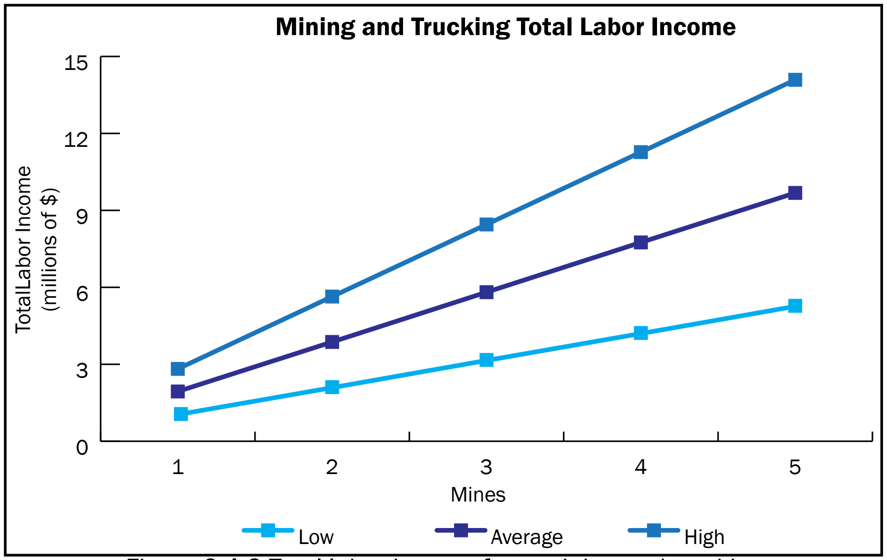

Figure 6.4.2 Total labor income from mining and trucking

process for determining baseline benefits associated with a single mine, this section provides a simplified explanation for the other scenarios.

As the table 6.4.3 shows, the low and high estimates overlap for mining at different levels of intensity. For example, the high-end impact estimate of jobs from one mine with processing is 85, while the low estimate for three mines with one processing center is 81 jobs. If three mines and one processing center come to Winneshiek County, an expected 81 to 213 total jobs should come with it. There can be an expected $3.6 million to $9.5 million in labor income to go with those jobs. For five mines and two processing centers, we expect between 139 and 362 total jobs, with $6.5 million to $16.2 million in total labor income. Labor income scales proportionally with the total jobs, so a high total labor income will not come with a low or average number of total jobs. As the intensity of mining increases, the range of the estimated impacts also increases, leaving greater uncertainty.

Aggregated Total Impacts of Mining, Trucking, and Processing						
Scenario	Jobs			Labor Income (millions)		
	Low	Average	High	Low	Average	High
1 Mine with Processing	34	60	85	1.54 M	2.70 M	3.86 M
3 mines, 1 processing	81	147	213	3.65 M	6.58 M	9.50 M
5 mines 2 processing	139	250	362	6.25 M	11.21 M	16.18 M

Table 6.4.3 Scenario impacts

County Revenue Changes

County revenue is expected to grow with the increase to income. It is important to note that while the income will increase, so will the services that the county must provide to the local residents, so a portion of the new county revenue will be needed to pay for the services that each new job demands. We have measured potential revenue increases for our low and high estimates for one mine and for one processing center. Winneshiek County modified own-source revenue includes property taxes; penalties, interest, and costs on taxes; licenses and permits; charges for service; and miscellaneous revenues.[24] In the 2012-2013 fiscal year, those revenue sources constituted approximately $9,214,608 in county revenue. Own-source revenue makes up 1.06 percent of Winneshiek County's total personal income of $873,422,000.[25]

Using the total labor income that is earned by Winneshiek County residents from the new mining, trucking, and processing jobs, we made estimates of the county receipts that will be realized from mining. Again, we use a range of values for one mine, low and high, as well as one processing center, low and high, to provide a range of county revenue increases. Approximately 1 percent of new labor income will be attributed towards the county revenue. Because each of the jobs has average earnings per job that is larger than Winneshiek County's average compensation per job of $40,599 in 2012,[26] we project a net gain to county revenue above the average demand for public services. This means that the county should have a budget surplus from the revenues generated by the workers for a mine or processing center. The total county revenue increase should be enough to pay for the services that new job holders consume, while also providing a minimal surplus to the county budget. For one mine, the revenue increase above-average demand is expected to be $549 for the low estimates and $1,520 for the high estimates. Net revenue gains from a single processing center are expected to range from $556 to $1,192.

24 The details of the exact source of each category of revenue are not available from the Department of Management.

25 U.S. Department of Commerce; Bureau of Economic Analysis

26 U.S. Department of Commerce; Bureau of Economic Analysis

Chapter 7 - Transportation Infrastructure Impacts

7.1 Introduction

Road deterioration, maintenance, and rehabilitation are ongoing concerns for communities large and small. Winneshiek County is responsible for the maintenance and construction of more than 1,058 roadway miles, consisting of a mixture of earth, granular, hard surface and paved roads.[1] County road expenditures consist of costs associated with operation, maintenance, extension, and total renewal of roadways.

Multiple factors affect roadway deterioration, necessitating continued roadway maintenance and improvement. These factors include environmental conditions, such as weather and temperature cycles; the original design and physical construction properties of the road; and time, or aging of the road. Overall sustained traffic loadings is the primary factor leading to roadway damage.[2] Heavy truck traffic is the biggest contributor to cumulative damage, while lightweight car traffic causes a much smaller impact.[3] As noted by the Wisconsin Transportation Information Center,

> *"Local officials have a responsibility to preserve [their] investments in roads by protecting them from excess damage caused by trucks carrying heavy loads....However, local officials must carefully balance the public good in protecting roads against the legitimate need for efficient transportation."*[4]

The hauling of sand from mines will require numerous trips by loaded and empty large-scale trucks. Therefore, it is imperative that the community understand the additional magnitude of deterioration that will be directly attributable to the frac-sand industry. This section begins by introducing a metric, the equivalent single axle load (ESAL), which is used to quantify road impacts throughout the chapter. Then, we discuss the derivation of truck traffic volumes from the mine scenarios presented in Chapter 5. Finally, we describe our method designed to estimate the loss of lifetime to Big Canoe Road[5] under one of our haul route scenarios, and discuss how this example may be of further use to Winneshiek County.

7.2 Equivalent Single Axle Load

To determine a magnitude of impact for additional mine traffic, we must first standardize traffic into a single measure of impact. The standardization is based on the notion that pavement fatigue, or damage, is directly related to the weight of a load and the frequency with which it is applied to the surface. We liken a road to a small piece of metal, such as a paper clip. If you bend the paper clip once, it will not break, but if you continue to straighten and bend the paper clip repeatedly, it eventually

1 Email from Steve Devries, Iowa County Engineers Association Service Bureau. February 23, 2015.

2 Oregon Department of Transportation, Policy Section "New Research on Pavement Damage Factors", June 2003. Available at: http://www.oregon.gov/ODOT/TD/EA/policy_notes/03_policy_notes/0603_new_resrch_on_pavement_damage.pdf

3 Congressional Budget Office, "Spending and Funding for Highways", *Economic and Budget Issue Brief*, January 2011. Available at: http://www.cbo.gov/sites/default/files/01-19-highwayspending_brief.pdf

4 Wisconsin Transportation Bulletin, "Using Weight Limits to Protect Local Roads". *Wisconsin Transportation Information Center*. Number 8, November 2003. Available at: http://wisctowns.com/uploads/ckfiles/files/WI%20Transportation%20Bulletin%20%238%20%20Weight.pdf

5 Because roads impacts are widely variable, the analysis performed to estimate road loss focuses on one stretch of road within Winneshiek County. Big Canoe road was chosen due to availability of road data, and its vicinity within an area that has been shown to have viable frac sand deposits. Other roads in the county may be subject to damage from truck traffic, and need to be considered by policy makers before mines are put into operation.

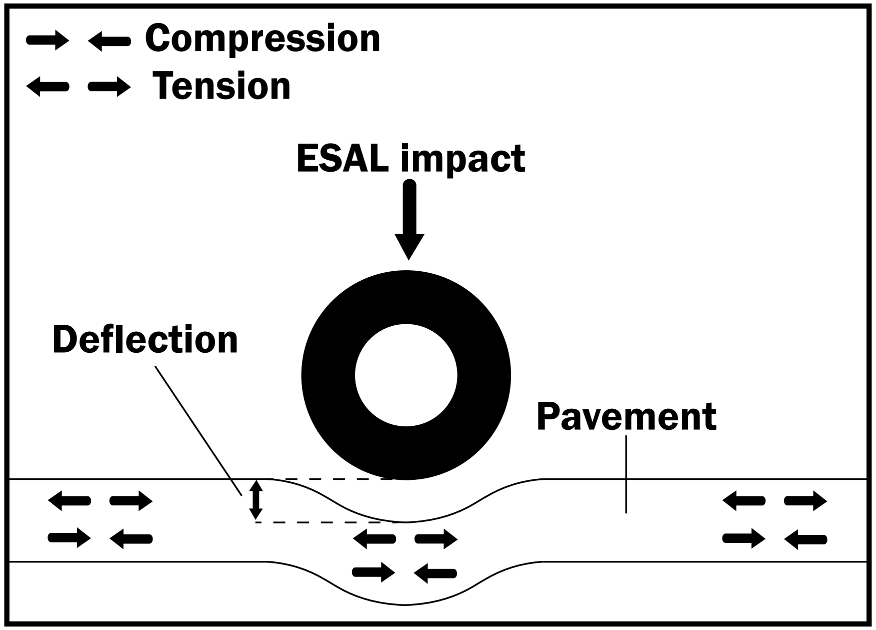

Figure 7.2.1 Deflection created by a vehicle moving over pavement

snaps. As vehicles and trucks repeatedly drive over a single point on a road, the weight distributed among the tires causes the pavement underneath to deflect. Over time, these deflections cause damage, such as cracking and rutting of the roadway

Other important attributes that determine the damage caused by a vehicle are its axle configuration and, subsequently, the weight distribution across each axle. The impact caused by a single vehicle is normalized for all cars and trucks using a measurement called Equivalent Single Axle Load. A "design ESAL is a cumulative traffic load summary statistic that represents a mixed stream of traffic of different axle loads and axle configurations predicted over the design or analysis period and then converted into an equivalent number of 18,000-lb. single axle loads summed over that period."[6]

6 Texas Department of Transportation, "Construction and Materials: What is an ESAL". 2005. Available at http://ftp.dot.state.tx.us/pub/txdot-info/cst/tips/flex_pave_des_faq.pdf

As total vehicle weights vary for specific truck types, differing wheel and axle configurations will alter the total impact caused by each truck. Because weight is distributed evenly across all axles, a vehicle with more axles carries less load per axel than the same vehicle with fewer axles. By standardizing every type of vehicle and axle configuration to an equivalent 18,000-pound single axle load, comparing the impact from all vehicle types and weights is possible. For example, a truck with five axles and weighing 80,000 pounds is equivalent to 2.4 ESALs, while the same truck with six axles is equivalent to 1.5 ESALs.[7] Again, the lower ESAL value causes less road surface impact. In contrast, a typical car weighing 4,000 pounds equates to 0.0004 ESALs. The relationship between ESALs, load configuration, truck axles, and pavement damage is beyond the scope of this report. But the assumptions and ESAL calculations explained in the next section are commonly used in the field of transportation engineering, and are useful in modeling the magnitude of the impact that mine-induced traffic could have on county roads originally designed for minimal truck use.

7.3 ESALs Attributable to Frac-Sand Transport

To determine the magnitude of impact that prospective mines might have on roads within Winneshiek County, ESALs were computed based on the varying mine output values presented in Chapter 5. We assume that firms seek to ship as much product as possible while utilizing the fewest number of trucks. By doing so, mine operations can maximize product delivery with the least possible expenditure. Large trucks with large payloads result in

7 Specific ESAL calculations for a particular road must also take into account the pavement types, functional class (i.e interstate versus arterial), and truck type. For this model a very basic calculation of ESALS was done assuming standard values for an asphalt road. It should be noted that these values can vary based on the aforementioned conditions, resulting in slightly higher or lower ESAL values when analyzed using specific road conditions

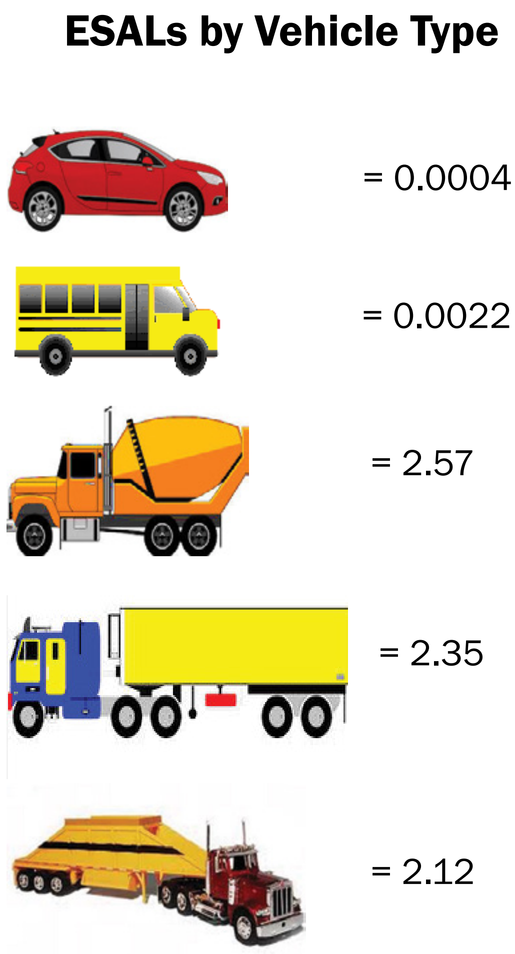

Figure 7.3.1 EASLs created by various vehicles

fewer trips overall, and are preferable to small trucks with small payloads.

With this in mind, we used a standard six-axle belly dump truck to model ESAL estimates from mining. These trucks were modeled with standard axle and weight configurations based on legally allowed limits for the State of Iowa. In Iowa, the maximum total vehicle weight is 80,000 pounds on any Interstate Highway System. On other roads in the network, trucks can operate above 80,000 pounds as long as they are on six or seven axles[8]. The scenario haul routes described in Chapter 5 do not include any interstate highways, and therefore trucks weighing more than 80,000 pounds are allowed. Thus, our model assumes a total weight of 90,000 pounds for a fully loaded truck, which is the highest weight allowed for six-axle vehicles, and 48,000 pounds for an empty truck on a return trip. These weights assume a 25-ton payload of sand in out-bound trucks. One belly dump loaded with 25 tons of material was calculated to have an ESAL value of 2.12, while the ESAL value for the empty truck is 0.281. Table 7.3.1 shows annual ESALs calculated from these parameters.

As with mine outputs, a range of annual ESALs were calculated from a small with low output to a large mine with a high output. On the low end of the spectrum, a small mine with a low output generates 2,693 annual trips by fully-loaded trucks, with same number of trips for returning empty trucks. This activity equates

ESALs Created By a Single Mine			
Mine Size	**Output Magnitude**	**Daily Round trips**	**Annual ESALs**
Small	Low	15	6,990
	Medium	30	13,990
	High	46	20,100
Average	Low	59	26,220
	Medium	121	53,310
	High	184	80,400
Large	Low	103	45,450
	Medium	213	93,510
	High	322	140,710

Table 7.3.1 ESALs created by a single mine of differing size and output magnitude

8 Iowa Department of Transportation, "Iowa Truck Information Guide", July 2014 to July 2-15 Edition. Available at: http://www.iowadot.gov/mvd/omve/truckguide.pdf

to 6,990 annual ESALs. For a medium-sized mine with medium material output, the annual ESALs increase to 53,310. A large mine with high output equates to 140,710 ESALs.

7.4 Estimation of Roadway Impact from Mine Traffic

Additional road traffic will be substantial if a mine locates in the county, regardless of its size. Because the most likely locations for mines are in rural areas, many of the roads are not suitable for this additional volume of heavy truck traffic. The impact to any one road from mining operations varies depending on the haul route, the quality of the road itself, the volume of sand, type of truck, seasonal variation, etc. Because of these variations, we developed a generalizable methodology to assess the impact one of a single mine. Calculations were performed under varying output scenarios for a single mine. As identified in Chapter 5, this most probable mine scenario is located on Big Canoe Road. To appraise the magnitude of road impacts, we estimated the cost of additional truck traffic to the 6-mile stretch of that road that falls on the likely haul route.

Current ESALS on Big Canoe Road

After deriving annual ESALs for a variety of scenarios, we determined the current ESALs along the identified haul route. To do so, average daily traffic (ADT) data for Big Canoe Road was obtained from the Iowa Department of Transportation.[9] This data includes a percentage breakdown of truck volume. Because traffic data on county roads is not as detailed as that recorded for state-operated roads, we made some assumptions regarding the breakdown of traffic by vehicle type based on national estimates from the U.S. Department of Transportation.[10] These figures were used to determine an approximate mixture of trucks by axle number and weight configuration for Big Canoe Road. Big Canoe road sees between 350 and 680 vehicles per day, with corresponding percentage of trucks ranging from 10 to 37 percent. This percentage was applied to the national distribution for axle number and weights to estimate total annual ESALS. Because ADT and percentage truck volumes vary, it was decided that our model should utilize median values for ADT and truck percentage. In this case, we assumed 350 total vehicles, 17.4 percent of which are trucks. Using these values, we estimate that Big Canoe Road currently handles 44,210 annual ESALs.

Road Impact Formula

We consider three elements for quantifying additional road impacts due to trucking of frac sand: the loss of roadway lifespan of the current road from the additional traffic, the additional maintenance costs that the county will incur, and the difference in the cost of construction for a new road based on the higher traffic volumes. Once each aspect is calculated individually their sum yields the total impact from the additional mine to the road in question.

$$\textit{Total Impact} = \begin{array}{c}\textit{Loss of Road}\\\textit{Lifespan}\end{array} + \begin{array}{c}\textit{Additional New}\\\textit{Road Cost}\end{array} + \begin{array}{c}\textit{Additional}\\\textit{Maintenance Cost}\end{array}$$

Estimating Loss of Road Lifespan

Loss of lifespan to the existing road is based on the design lifetime of the road, and how many lifetime ESALs a road was designed to handle. Here, we focus on a 6.06-mile stretch of Big Canoe Road, where the most likely mine site is located. We assess road impacts for a medium-sized mine with low, medium, and high levels of output.

9 Iowa Department of Transportation "Geospatial Technologies: Downloads, GIMS History 2013". Available at: http://www.iowadot.gov/gis/downloads/zipped_files/GIMS_History/2013/

10 US Department of Transportation, "1997 Federal Highway Cost Allocation Study", August 1997.

According to the Winneshiek County Engineer, Lee Bjerke, Big Canoe Road was built in 2008. It was designed to last 30 years with current traffic and handle 1,000,000 ESALs.[11] Because this lifetime figure and current traffic ESALs don't equate, we used three different models to determine the road's projected lifetime with current traffic volumes and with additional traffic. These models provide a range of impacts to help us address some of the uncertainty in our estimates. They are:

1. Assume 30-year lifetime at current traffic volumes, 44,150 annual ESALs and 1,324,500 lifetime ESALs
2. Assume 23-year lifetime at current traffic volumes with 1,000,000 lifetime ESALs
3. Assume 30-year lifetime and 1,000,000 lifetime ESALs, which is 33,333 annual ESALs

Using these three models, we first determined the portion of lifetime ESALs that have already been consumed. For models 1 and 2, 44,150 annual ESALs across seven years in operation equals 309,050 ESALs consumed to this point. Next, viable years remaining were calculated from the following formula:

$$\text{Viable Years Reamining} = \frac{(\text{Lifespan ESALs} - \text{Consumed ESALs})}{\text{Annual ESALs}}$$

In models 1 and 3, there are 23 viable years remaining on Big Canoe Road. Under our second method, there are 16 viable years remaining on the road. The next step is to estimate the viable years that would remain under additional truck traffic under the mining scenario, which requires summing the current ESAL value with that associated with trucking of frac sand. This summation gives a new annual ESAL estimate, which was used to recalculate viable years remaining. The difference between viable years remaining for non-mining and mining scenarios is the lifetime loss impact of the mine. For example, Big Canoe Road is projected to lose between 8.56 and 14.15 viable years if an average-sized, medium-output mine locates at our primary site. Table 7.4.1 gives calculations for models 1, 2, and 3.

Big Canoe Single Mine Road Impacts					
Mine Size-Magnitude	Road Lifetime Method	Viable Years remaining without mine	Viable Years remaining with mine	Viable Years Lost	% of Remaining Lifespan Consumed by Mine
Small-Medium Mine	One	23	17	6	18
	Two	16	12	4	17
	Three	23	16	7	30
Average-Medium Mine	One	23	10	13	42
	Two	16	7	9	38
	Three	23	9	14	62
Large-Medium Mine	One	23	7	16	52
	Two	16	5	11	47
	Three	23	6	17	74

Table 7.4.1 Big Canoe Road lifespan loss analysis results

Monetizing the Impact

With the loss of road lifespan established, we monetized cost to the County based on the original cost of building the road. This value was adjusted to 2015 terms using the Consumer Price Index from the Bureau of Labor Statistics, putting the cost of the road in terms of 2015 dollars. In our example, the cost of construction for Big Canoe Road was $182,200 per mile 2008, which equates to a total project cost of $1.104 million. Adjusting for inflation, this equates to $199,520 per mile and $1.209 million for the total project.

11 Lee Bjerke, Winneshiek County Engineer.

We assume that trucks travel nearly the entire stretch of road; thus we can use the entire project cost to determine what portion of the County's investment will be consumed by the truck traffic. If a smaller road segment is used by the trucks, project cost should be scaled by the fraction of road that is used. Multiplying the fraction of viable years lost by the total cost of the project gives the fraction of cost that is used the mine, and thus monetizing loss-of-life due to mining.

In our example, an average-sized, medium-output mine impacts Big Canoe Road within a range of $456,971 to $570,348 over the lifetime of the road.

Big Canoe Monotized Loss of Lifespan		
Mine Size-Magnitude	**Road Lifetime Method**	**Cost of Portion of Road Consumed by Mine**
Small-Medium Mine	One	222,824
	Two	506,736
	Three	629,401
Average-Medium Mine	One	200,695
	Two	456,412
	Three	566,896
Large-Medium Mine	One	274,037
	Two	570,348
	Three	683,371

Table 7.4.2 Big Canoe Road cost of road lifespan that would be consumed by mines of varying size and output magnitude

Per Trip Impact

To set up a road use fee, the impact per trip should be monetized and charged to the mine, so the impact of the additional traffic can be reimbursed to the county. We have developed methodology to determine a road use fee. Similar to our lifetime analysis, we will use Big Canoe Road as an example.

We must first determine the cost per ESAL per mile that the county invested in the roads along the haul route, by dividing construction cost by the design lifetime ESALs. Assuming 1 million lifetime ESALs, the county spent $0.20 per mile per EASL to construct Big Canoe Road. Once the investment cost is determined, we can multiply by the number of miles and the ESALs per trip to determine the cost that is created by each trip. Because each load of sand corresponds with two truck trips, on leaving the mine loaded, and one going back to the mine empty, we will calculate two different fees depending on the weight of the truck.

A loaded truck is projected to produce approximately 2.12 EASLs, while and empty truck is expected to create 0.30 ESALs per trip. Multiplying those by the construction cost per ESAL mile and miles on the road, we can determine a per trip cost for both loaded and unloaded truck trips. For Big Canoe Road, a single loaded truck will create an estimated $2.56 in impact while an unloaded truck will create an estimated $0.36 in impact. The rest of the haul route will create additional impact on the road system, and should be included in developing a use fee.

Cost Difference for a New Road

Eventually, the current road must be rebuilt and improved. When this occurs, a similar lifetime analysis should be completed to determine the portion of the road's lifespan that will be consumed by mine traffic. If a road must be rebuilt with the mine traffic taken into account, there will be additional cost due to the fact that design parameters will have to be adjusted. These design parameters include the increase cost associated with thicker road layers, which require more materials. The additional cost of this new road should be considered an impact of the mine.

Additional Maintenance Cost

In some cases, the County may prefer to complete additional maintenance to extend the lifetime of a road that receives mine traffic. In those cases, impact is reduced as road lifetime extends. Similar to building a new road, the cost from the extra maintenance should be considered as a cost of the mine to the road infrastructure.

7.5 Summary

If mining comes to Winneshiek County, the County must strike a balance between economic growth and the inevitable cost for infrastructure required to support mining activity. Depending on the intensity of this activity, the impact to the local road system will be substantial. As discussed, the majority of wear on road systems is imposed by heavy truck traffic. Many of county roads are not built to withstand the additional strain associated with a mining operation. An average mine will add between 13,990 and 93,510 ESALs annually to the roads on its haul routes. Total mine impact is equal to road lifetime loss plus the cost difference for a new road and the cost of maintenance. The majority of the impact comes in the form of loss to roadway lifetime. As our example shows, that impact can be substantial.

Chapter 8 - Property Values and Taxes

8.1 Introduction

Residential property values are important to property owners. For most Americans, home ownership is the largest source of wealth. As of 2010, primary residence accounted for 30 percent of all assets held by U.S. households.[1] Numerous studies have linked the value of one's home to higher-quality community amenities such as better performing school districts, safer neighborhoods, and a greater abundance of social and recreational opportunities.[2] Studies on mining effects have shown that a spatial relationship exists between the proximity of residences to mines and decreased market value.[3] Building off existing literature and analysis, we simulate the effects of similar conditions to Winneshiek County residences given a medium-sized, 200-acre mine at three potential locations. This chapter calculates the potential changes in property values and property taxes collected from County properties. It also estimates tax revenue streams from a medium-sized industrial frac-sand mine. Our analysis finds that potential future increases in tax revenue from the operation of a medium-sized, 200-acre frac-sand mine will likely be offset by losses in property values and in homeowners' equity.

8.2 Background Information

Changes that occur in one's property value not only affect individual property owners, but also the greater community. A change in the market value of one's residence can alter the market values and sales prices of adjacent residences. The local county assessor determines the fair market value of residential, commercial, and industrial property. Assessors typically use three approaches to determine property values, including a market approach, which uses a sales ratio of comparable properties in an area to determine a general assessment level.[4] [5] In the case of industrial frac-sand mining expansion in Winneshiek County, monitoring the assessed values of agricultural properties will be critical since mining will likely take place in the county's more rural zones.[6] In Winneshiek County, agricultural property is assessed at 100 percent productivity and net earning capacity.[7]

If residential market values decrease, so will the values at which properties are taxed (or assessed property values). In Winneshiek County, properties are assessed at 100 percent market value every two years. Property taxes are the leading source of governmental revenue for most local governments. Nationally, approximately 30 percent of county revenue and 75 percent of taxable revenue is derived from property taxes.[8] In Winneshiek County in 2013, property taxes accounted for 41 percent of the County revenues.[9] Generally, when assessed property values decrease for a large enough share of the tax base, property tax rates in that community will increase as local governments aim to provide a similar standard of services,

1 Neal, M. (2013). "Homeownership Remains a Key Component of Household Wealth". Retrieved from https://www.nahb.org/generic.aspx?genericContentID=215073&channelID=311.

2 Weiss, Jonathan D. (2004). "Public Schools and Economic Development". Retrieved from http://www.mea.org/tef/pdf/public_schools_development.pdf

3 Williams, Austin. (2011). "The Impact of Surface Coal Mining on Residential Property Values: A Hedonic Price Analysis". Retrieved fromhttp://trace.tennessee.edu/cgi/viewcontent.cgi?article=1096&context=pursuit.

4 Retrieved from http://www.winneshiekcounty.org/market-value.html.

5 The remaining two methods, The cost approach and income approach, are less applicable here, but are still noteworthy. In the cost approach, an estimate of the cost of labor and materials necessary to replace a current property is provided. The value of the land is then added to the cost of construction replacement. In the income approach, a property's ability to induce income is considered.

6 IBID.

7 IBID.

8 This figure includes industrial, commercial, and residential collections. The Tax Policy Center Briefing Book: "How taxes Work". Retrieved from http://www.taxpolicycenter.org/briefing-book/state-local/specific/property.cfm.

9 Retrieved from http://www.winneshiekcounty.org/uploads/PDF_File_83081444.pdf.

regardless of fluctuations in the local tax base.

The local levy rate is determined by the amount of revenue that is needed to provide public services each year.[10] This is the rate that a taxing entity calculates and then applies to all taxable property in a jurisdiction in order to match projected revenues with projected expenditures. When a high enough number of properties experience decreases in assessed value, this rate may increase.

8.3 Frac-sand Mining's Impact on Property Values

Methodology

Mining is an industry that, when unregulated, can exert social and environmental costs that are greater than the potential returns from the mining company. These social costs are manifested through external costs such as increased noise, light, and particulate pollution from both point sources and transportation systems.[11] Hedonic models provide an effective way to capitalize these costs. In this analysis, we utilize the widely-accepted methodology employed by Diane Hite that examines how proximity to a mine decreases the market value of properties.[12] These models isolate the contributions of specific factors on the prices and values of housing. We used this approach to estimate the proximity of a residence to a mine while controlling for other attributes that influence home values, such as number of bedrooms and bathrooms, square footage, property lot size, and age of housing structure.[13]

The hedonic model is based on a statistical regression analysis. In this analysis, distance from a mine is an independent variable of interest and sale price is the dependent variable. Hite's research examines the effect of distance from a gravel mine on the sale price of 2,552 residential properties in Delaware County, Ohio between 1996 and 1998.[14] Hite uses a mix of suburban and rural settings and housing densities.[15] Her research finds a large, statistically significant relationship between property values and distance from mine. The elasticity of home value with proximity to a mine is 0.097, which implies that a 10 percent increase in distance from a mine is associated with an almost 1percent increase in home values, holding other variables constant.[16] The same dynamic is true of the inverse relationship. Property values decrease with decreasing distance to the mine.

Hite's model estimates that properties located within a 0.5-mile radius of a mine experience a 20 percent reduction in value. Properties located between 0.5 and 1 mile of a mine are projected to experience a 14.9 percent reduction in value. Between 1 mile and 2 miles, property values are projected to decline by 8.9 percent. Lastly, properties between 2 and 3 miles from a mine are projected to decrease in value by 4.9 percent.[17]

Application to Winneshiek County

We utilized the three plausible mining scenarios that are outlined in Chapter 5.[18] Site 1is located in the northeast portion of Winneshiek County, along Big Canoe Road near the Allamakee

10 Retrieved from http://www.investopedia.com/terms/m/millagerate.asp.
11 Retrieved from http://economics.fundamentalfinance.com/negative-externality.php.
12 Erickcek, George. (2006). "An Assessment of the Economic Impact of the Proposed Stoneco Gravel Mine Operation on Richland Township". Upjohn Institute for Employment Research.
13 IBID.
14 IBID.
15 Hedonic coefficients may experience some variability to scenarios in Winneshiek County due to differences in housing density and overall population. However, numerous studies from Upjohn Institute economist George Erickcek have employed Hite's exact coefficients in an attempt to monetize property value losses impacted by environmental disamenities.
16 IBID.
17 IBID.
18 In an attempt to avoid ethical complications which might arise from locating mines on actively-owned parcels, the hypothetical mine centroids were placed in the middle of roads.

County border. Site 2 is more centrally located within the County, and is closer to the City of Decorah. Site 3 mining was placed in another high probability mining zone in the north-central portion of the county. For each of the three scenarios, concentric buffers from the mine were derived using similar distances as used by Hite. We selected only parcels which contain a residence, obtaining assessed values for homes within each buffer ring. [19]

Table 8.3.1 shows the results of Hite's hedonic model when applied to the first potential mining site. While the percent of property value loss is greater for residences within 1 mile of the mine, over half of the total lost property value for this scenario occurs between 1 and 3 miles from the mine, because in this scenario 51 out of this scenario's 61 impacted properties (84 percent) are located in this zone. However, as percent decrease in assessed value diminishes with distance, the average loss in property value for each home that is more than1 mile out is between $7,000 and $15,000, compared to an average property value loss of $38,809 for residences within 0.5 miles of the mine. The total estimated lost property value for this scenario is $841,356.

In the second scenario, which was designed to estimate impacts from a mine located nearer to Decorah, we project total property value losses at $1,429,955. As this location is closer to the county's population center, this second scenario would impact 96 properties. Similar to the first scenario, the majority (85percent) of impacted properties are located between 1 and 3 miles from the mine. Within these distances, total property value loss is more than $1,000,000, with average loss per home between $9,000 and $19,000. The highest average property value loss for this scenario takes place between 0.5 and 1 miles, where the average loss is estimated at $29,201.

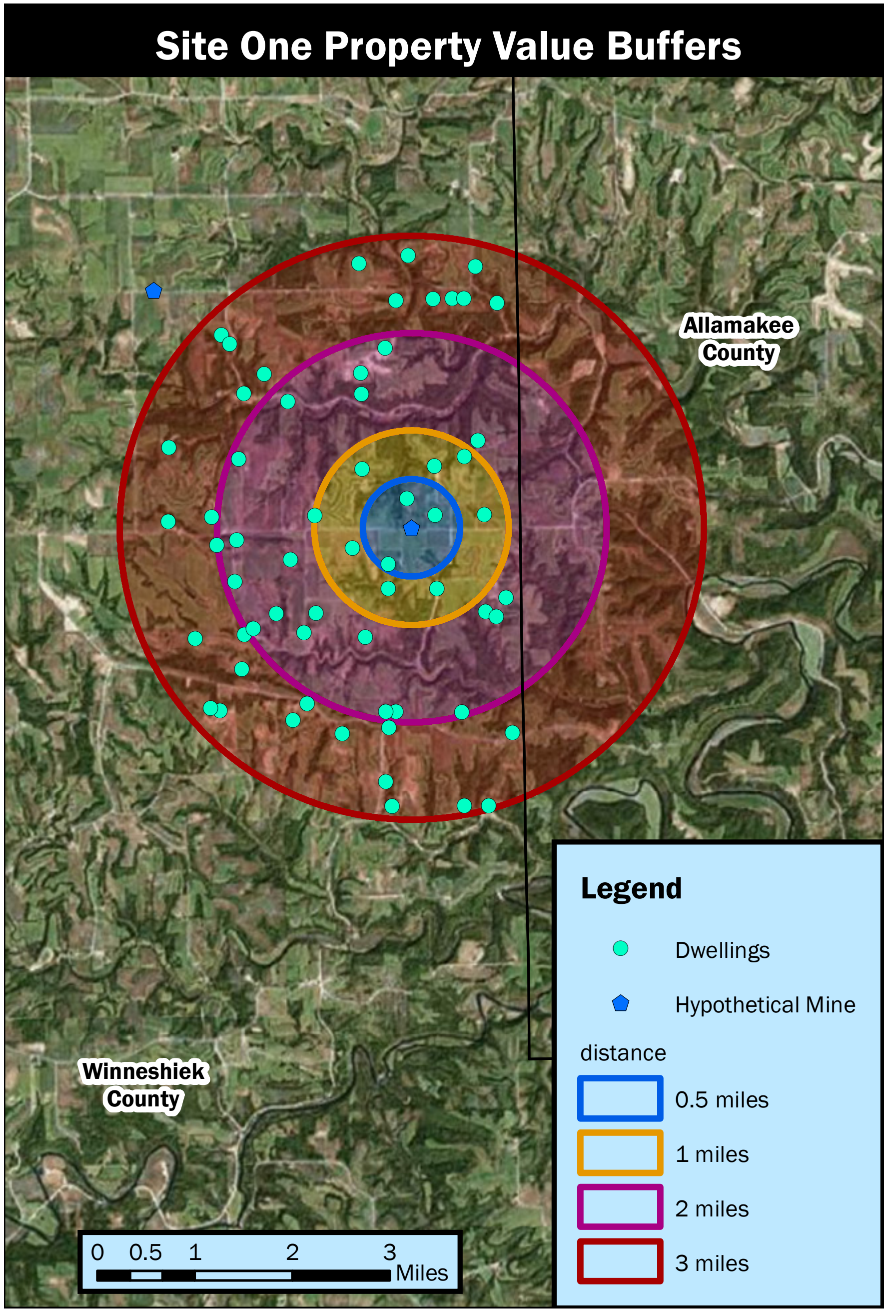

Figure 8.3.1 Site one property value decline buffers and dwellings

19 Properties in Allamakee County were not used in this analysis.

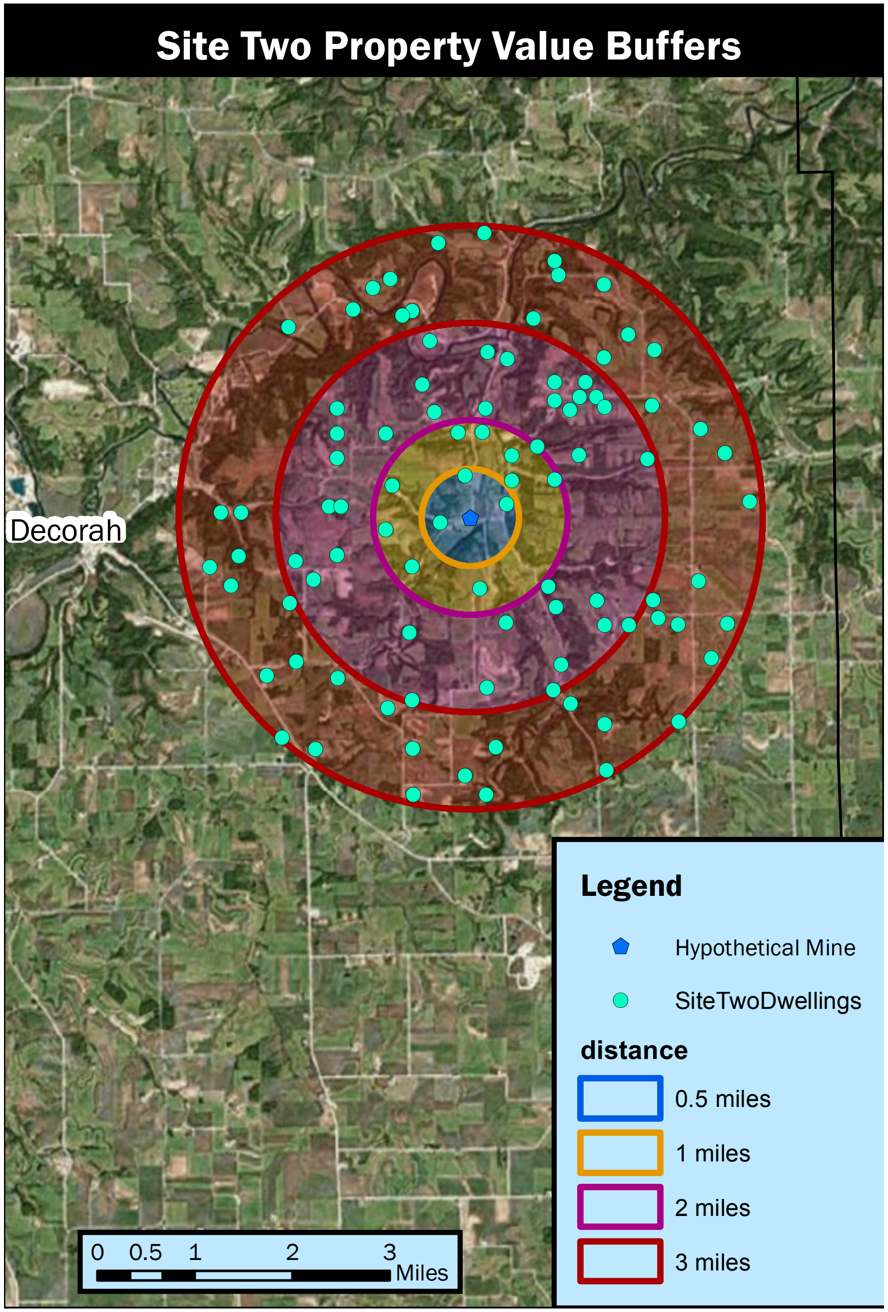

Figure 8.3.2 Site two property value decline buffers and dwellings

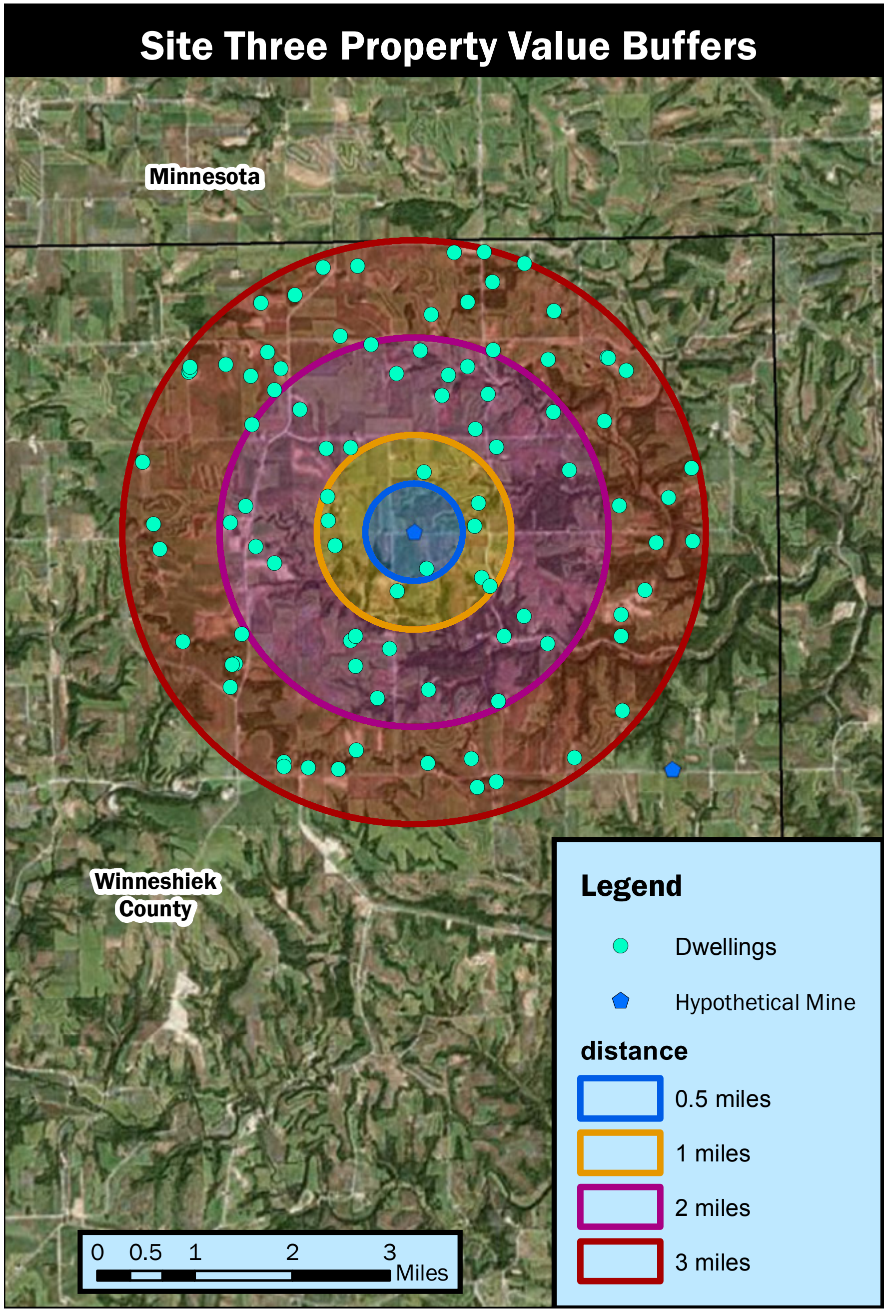

Figure 8.3.3 Site three property value decline buffers and dwellings

Scenario three shows similar total estimated property value losses to scenario two, with a total property value loss of $1,348,818. Despite its more rural location, this scenario would impact the most properties, with 114 properties located within 3 miles of the mine. Over 91percent of the properties impacted in this scenario are located between 1 and 3 miles from the mine. The resulting total property value loss incurred in these zones is estimated at over $1,100,000 with an average loss per home between $18,000 and $30,000. As in scenario two, the highest average property value loss occurs between 0.5 and 1 miles, with the average loss estimated at $35,781.[20]

Findings

Our estimates show that the total cost to properties within 3 miles of a 200-acre mine could range from $800,000 to $1,500,000, depending on mine location. Total property value losses will be greatest 1 to 3 miles away from mines, as more properties are located within buffers of increasing area. However, average loss in property value per household is greatest for homes within a 1-mile radius of the mine, with percent losses ranging between 14.9 percent and 20 percent. Mines located near suburban development will generate larger amounts of lost property value, as is the case in scenarios two and three, where the total amount of lost property value is estimated at $1.3 million and $1.4 million respectively. For a hypothetical scenario in which all three mines are built and distributed such that 3-mile buffers do not overlap, the total estimated property value loss is $3.6 million.

Site One Lost Property Value		
Distance to Mine	**Total Lost Assessed Value**	**Average Lost Assessed Value**
0 - 0.5 Mile	116,428	38,809
0.5 - 1 Mile	189,798	27,114
1 - 2 Mile	300,807	14,324
2 - 3 Mile	234,324	7,811
Total	841,385	

Table 8.3.1 Total lost property value at site one

Site Two Lost Property Value		
Distance to Mine	**Total Lost Assessed Value**	**Average Lost Assessed Value**
0 - 0.5 Mile	61,546	20,515
0.5 - 1 Mile	262,813	29,201
1 - 2 Mile	680,222	18,895
2 - 3 Mile	425,375	9,247
Total	1,429,955	

Table 8.3.2 Total lost property value at site two

Site Three Lost Property Value		
Distance to Mine	**Total Lost Assessed Value**	**Average Lost Assessed Value**
0 - 0.5 Mile	20,392	20,392
0.5 - 1 Mile	178,906	35,781
1 - 2 Mile	447,668	29,845
2 - 3 Mile	701,852	18,470
Total	1,348,818	

Table 8.3.3 Total lost property value at site three

20 In an attempt to simplify this analysis, we applied one coefficient for each buffer ring. It should be noted that properties that are closer to buffer ring boundaries will likely experience losses in value that are greater or less than the applied buffer average used in this analysis.

8.4 Frac-sand Mining's Impacts on Residential Property Taxes

Lost tax revenue on properties impacted by the mine was estimated to affect revenue shortcomings that might be imposed on the county should frac-sand mining locate in the county. We use county parcel data to obtain 2013 assessed values for properties within 3 miles of potential mine sites. We compare current assessed values and hedonic estimates of property value losses in each buffer. We applied the rollback taxable value that is applied to assessed values.[21,22] Agricultural properties are taxed at a rate of 44.7 percent, while residential properties are taxed at a rate of 55.74 percent.[23] After multiplying the taxable value rates by the starting assessed values, we obtain the taxable property values for both mining and non-mining scenarios.

We then applied the county's levy rate to the taxable property values. Using an average from the last three tax years (2011-2013), we apply a levy of 26.69195 to the taxable values. This leaves us with a gross amount of property taxes due for both mining and non-mining scenarios. Though each individual property can be eligible for a wide range of tax credits, for this analysis we only applied two tax credits to the gross amount of taxes due. A 2013 homestead credit of $125.97 was applied to all residential properties. In addition, properties classified as agricultural or agricultural residential received an Agricultural Land credit of $31.28. The resulting net amount of taxes due may be slightly lower given that more credits may to be applied to each separate household. After applying credits, we arrive at our final estimation of net taxes due in one year for properties within the hedonic model range given mining and non-mining scenarios.

$$\text{Net Taxable} = \text{Assessed Value} \times \text{Taxable Value}$$

$$\text{Gross Tax Due} = \frac{\text{Net Taxable}}{1{,}000} \times \text{Levy Rate}$$

$$\text{Net Tax Due} = \text{Gross Tax Due} \times \sum \text{Tax Credits}$$

Figure 8.4.1 Tax calculation formulas

21 The taxable value is derived from the Iowa Department of Management for the year 2013.

22 Data retrieved from http://www.dom.state.ia.us/local/valuations/.

23 IBID.

Application to Winneshiek County

By using the same geographical methodology we used in estimating property value losses, we apply the previously described methods to each residential and agricultural property impacted by the hedonic model. For the first simulated mining location, the total amount of one-year lost property taxes lost is $10,038. An estimated $6,385 or 64 percent of this potential lost revenue would come from properties located between 1 and 3 miles from the mine. An estimated $2,265 or 23 percent of potential revenue would be lost from properties located between 0.5 and 1 mile from the mine.

With the second simulated mining location, the total amount of one-year property taxes lost is $17,061. An estimated $13,131 or 77 percent of this lost potential revenue would come from properties located between 1 and 3 miles from the mine. An estimated $3,136 or 18 percent of potential revenue would be lost from properties located between 0.5 and 1 mile from the mine. As was the case when examining the impacts of lost property value, the lost amount of property taxes from this second simulated mining location figures to be higher due to its proximity to the county's population center of Decorah.

In the third simulated mining location, the total amount of one year property taxes lost is $16,114. An estimated $13,737 or 85 percent of this potential lost revenue would come from properties located between 1 and 3 miles from the mine. An estimated $2,135 or 13 percent of potential revenue would be lost from properties located between 0.5 and 1 mile from the mine. These losses are similar in proportion to those incurred from direct loss of property value.

Findings

As was the case when estimating total property value losses, the greatest losses (77-85 percent) in potential tax revenue for all three simulated mine locations would occur at a distance between 1 and 3 miles from the mine. Mines that would locate near the second and third simulated locations would contribute to a loss of about $17,000 and $16,000 in annual property tax revenue respectively. Should three similarly situated mines develop across the county, the total lost tax revenue for the county is estimated at approximately $43,213 for one tax year.[24] For 2013, this loss would amount to 0.57 percent of Winneshiek County's total property tax revenue.

8.5 Property Tax Revenues from Frac-sand Mines

Proponents of frac-sand mining highlight the returns that can be achieved from property taxes garnered from mining sites.[25] Applying market values that mining companies in Wisconsin have

Figure 8.4.1 Projected property tax loss

used to acquire land, we set a high, medium, and low average for mining land market value per acre at $15,000, $10,000, and $5,000 per acre respectively.[26] Using these per-acre values, we project the total value of land for small (50 acres), medium (200 acres), and large (350 acres) mines. The process for projecting property taxes due from the mine is similar to the methodology used to project property taxes from residences and agriculture, with a few exceptions.

For each starting per-acre value and for each mine size, an industrial and agricultural rollback or taxable value is applied to the starting total value of the land. The industrial land in the state of Iowa is taxed at a rate of 90 percent, whereas agricultural land is taxed at 44.7 percent. Incorporating two different taxable values accounts for a precedent within the state of Iowa that allows mines to be classified as agricultural land for property tax purposes. Naturally, if frac-sand mines in Winneshiek County are granted this advantage, the taxable

24 This estimate does not factor in additional tax credits that might also lower the net amount of taxes due.

25 "Communities at Risk: Frac-sand Mining in the Upper Midwest". (2010). Retrieved from http://www.civilsocietyinstitute.org/media/pdfs/092514%20csi%20bar%20frac%20sand%20mining%20report%20final2%20-%20embargoed.pdf.

26 Retrieved from http://wisconsinwatch.org/series/frac-sand/.

return for the county will be significantly lower than when they are taxed as industrial lands.

The same levy rate of 26.69195 that was applied to residential and agricultural property taxes in the previous section is applied to both mines classified under industrial and agricultural properties in this analysis to calculate the gross amount of taxes due. Again, an array of credits can be applied to this gross total to lower the net amount of taxes due. Using a 2013 figure, a business property tax credit of $523 was applied to estimates in this simulation.[27] We arrive at the estimated amount of net taxes due after this credit is applied to all of the value ranges in this simulation.

Net Taxes Due Based on Property Use and Size			
Taxable Value per Acre ($)	Parcel Acres	Property Type	Net Taxes Due ($)
5,000	50	Industrial	5,483
	200	Industrial	23,500
	350	Industrial	41,517
	50	Agricultural	2,460
	200	Agricultural	11,408
	350	Agricultural	20,357
10,000	50	Industrial	11,488
	200	Industrial	47,523
	350	Industrial	83,557
	50	Agricultural	5,443
	200	Agricultural	23,340
	350	Agricultural	41,237
15,000	50	Industrial	17,494
	200	Industrial	71,545
	350	Industrial	125,596
	50	Agricultural	8,425
	200	Agricultural	35,271
	350	Agricultural	62,116

Table 8.5.1 Net property taxes due from mine sites of varying valuations, Property type, and size

27 IBID[17].

Application to Winneshiek County

Given a value of $5,000 per parcel-acre, mines would produce an estimated annual yield between $5,483 and $41,517 when taxed as an industrial classification. When taxed as an agricultural classification, these mines would yield between $2,460 and $20,357 annually.

At a medium value of $10,000 per parcel-acre, mines would produce an estimated annual yield between $11,448 and $83,557 when taxed as an industrial classification. When taxed as an agricultural classification, these mines would yield between $5,443 and $41,237 annually.

At a high value of $15,000 per parcel-acre, mines would produce an estimated annual yield between $17,494 and $125,596 when taxed as an industrial classification. When taxed as an agricultural classification, these mines would yield between $8,425 and $62,116 annually.

Findings

These estimates account for a wide range of sizes of mining. On the high end, a 350-acre mine that carries an average per-parcel value of $15,000 and is taxed at an industrial rate will produce an estimated annual property tax contribution of $125,596. This mine alone would increase current County property tax revenue by 1.7 percent. Conversely, a 50-acre mine taxed at an agricultural rate would produce an estimated annual property tax contribution of just $2,460 and would increase property tax revenue by just 0.03 percent. If three medium-intensity mines were built, the estimated tax yield for the County would range between $70,499 (for parcels with a $5,000 average valuation) and $214,636 (for parcels with a $15,000 average valuation). On the high end, a yield of $214,636 would increase property tax revenue by about 2.8 percent.

8.6 Summary

Total property value loss is greatest if frac-sand mines develop sporadically throughout the county. This type of development will substantially lower the equity that many homeowners have worked generations to accumulate. Impacts from concentrated mining development would be less widespread, but could have more magnified losses in property value if hedonic property loss values increase with more intensive mining. Studies on this relationship have not yet been performed. Given current property market values, gains and losses from projected property taxes are estimated to be minimal in impact, with property losses for the three simulated mines depriving the county of 0.57 percent of its current tax revenue from property taxes, and property gains from three similarly sized mines projected to increase total property tax revenue by a maximum of 2.8 percent. The lost projected revenue figure of 0.57 percent could potentially be large enough to impact future property tax millage rates.

Regulation to lessen the burden felt by property owners adjacent to prospective mine sites should be considered. Chippewa and Howard counties in Wisconsin have adopted property-value agreements with mining companies in their counties. Under such an agreement, a property's market value is frozen at the most recent pre-mining evaluation rate. If property owners wishing to sell cannot do so at previous market value, mines must make up the difference in price. After six months, mines have the option to purchase the properties from the homeowners at the previously determined market value.[28] While this solution does not rectify all of the negative quality-of-life issues that might be capitalized, it does provide homeowners the opportunity to recuperate any lost property equity.

28 Retrieved from http://wisconsinwatch.org/2014/03/frac-sand-mines-credited-for-rising-dropping-property-values/.

Chapter 9 – Impacts on Water Quality and Tourism

9.1 Introduction

The Winneshiek County Board of Supervisors expressed concern about the potential for mining to negatively impact tourism, which is comprised largely of in-state visitors who come to experience the region's scenic bluffs and winding waterways. Locals take particular pride in the area's trout streams, which have been the focus of recent restoration efforts and are now among the most popular angling destinations in the state. As a result of these efforts, Winneshiek County now boasts seven streams that support naturally reproducing brook or brown trout.[1]

Environmental stewardship has paid dividends. The 2011 Trout Angler Survey estimates that North Bear Creek attracted 29,931 angler trips that year, while South Bear Creek attracted 21,877 visits. Intensive mining may reduce tourists' desire to visit by disrupting recreational ambiance and/or by impacting surface water quality to the point that actual fish populations decline. Demand for trout fishing is a function of biomass: as population declines and the probability of hooking a fish drops, willingness to fish declines and fewer anglers visit the stream.[2] If intensive frac-sand mining comes to Winneshiek County, there is a risk that chemical pollution resulting from the use of flocculants and/or sediment discharge could impair trout habitat and revert the successes of recent restoration efforts.

To mitigate surface and ground water impacts of mining, the County may adopt a regulatory framework that includes requirements for a minimum setback from all or some streams, karst geology, and other features. However, quantifying the risk and magnitude of environmental impacts is stymied by uncertainty. We can get some sense of environmental risk by examining the prevalence of storm water violations in the state of Wisconsin, because many mining facilities are repeatedly cited for sediment pollution of surface water. However, these citations do not describe the severity of discharge, but only indicate that the conditional terms of the permit were broken. They do not quantify the extent to which natural habitat was affected, nor do they offer any insight into the magnitude of impact, if any, to fish populations and the fishing economy. Likewise, attempting to valuate Winneshiek County Trout streams is a thorny proposition. Even if we could identify the exact number for direct visitor spending associated with these recreational waters, we would still fail to account for the intrinsic value of wild trout habitat or the investments of time and money to restore the habitat. Ultimately, the County must weigh these matters qualitatively when considering policy development.

Notwithstanding these caveats, we conducted three analyses to quantify potential costs to the environment and the local tourism economy. First, we examine mine violations in the state of Wisconsin to gauge the likelihood of noncompliance with regulatory agreements. Second, we conduct a comparative analysis of tourism trends in mining and non-mining counties in Wisconsin. By comparing trends in direct visitor spending across a period that captures pre-mining activity, we get some sense of the association – and potential tradeoffs – between the industrial mining and tourism economies. Third, we perform a sight-line analysis for two of the three mining scenarios outlined in Chapter 5 to determine whether a mine would be visible to observers at Winneshiek County's most popular recreation sites.

1 Classification of Trout Natural Reproduction. Inventory obtained via email with Theresa Shay, Iowa Department of Natural Resources.

2 Melstrom, R. T. et al. Valuing recreational fishing quality at rivers and streams. (2015) Water Resources Research, 51, 140-150.

9.2 Winneshiek County Tourism Economy

Tourism has been an important component of Winneshiek County's economy for several generations. The scenic geology of Winneshiek County and neighboring Allamakee County is unique to Iowa's predominantly agricultural landscape, bearing more resemblance to the natural landscapes of southern Minnesota and southwest Wisconsin.[3] Its natural landscape makes Winneshiek County a popular destination for travelers seeking a variety of outdoor recreational opportunities. Recent estimates show that Winneshiek County averages more than 37,000 visitors annually.[4] Direct expenditures from these visitors total more than $29 million per year.[5] The U.S. Travel Association estimates that these expenditures generate more than $280,000 in local tax receipts, and support 330 jobs in the local economy – more than we have projected for any mining scenarios.[6]

Winneshiek County's tourism economy is bolstered by several significant cultural attractions, such as Nordic Fest and events hosted by Luther College, but most out-of-county visitors are drawn to the area's outdoor recreational offerings. Because Winneshiek County's physical landscape is an integral force in its tourism economy, local residents and County officials have expressed concern regarding the placement and intensity of frac-sand mining in the county. Chief among these concerns is how an expansion of the frac-sand mining industry might alter the bluffs in the county's northern region.

Another major concern revolves around the potential for pollution and runoff from the mine to damage ground and surface water resources. This concern is directly tied to the local fishing industry, as many of Winneshiek County's cold-water streams are among the most popular in the state. The 2011 Trout Angler survey canvassed 3,980 fishers who purchased permits in Iowa. Respondents ranked North Bear Creek first in terms of total angler trips, and South Bear Creek third. In 2011, 20 percent of all individuals who purchased an Iowa license fished North Bear Creek at least once, and 17 percent fished South Bear Creek. On average, each of these individuals made approximately four visits to those sites. Mining poses negative externalities that are assumed to diminish the experience of visitors and locals alike, and could have significant economic consequences if mining, processing, or trucking occurs near popular recreation destinations.

9.3 Winneshiek County Fisheries

Iowa's agricultural practices have negative impacts on natural trout habitat. When poor farm management practices cause excess sediment, nutrients, and bacteria to wash into trout streams, trout habitat is degraded. Excessive siltation, in particular, is considered the most important factor that limits usable trout habitat.[7] Brook and Brown Trout spawn in November and hatch in March. If excess sediment washes into streams during that period, it can reduce oxygen supply and kill fish eggs.[8] From a biological perspective, it is important to maintain self-sustaining trout populations. In addition to their intrinsic value and value for biodiversity, wild streams are an added draw anglers.

Active watershed management is critical to limiting stream

3 Driftless Area Initiative. Retrieved from wwww.driftlessareainitiative.org/aboutus/defining_driftless.cfm

4 Interview with Winneshiek County Visitors and Convention Bureau

5 U.S. Travel Association. The Economic Impact of Travel on Iowa Counties. 2013

6 Ibid.

7 Berkman, H.E. and Rabeni, C.F. Effect of Siltation on Stream Fish Communities. Environmental Biology of Fishes, 18 No. 4, 285-294. 1987

8 Iowa Department of Natural Resources. The Rebirth of Iowa Trout Streams. 2006.

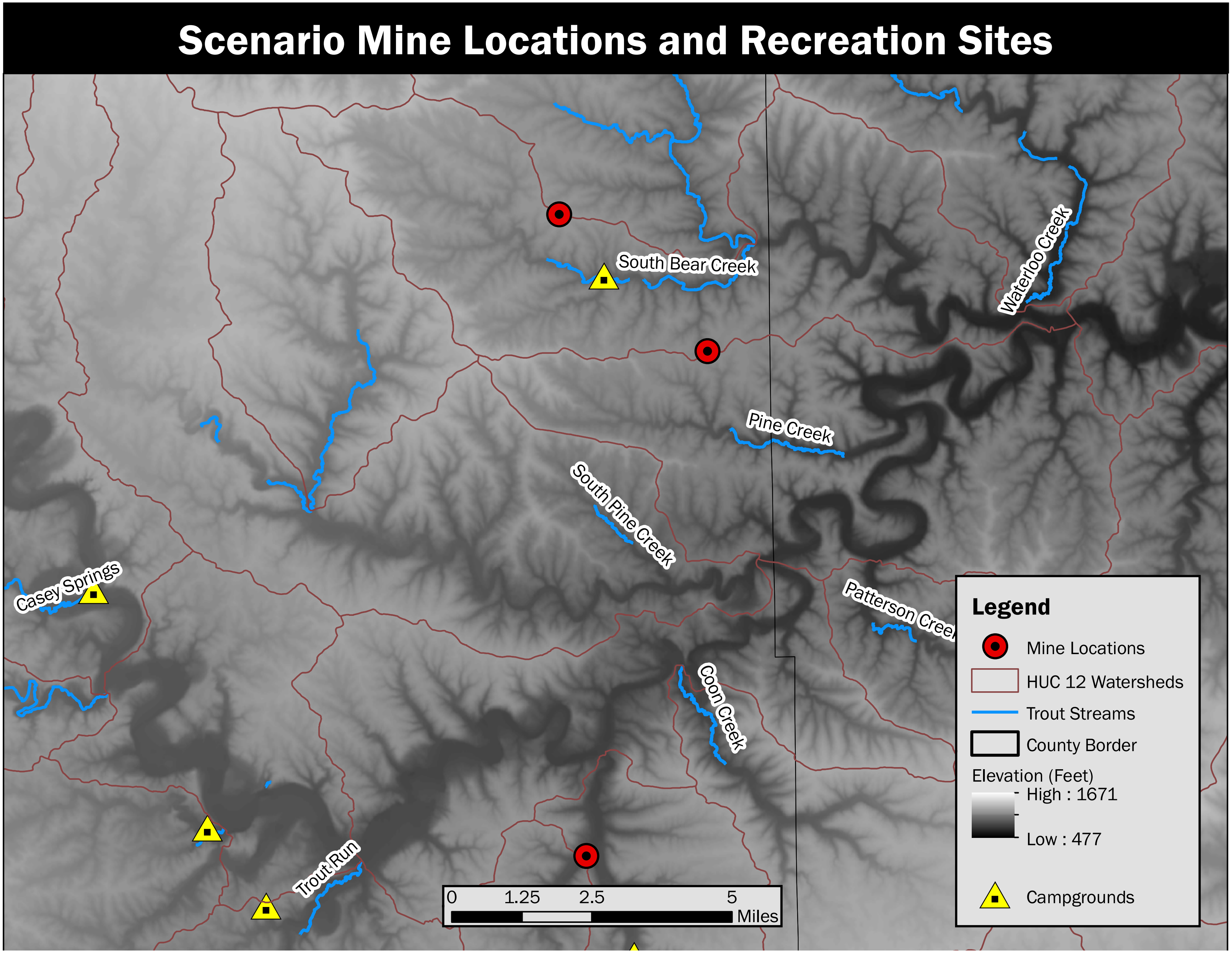

Figure 9.3.1 Mine locations and trout strams in Winneshiek County

siltation. In 1980, only six Iowa trout streams supported naturally reproducing trout populations.[9] By 2006, watershed-wide restoration projects were under way to restore the North, South, and Middle Bear fisheries in Winneshiek County, as well as the fisheries at South Pine Creek and Coon Creek. Today, there are seven streams in Winneshiek County alone that support wild Brook and Brown trout.[10]

In addition to sedimentation, reduced groundwater volumes could also have deleterious effects on trout populations in Winneshiek County. Large volumes of water are required for the sand washing process. Over-withdrawals from the groundwater supply may cause a cone of depression to form, and ultimately lead to stream fragmentation and reduced trout habitat if the surface-groundwater connection is severed.[11]

9.4 Analysis 1 – Wisconsin mine violations

A November 2014 study by the Land Stewardship Project documents environmental violations by Wisconsin frac-sand mine facilities.[12] In late 2014, 24 of 47 operating facilities had violated the conditions of a state environmental permit. The report names 20 facilities that are at Stage 2 or Stage 3 in the regulatory process, indicating that they continued to violate the terms of their state permit after they were notified of the violation (Stage 2) or after an Enforcement Conference with Wisconsin Department of Natural Resources (Stage 3). Of the 20 facilities identified, 17 committed a violation of their storm water permit. The majority of these citations were for repeated discharge of excess sediment, which led to excessively turbid surface waters.

Wisconsin Mine Stage 2 and 3 Violations

County	Facility Type	Company Name	Distance to Surface Water (ft)	Violation
Trempealeau	Mine/ Processing	Alpine Materials Corp.	626	Stormwater
Trempealeau	Mine/ Processing	Brannt Valley Excavating	493	Stormwater
Barron	Mine	Chieftain Sand	85	Stormwater
Chippewa	Mine/ Processing	Chippewa Sand Co	968	Stormwater
Barron	Mine	Great Northern Sand	1,110	Stormwater
Clark	Mine	Panther Creek Sand	329	Stormwater
Crawford	Ship Out	Pattison Sand Co	1,047	Stormwater
Trempealeau	Mine/ Processing/ Ship Out	Preferred Sand	84	Stormwater and air pollution permit
Trempealeau	Mine	Sierra Frac Sand	466	Stormwater
Monroe	Mine/ Processing/ Ship out	Smart Sands, Inc	70	Stormwater
Barron	Processing/ Ship out	Superior Silica Sands	1,249	Stormwater
Burnett	Mine	Tiller Corporation	273	Stormwater

Table 9.4.1 Wisconsin frac sand facility Stage 1 and 2 environmental violations and their distance to surface water in feet.

9 Iowa Department of Natural Resources. The Rebirth of Iowa Trout Streams. 2006.
10 Classification of Trout Natural Reproduction. Inventory obtained via email with Theresa Shay, Iowa Department of Natural Resources.
11 Kline and Osterberg
12 Cite Land Stewardship Project study here

The prevalence of environmental infractions in Wisconsin informs about potential environmental risk associated with the frac-sand mining industry. For these noncompliant facilities, shortest distance to primary and intermittent streams was computed. As Table 9.4.1 indicates, the list includes three facilities with stream setbacks greater than 1,000 feet. Actual setbacks could be somewhat shorter than those given here, assuming the point data was derived or digitized from facility center-points. Nevertheless, our analysis suggests that a setback of 1,000 feet is not sufficient to mitigate threats to surface water quality. Furthermore, the large representation of companies at violation Stage 2 or 3 demonstrates that state regulatory enforcement measures are not stringent enough to prevent repeat offenses. In Winneshiek County's bluffs region, steep slopes accelerate the travel of pollutants across the watershed, which ultimately magnifies the volume of pollutants that concentrate in streams. Therefore, pre-empting surface water quality risks through a strict setback policy is desirable.

9.5 Analysis 2 – Wisconsin Tourism Impacts

With Wisconsin experiencing an early, aggressive development the frac-sand mining industry, this analysis compares tourism trends from a sample of mining and non-mining counties in that state. More than 125 mines and processing facilities are either in operation or are planned for operation in Wisconsin. Many of these mines began operating since 2011.[13] To investigate whether intensified mining has had a tangible impact on the tourism economies of Wisconsin's more heavily mined counties, annualized direct visitor spending data was procured from the State of Wisconsin Department of Tourism.[14] Total direct visitor spending in 10 heavily mined counties was examined and compared with total direct visitor spending in 10 non-mining counties for the years 2003-2013. The percent change in direct visitor spending was recorded for these counties. We sought to use contiguous counties for both mining and non-mining sample groups.

As is evident in Figure 9.5.2, in the sample of mining counties, a slight decrease in the mean year-over-year percent change is detected. The linear average percent change between 2003 and 2013 decreases from 2.4 percent to 1.0 percent. However, the average change in direct visitor spending year-over-year increased in mining counties in 2011-12 and 2012-13 by 3.7 percent and 3.1 percent, respectively. These increases happened

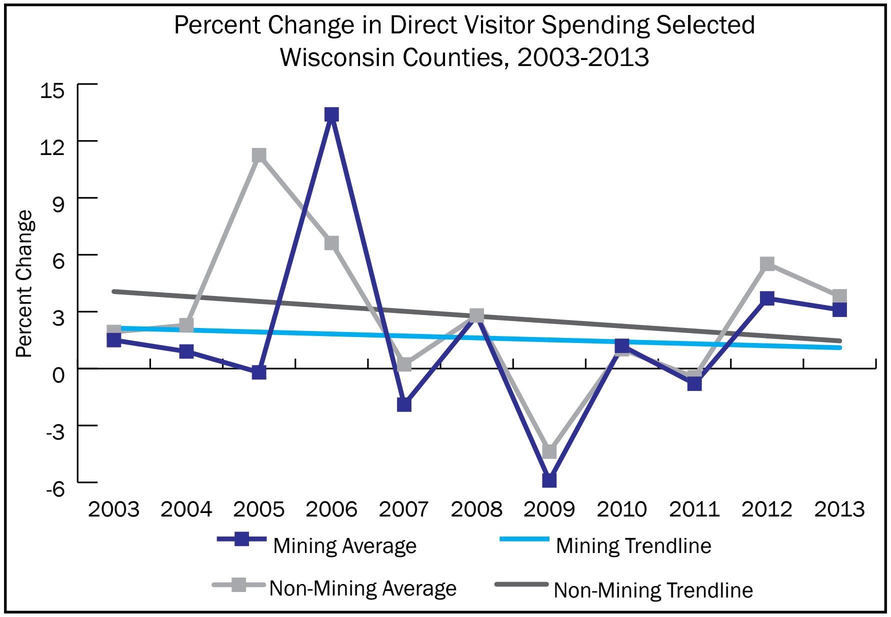

Figure 9.5.2 Average percentage change in annual visitor spending in selected non-mining Wisconsin counties

13 12 Sandy GIF's: An Animated Guide to Wisconsin's Frac-Sand Rush. Retrieved from http://wisconsinwatch.org/2015/04/12-sandy-gifs-an-animated-guide-to-wisconsins-frac-sand-rush/.

14 http://industry.travelwisconsin.com/research/economicimpact

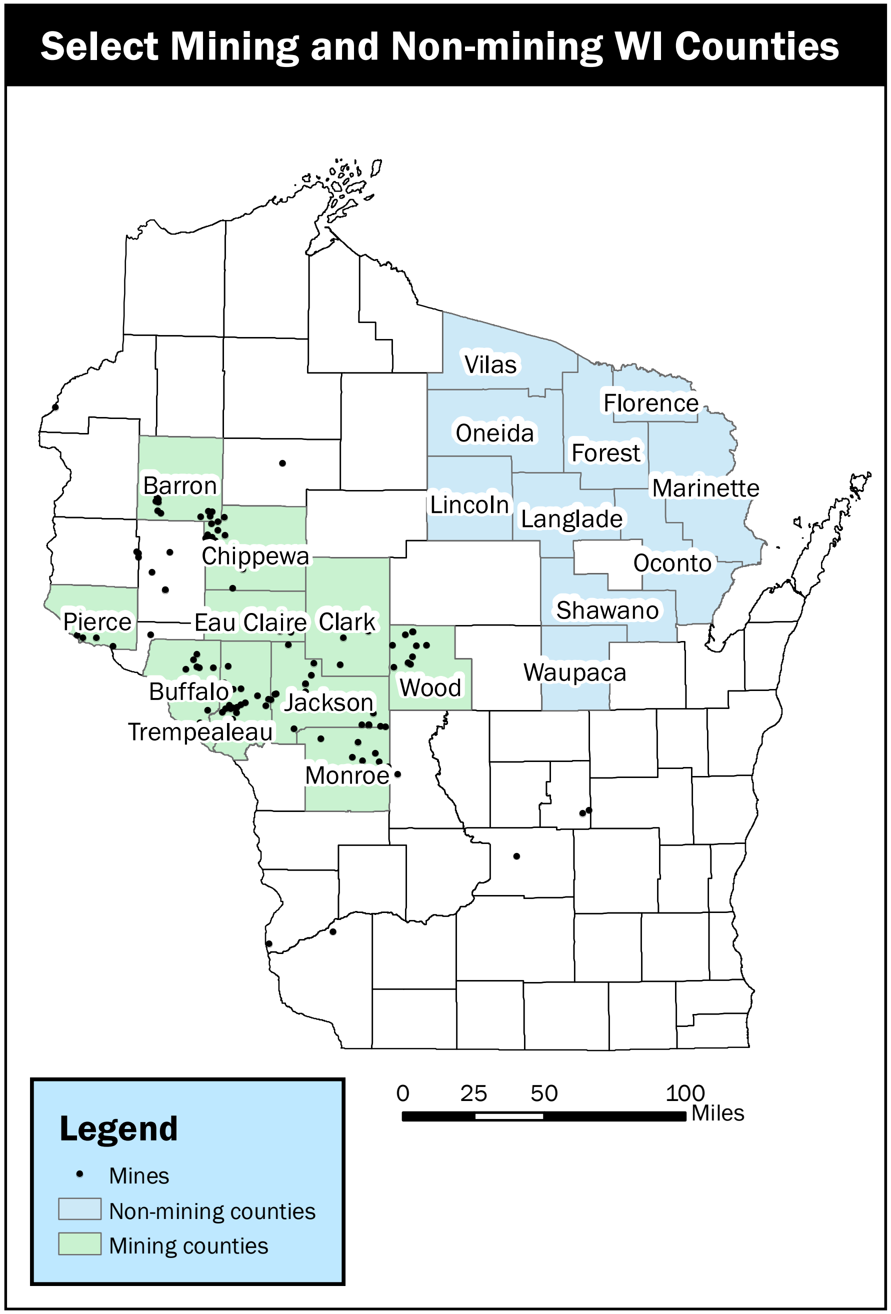

Figure 9.5.1 Map of selected Wisconsin Counties for exploring tourism impacts

during a time of rapid industrial expansion of frac-sand mining in this region.

In non-mining counties, the year-over-year linear average of percent change in direct visitor spending decrease from 4 percent in 2003 to 2 percent in 2013. Both samples exhibit decreases in direct visitor spending during years impacted by the national recession, but have since seen rises in direct visitor spending. However, this analysis is based on limited Wisconsin data and correlation between mining activity and a decline in direct visitor spending cannot be established without more rigorous study.

9.6 Analysis 3 – Sight lines

We assume that a visual or audible connection between mines and recreational areas would diminish tourists' experience. Indeed, both Winneshiek County residents and officials have reiterated their concerns that mining could mar the region's signature hilltops. Without performing a full-scale viewshed analysis, an abbreviated sight-line analysis provides a simple way to scope this issue.

To perform the site-line analysis, a national digital elevation model (DEM) at 30-meter resolution was obtained from Iowa's Natural Resources Geographic Information Systems Library. To make three-dimensional analysis possible, the raster was converted to a triangular integrated network (TIN) using the Raster to TIN tool in ArcGIS. The z-tolerance, which specifies the maximum allowable error between elevations in the input raster and elevations in the output TIN, was set to 5 feet. Because the original DEM did not account for vegetation, the associated TIN models an appropriate scenario in which only the least obstructed views are possible.

Polygons were digitized for two mine scenarios located in the HUC-12 watersheds containing North and South Bear Creeks. They were extruded 20 vertical feet from the surface of the TIN to account for activity that may be visible above the open pit of the mine. Observation points were sampled with intent to get full-stream coverage, and to create sightlines across lower elevations when possible, with the intention of demonstrating unobstructed views to the mine. Ten sight lines were constructed from the perspective of a 6-foot observer, with five connecting observers to the primary scenario south of South Bear Creek, and five connecting observers to an alternative location north of the stream.

Figure 9.6.1 shows that mines situated at our predicted locations would not be visible to recreationalists in the river valley. It is also noteworthy that the two scenarios modeled in this analysis are both located on a watershed boundary. Although these specific sites were selected primarily for purposes of maintaining landowner anonymity, the predictive geological layers do generally favor locations at higher elevations. This is not insignificant, as points located on a watershed boundary are located farthest from the stream, allowing discharges to filter across the greatest distances possible.

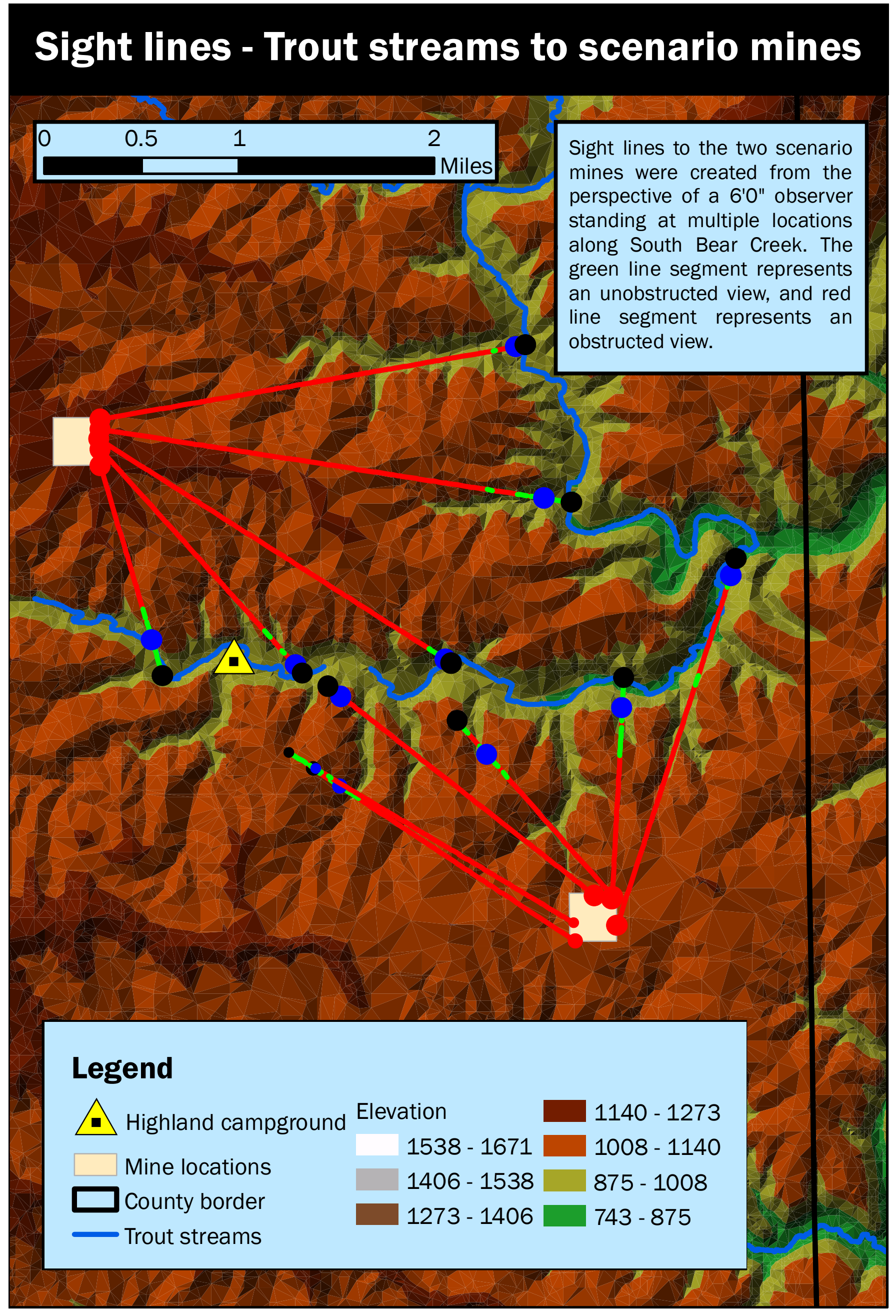

Figure 9.6.1 Sight lines from South Bear Creek two hypothetical mine sites

9.7 Summary

Our first analysis demonstrates that 1,000-foot setbacks are not sufficient to mitigate pollution of surface water by sediment runoff from the mine. Although noncompliance with environmental regulations is common across many industries, a survey of Wisconsin facilities shows that the rate of noncompliance is higher for industrial frac-sand mining than other regulated industries, and may be as high as 80 percent.[15]

15 Land Stewardship Project

Seventeen of 20 facilities cited for Stage 2 and Stage 3 violations committed storm water violations. While we have not attempted to quantify the impacts of over-sedimentation on trout habitat, we do know that punitive action is inconsequential, and that lax enforcement encourages continual noncompliance. However, it appears that, overall, the tourism economy has not suffered in Wisconsin's mining counties. Our sight-line analysis shows that, for the scenarios in which mines are located proximal to the most popular trout streams in the County, they will not visible to most outdoor recreationalists. The chances of seeing or hearing direct mining activity are slim.

Chapter 10 – Public Health Impacts

10.1 Introduction

The proliferation of mining across the Driftless Region has led to growing concern that increased emissions of particulate matter, including silica dust, may pose a threat to public health. The small size, round shape, and crystalline composition that distinguish frac-sand as an exceptional proppant are also enable silica particles to become lodged deep in the lungs. While research links silica inhalation to increased risk of silicosis, lung cancer, autoimmune disorders, and other diseases, less is known about the magnitude of emissions generated by mining point and mobile sources and level of public health risk that is associated with this impacts.[1] Likewise, a safe exposure threshold has not been established.

The Environmental Protection Agency does not regulate silica emissions through the National Ambient Air Quality Standards (NAAQS). Without regulation, there has been limited effort to monitor silica emissions from frac-sand mines. To fill in these gaps, researchers from the University of Iowa College of Public Health are studying emission rates of silica from frac-sand mine and processing centers, along with investigating the toxicological effects of dust inhalation.

In the meantime, because NAAQS do not regulate silica for pubic health, our analysis focuses on the amount of emissions of other pollutants that may enter the atmosphere as a result of frac-sand mining. The emission of other pollutants at a high rate would signal the need for further study of silica emissions in Winneshiek County. To provide this scope, we first examined baseline emissions for particulate matter (PM10 and PM2.5), carbon monoxide (CO), nitrogen oxides (NOX), sulfur dioxide (SO2), and volatile organic compounds (VOC) in Winneshiek County. Then, we incorporated emission factors for the processes of frac-sand production and distribution. Finally, we compared projected emissions from frac-sand mining to baseline figures from 2008 to determine the relative magnitude of additional air pollution.

1 Esswein, E. J., Breitenstein, J., Snawder, J., Kiefer, M., & Sieber, W. (n.d.). Occupational Exposures to Respirable Crystalline Silica During Hydraulic Fracturing. Journal of Occupational and Environmental Hygiene.

10.2 Emissions Estimates

To examine the potential risk to public health from frac-sand mining in Winneshiek County, we estimated atmospheric emissions for a single mine scaled across low, medium, and high production outputs. Emissions are produced at three steps in the mining process: sand extraction, processing, and transportation to a rail hub for shipment. Even if mines operate in Winneshiek County, it is possible that sand will be processed elsewhere. Nevertheless, we estimated emissions associated with processing activity to quantify the full scale of potential impacts. The comparison of marginal emissions to this baseline stands as a first-order risk assessment.

To contextualize these estimates, we compared concentrations of PM10, PM2.5, CO, NOX, SO2, and VOC associated with mining and trucking activity to baseline estimates for each pollutant from the 2008 National Emissions Inventory (NEI).

Winneshiek Coutny 2008 NEI							
	CO	NOX	PM10	PM2.5	SO2	VOC	Total
Mobile	10,485	1,859	74	68	952	1,182	14,619
Point	10,527	2,296	11,026	1,997	1,126	1,545	28,516
Total	21,011	4,155	11,100	2,065	2,078	2,727	43,136

Table 10.2.1 Total emissions in Winneshiek County in 2008, in tons

Methods

Each step in the mining process generates additional emissions for various pollutants. Blasting, processing, and trucking activities create different emissions. To accurately estimate the marginal emissions from mining, we examined emissions from mining, processing, and trucking independently. Depending on activity, emissions units are given per ton sand extracted, per ton sand processed, or per truck mile. To estimate emissions, we multiplied each NEI emissions factor by the actual mining activity to get an annual estimate of emissions. For processes that were not given an emissions factor for PM2.5, we assumed that PM2.5 constitutes 20 percent of PM10.[2]

To show the intensity of incremental emissions, we compared mine emissions to the actual Winneshiek County emissions for each pollutant type as reported by the 2008 NEI. At each step, we assumed a medium, 200- acre mine, with high, average, and low output estimates.

Point Source Emissions

Point source emissions are released during sand extraction and processing. If sand is processed at the mine, we expect a reduction in mobile emissions, as only the refined portion of aggregate would be transported by truck.

Emissions from Sand Extraction

To examine emissions from the mine, we accounted for two aggregate extraction methods, uncontrolled blasting and wet drilling. Using emissions factors for PM10, we made estimates of PM10 emission from the mining process itself. PM2.5 emissions were calculated based on our assumption that they constitute 20 percent of PM10.

We estimate that PM10 emissions from blasting and wet drilling will range between 10.24 and 31.91 tons annually for an average-size mine. On the high end, marginal PM10 emissions are approximately 0.29 percent of total PM10 emissions in Winneshiek County in 2008. Additionally, we project that PM2.5 emissions from sand extraction will range from 2.05 to 6.38 tons for a single 200-acre mine, which is about 0.31 percent of total PM2.5 emissions from 2008.

Mine Site Point Source Emissions			
	Single Mine High	2008 County Total	% of 2008 Total
PM2.5	5,789	1,035,656	0.559
PM10	28,946	10,069,484	0.288

Table 10.2.2 Point source table from a single mine

Processing Center Point Source Emissions			
	Single Mine High (kg)	2008 County Total (kg)	% of 2008 Total
PM2.5	13,147	1,035,656	1.270
PM10	65,737	10,069,484	0.653

Table 10.2.3 Point source emissions from a processing center

Emissions from the Sand Processing

Processing emissions can originate from various activities. We assume that mining companies will engage in fines crushing, dry sand and gravel screening, and truck loading and transport off the site. Our model implements material drop points, and we assume that each of these steps has two drop points – one into the system, and one out of it. We assume that tons of processed sand are equal to mine output. This model outputs emissions

2 Mining and Quarrying Area Source Category Calculation Methodology Sheet, http://www.ce.sc.edu/deptinfo/members/faculty/ray/web1/Ugrad/ECIV%20303/Blasting/EPA%20MiningandQuarrying.pdf

of PM10, PM2.5, SO2, NOX, CO, and VOC. All of the SO2, NOX, CO, and VOC emissions originate from vehicle engines and the generators that are used to power industrial equipment.

We project that a processing center will produce between 25.88 and 72.46 tons of PM10 annually, and approximately 3.86 tons of PM2.5. Because the majority of the sand is larger than PM2.5, there will be very little PM2.5 emissions from sand processing. Total emissions from the mine are expected to range between 0.38 percent and 0.54 percent of 2008 totals for Winneshiek County.

Mobile Source Emissions

To estimate additional mobile emissions that arise from long-haul trucking, we account for haul route distance and vehicle miles traveled. As in Chapters 5 and 7, we assumed a hypothetical mine location on Big Canoe Road with three scenario haul routes. Different mining intensities yield a wide range of total output and truck trips, and thus a wide range of emissions impacts. For this analysis, we model the impacts from diesel-powered, long-haul semi-tractor trailer rigs that the EPA categorizes as Gross Vehicle Weight (GVW) Class VIIIa. Trucks in this class weigh between 33,001 and 60,000 pounds.[3] For diesel truck traffic, the EPA provides emissions factors for VOC, CO, NOX, PM2.5, and PM10.

Because two of the routes are primarily located in Allamakee County, we compared emissions along Allamakee route segments to actual emissions from Allamakee County in 2008 rather than using the NEI estimate for Winneshiek County. Clearly, airsheds do not align with jurisdictional borders, yet this was the best approach for comparison. For both Route 1 and Route 2, 96 percent of the road miles are located in Allamakee County, while the remainder is located in Winneshiek County.

3 Average In-Use Emissions from Heavy-Duty Trucks

Total annual emissions from transport via Route 1 and Route 2 are estimated to range between 7.29 tons and 22.70 tons. These concentrations were compared to baseline emissions from Allamakee County in 2008. Marginal emissions are expected to range from 0.02 to 0.06 percent of the total for that year.

Route 3 is located entirely in Winneshiek County, so all emissions are attributed to that county. Estimated annual emissions along this haul route range from 7.27 to 25.77 tons. Those emissions represent 0.03 to 0.10 percent of total annual emissions in Winneshiek County in 2008.

Mobile Source Emissions from Sand Transport						
	Output Magnitude	Total Annual (tons)	Total in WC (tons)	% of WC Total Emis.	Total in AC (tons)	% of AC Total Emis.
Route 1	Low	7.29	0.30	0.00	6.99	0.02
	Average	14.99	0.62	0.00	14.37	0.04
	High	22.70	0.94	0.00	21.76	0.06
Route 2	Low	7.29	0.30	0.00	6.99	0.03
	Average	14.99	0.62	0.00	14.37	0.05
	High	22.70	0.94	0.00	21.76	0.08
Route 3	Low	8.27	8.27	0.03	0.00	-
	Average	17.02	17.02	0.06	0.00	-
	High	25.77	25.77	0.10	0.00	-

Table 10.2.4 Mobile source emissions from sand transport, broken down by county based on route miles

10.3 Summary

To scope the potential risk that industrial frac-sand mining poses to public health, we must consider additional emissions in the context of baseline emissions. Because the incremental increase in emissions from sand extraction, processing, and transport represent a minimal proportion of baseline emissions under all three intensity scenarios, we have not further scaled emissions for a multiple-mine scenario. Mining point sources emit the largest volumes of PM 2.5, which include crystalline silica particles. Although individuals who reside or work near mines, processing centers, or haul routes are at greater risk to exposure, the overall risk to public health is small. The majority of Winneshiek County's population is located to the southwest of the highest probability mining area, while winds blow generally east. The majority of emissions will move east, away from the population center. Based on our most likely site scenarios for the hypothetical mines, few people will be exposed to point source emissions, limiting the impact that the mining has on public health.

Conclusion

The impacts of potential future frac-sand mining operations in Winneshiek County will be dispersed among accounts that affect county, private, and social welfare. Monetizing mining's impacts across these accounts is difficult since individuals and organizations derive varying degrees of utility and hardship from each impact. Furthermore, the impacts of mining will be experienced on different time scales. Some impacts, such as gains in tax revenue, will accumulate on an annual basis, while other impacts, such as impacts to roadway infrastructure, will be dispersed over longer periods. While this analysis estimates mine lifespan to be between 10 and 15 years, it is possible that impacts will accrue over periods that extend beyond a mine's projected lifespan.

The operational and lifespan costs of mining's impacts on Winneshiek County's road network would be one of the more noticeable costs endured by County accounts. Should a single mine utilize Big Canoe Road as a primary trucking artery, this analysis estimates that the loss of viable lifespan on the road will be $489,000. As this would only be a small segment of the overall haul route, additional impacts to County roads and infrastructure are certain. Additionally, this analysis assumes that current maintenance practices continue. Increased maintenance costs as a result of expedited road life loss remain unquantified. This report provides methodology for estimating the impact to road infrastructure that can be utilized by the County.

An additional impact associated with County accounts will be the annual gains the County receives in tax revenue generated by the mine itself. Property tax losses that would occur as a result of diminishing property values are marginal, ranging between $10,000 and $17,000. It is expected that a medium-sized mine will offset these losses and produce annual gains in tax revenue ranging between $30,000 and $50,000 per year.

Social costs that will be incurred by the county's general population will be exhibited in any potential future losses that occur in the county's fishing and tourism industries, in addition to health and quality-of-life costs produced by increased emissions from mining and trucking. Preliminary analyses conducted as a part of this report find that costs associated with tourism may be overstated. Likewise, increased emissions are projected to impose minimal increases to the county's baseline emissions. Nevertheless, many quality-of-life costs are unquantifiable, and must be evaluated qualitatively. In the event that mining occurs at large intensities, all social costs increase.

The final set of accounts impacted by mining are private accounts, which increase the utility or hardship of individual citizens. One of mining's more appealing benefits is the amount of anticipated labor and direct, indirect, and induced income that accompany the industry's place in the local economy. On an annual basis, our analysis estimates that approximately $1 million will be achieved by members of the local economy. Conversely, we project that total residential property values will decrease by $841,000 for residences within a 3-mile radius of hypothetical mine sites. Unlike labor income, which is an annualized gain, losses to property values will accrue over the lifespan of the mine, and will likely continue to produce losses as long as the mining site remains an environmental disamenity.

While frac-sand mining is expected to produce some benefits to the local economy with respect to labor income and industrial tax yields, the negative consequences of mining have been well-documented in this report. Should Winneshiek County officials choose to engage in the frac-sand mining industry in the near future, this report would recommend exploring the following:

Recommendations

1. Limit the mining extraction area to 40 acres.

This cap on mining activity will help limit the intensity of mining activity and thus reduce most of the impacts quantified in this report. While mines can purchase more total acreage than 40 acres, allowing only 40 acres to be mined at a time significantly reduces total impacts. Regulations can be structured that prohibit future mining until each previous 40-acre site has been reclaimed back to its previous land use, or the best use possible.

2. Impose a road-use impact fee based upon a per-ESAL or per-load structure.

Based on our road analysis, road construction costs can be represented in a per-ESAL-mile value. After determining the amount that the County invested in each ESAL mile on each road used by the mines, a cost per trip for loaded and unloaded trucks can be calculated. That cost represents the monetized impact created by a single truck trip. Charging the mining companies a road-use fee based on this analysis will allow the County to recoup the investment made in the amount of the road lifetime that is consumed by mine traffic.

3. Provide mining setbacks of at least 0.5 MI from each water surface.

Our research showed that the majority of storm water violations occurred with mines located within 1,500 feet of the nearest waterbody. Extending setbacks to 0.5 mile not only reduces the likelihood of contamination, but also greatly reduces the potential for mining infrastructure to overlap the line of sight of individuals in some of the county's more popular tourism destinations. Because pollutants travel quickly over steep slopes, long setbacks are needed in Winneshiek County's bluffs region.

4. Opportunities for follow-up questionnaire in the 2016 Trout Angler Survey.

Further study could help in valuation of the county's trout streams and estimate the likelihood of a tangible tourism impact. To obtain more data, we encourage the 2016 Iowa River Survey to implement a follow-up study designed to compare the value of wild streams versus stocked streams, and investigate potential effects to stream use of specific changes to the natural ambience in Iowa's Driftless Region.