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Introduction

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The technologies of horizontal drilling in conjunction with hydraulic fracturing have greatly expanded the ability to profitably recover natural gas and oil from shale. Hydraulic fracturing, also called fracking or hydrofracking, is a method used to access oil bearing shales and limestones and extracting oil and natural gas. Fracking requires a proppant, which are particles that hold open fractures in the shale that allow the oil or gas to be collected. Silica sand is used as a proppant. Nationwide, frac sand production almost doubled from 2009 to 2010, to 12.1 million tons, according to the U.S. Geological Survey.

Large silica sand deposits are located in south central and southeast Minnesota and western Wisconsin. The demand for sand has resulted in many new mining and processing plant proposals being submitted to local and state government agencies. The potential economic impacts on the local and state economies have generated great interest. Potential impacts to the landscape, natural resources, and health of residents in the areas of these proposed facilities have generated great concern.

In 2012 the Environmental Quality Board received a petition supporting the preparation of a Generic Environmental Impact Statement to analyze the potential environmental effects of the industry. Such a study would require significant time and financial resources. While the preparation of a GEIS remains an option, the EQB has prepared this report on silica sand in an attempt to assemble what we know about the topic and what we don’t know.

This report does not pretend to be encyclopedic. It is a summary of information relevant to the questions at hand. It is recognized that the information presented here can and should be augmented and improved as more is learned.
I. BACKGROUND ON SILICA SAND

- What is silica sand?

Silica or silicon dioxide (SiO$_2$), also called quartz, is one of the most common minerals found on the earth’s surface. Silica is a major component of many different kinds of rocks (like granites and gneiss) and comes in many different varieties.

Sand refers to a particle size. All sands are not the same. For example, construction sand and gravel is used to build and maintain roads and bridges. Construction sand and gravel consists of many different rock types and sizes. Some rocks are angular and other rocks are rounded. In contrast, industrial silica sand is mined from sandstone formations that have undergone geologic processes that produced well-rounded, well-sorted sand and gravel that consists of almost pure quartz (silicon dioxide).

Mining of silica sand has occurred in Minnesota and Wisconsin for over 100 years. Some of the sand caves in Minneapolis and St. Paul are mines, the sand from which was used for making beer bottles and for foundry sand. Mining of industrial silica sand has been continuously occurring in LeSueur County for over 50 years. Washington County has intermittently hosted silica sand mining for over 60 years. Counties that have historically hosted silica sand mines include: Ramsey, Hennepin, Dakota, Goodhue, Anoka, Pine, LeSueur, and Scott. (DNR Industrial Minerals: Inventory of Industrial Mineral Pits and Quarries in Minnesota, 1990, Minnesota Department of Natural Resources, Vol 1 and 2, pp.415)
Silica sand is widely used in many applications. In 2010, about 41% of the U.S. tonnage was used as hydraulic fracturing sand and well-packing and cementing sand, 26% as glassmaking sand, 11% as foundry sand; 6% as other whole-grain silica; 6% as whole-grain fillers and building products; 3% as ground and unground sand for chemicals; 2% as golf course sand; 2% for abrasive sand for sandblasting; and 3% for other uses. (U.S. Geological Survey, Mineral Commodity Summaries, January 2012)

- What Is ‘Fracking’ and Why Is Sand Needed?

Hydraulic fracturing, also called fracking or hydrofracking, is a method used to access oil bearing shales and limestones to extract oil and natural gas. The process involves the pumping of a fracturing fluid under high pressure to generate fractures or cracks in the target rock formation. This allows the natural gas (or oil) to flow out of the shale to the well in economic quantities. For shale gas development, fracture fluids are primarily water based fluids mixed with additives that help the water to carry sand proppant (frac sand) into the fractures. Water and sand make up over 98% of the fracture fluid, with the rest consisting of various chemical additives that improve the effectiveness of the fracture job. Each hydraulic fracture treatment is a highly controlled process designed to the specific conditions of the target formation. (Modern Shale Gas Primer, USDOE 2009)

A typical gas well is drilled vertically one to two miles below the surface. In North Dakota, the wells average between 9,000 to 10,000 feet deep. When the oil shale is reached, the well is
drilled laterally, typically for 5,000 to 10,000 feet. There can be up to three lateral extensions within a well. The actual thickness of the bed can be very thin, eight feet or so.

The base is usually water but can include methanol, liquid dioxide, and liquefied petroleum gas. Proppant consists of particles that hold open the fractures. Silica sand is used as a proppant. Chemical additives include friction reducers, scale inhibitor, solvents, acids, and niocides that are added to protect equipment.

The propped fracture is only a fraction of an inch wide and held open by the frac sand. A well uses thousand of tons of sand, depending on how many stages of pumping and fracking occurs.

There has been some misunderstanding about mining that occurs in Minnesota. There are no oil or gas fracking mines in Minnesota. It is the silica sand—frac sand—that is being mined in Minnesota. This sand in transported elsewhere in the county to oil fields as well as foundries and glass manufacturers.

Frac Sand Specifications

Frac sand specifications are set by the American Petroleum Institute (API). The primary considerations are the physical characteristics of the sand such as size, sphericity, roundness, crush resistance, and mineralogy. Not all the sandstones in Minnesota meet the specifications for frac sand.

Grain size 20/40 mesh is most widely used. 90% of the sand is to fall within the specified particle range. Not more than 1% of the total sample can fall on the first or last sieve in the series. Clay and silt size particles >105 microns are removed with the processing, as well as weak and crusted grains.

<table>
<thead>
<tr>
<th>Product Mesh Size (holes per square inch)</th>
<th>8/12</th>
<th>10/20</th>
<th>20/40</th>
<th>70/140</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grain Size (Diameter)</td>
<td>2.38 to 1.68 millimeter</td>
<td>2.00 to 0.84 millimeter</td>
<td>0.84 to 0.42 millimeter</td>
<td>210 to 105 microns</td>
</tr>
<tr>
<td>Sediment</td>
<td>Fine Gravel to Coarse Sand</td>
<td>Very Coarse Sand to Coarse Sand</td>
<td>Coarse Sand to Medium Sand</td>
<td>Fine Sand to Very Fine Sand</td>
</tr>
</tbody>
</table>

source: American Petroleum Institute and MnDNR

- Location of silica sand resources

The last mineral survey was completed by USGS in 2010. As defined in the USGS 2010 Minerals Yearbook, industrial sand and gravel, often called “silica,” “silica sand,” and “quartz sand,” includes sands and gravels with high silicon dioxide (SiO<sub>2</sub>) content. There were 29.9 million metric tons (Mt) of industrial sand and gravel produced in the United States in 2010. The Midwest led the Nation with 49%, followed by the South with 39%, the West with 7%, and the
Northeast with 5%. The leading producing States were, in descending order: Illinois, Texas, Wisconsin, Minnesota, Oklahoma, North Carolina, California, and Michigan. Their combined production represented 64% of the national total. Minnesota produced 1,940 Mt, or 6%. *(USGS 2010 Minerals Yearbook Tables 2 and 3)*

**INDUSTRIAL SAND AND GRAVEL SOLD OR USED IN THE UNITED STATES 2010**

**BY GEOGRAPHIC DIVISION**

<table>
<thead>
<tr>
<th>Geographic region</th>
<th>Quantity (thousand metric tons)</th>
<th>Percentage of total</th>
<th>Value (thousands)</th>
<th>Percentage of total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Northeast:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>New England</td>
<td>127</td>
<td>*</td>
<td>$6,380</td>
<td>1</td>
</tr>
<tr>
<td>Middle Atlantic</td>
<td>1,440</td>
<td>5</td>
<td>47,000</td>
<td>5</td>
</tr>
<tr>
<td>Midwest:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>East North Central</td>
<td>9,910</td>
<td>33</td>
<td>346,000</td>
<td>33</td>
</tr>
<tr>
<td>West North Central</td>
<td>4,600</td>
<td>15</td>
<td>163,000</td>
<td>16</td>
</tr>
<tr>
<td>South:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>South Atlantic</td>
<td>3,480</td>
<td>12</td>
<td>93,400</td>
<td>9</td>
</tr>
<tr>
<td>East South Central</td>
<td>1,290</td>
<td>4</td>
<td>40,900</td>
<td>4</td>
</tr>
<tr>
<td>West South Central</td>
<td>6,880</td>
<td>23</td>
<td>274,000</td>
<td>26</td>
</tr>
<tr>
<td>West:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mountain</td>
<td>500</td>
<td>2</td>
<td>14,000</td>
<td>1</td>
</tr>
<tr>
<td>Pacific</td>
<td>1,680</td>
<td>6</td>
<td>49,900</td>
<td>5</td>
</tr>
<tr>
<td>Total</td>
<td>29,900</td>
<td>100</td>
<td>1,030,000</td>
<td>100</td>
</tr>
</tbody>
</table>

Data are rounded to no more than three significant digits; may not add to totals shown.

*Less than ½ unit.*

*source: USGS 2010 Minerals Yearbook, Table 2*

In 2010 the U.S. produced 12,100 thousand metric tons of sand used for hydraulic fracturing. The Midwest produced 8,080 thousand metric tons, 67% of the national total. *(USGS 2010 Minerals Yearbook Table 6)*

The map below shows first encountered bedrock. The areas in red show the distribution of sandstone formations. Depending on the geologic setting (like Illinois) there may be areas where the first bedrock (i.e. limestone and shales) are being removed to access sandstone. As a result, the upper Midwest hosts significant sandstone resources. The deposits in Wisconsin and Minnesota are spread out over very large areas and near the land surface compared to other states.
The next map is a simple categorization of counties by the accessibility to mine silica sand resources. The dark brown color indicates where extensive silica sand resources are exposed at or near the land surface. (Runkel, A., 2012: Quartz-rich sandstone bedrock layers at or near (approx 50 ft) land surface, Minnesota Geologic Survey, Draft Map). The light brown or tan color indicates where silica sand is being accessed along incised river corridors. This area has been recently glaciated, so there is thick glacial overburden over the silica sand deposits as you move away from river corridors. The green represents counties where glacial sediment and/or bedrock limit the access to silica sand resources or where near surface resources are small in areal extent.
Five mines have been identified by the Minnesota Geologic Survey that extract industrial silica sand in Minnesota (source: Runkel, A., 2012: Quartz-rich sandstone bedrock layers at or near (approx 50 ft) land surface, Minnesota Geologic Survey, Draft Map.). One additional mine has come on-line since December of 2012. A number of small silica sand mines supplying local uses of sand exist in southeastern Minnesota. These mines extract sand for agricultural uses (such as cow bedding) and fill. Commercial silica sand mines may or may not process the sand on-site. Several off-site processing plants are currently known to receive silica sand from various mining operations in Minnesota and Wisconsin. To date, five counties, Winona, Goodhue, Wabasha, Houston, and Fillmore, passed moratoria on new permits for industrial silica sand mining. Some have extended their moratoria.
The next graphic is a stratigraphic column represents the vertical order, or stratigraphy, of Paleozoic rock units with the oldest on the bottom and the youngest on the top.

![Stratigraphic Column](image)

Source: Minnesota Geological Survey  
Photo by MnDNR

Depending on its depth, the sand is accessed by surface mining, bench mining, or underground mining. For example, mining in the central part of the state along the Minnesota River corridor is dominated by surface mining. Southeastern Minnesota has the potential for surface mining, bench mining, and underground mining.
Aerial photo of a surface mine.

Representation of an area with the potential for surface, bench, and underground mining.

Modified from Tony Runkel, Minnesota Geologic Survey

Representation of an area with the potential for surface, bench, and underground mining.
Comparison of Silica Sand Mining to Other Sand and Gravel Mining

<table>
<thead>
<tr>
<th>construction sand and gravel</th>
<th>industrial silica sand</th>
</tr>
</thead>
<tbody>
<tr>
<td>same</td>
<td>same</td>
</tr>
<tr>
<td>Surface mining: backhoes, bulldozers, excavators, screens, and conveyors</td>
<td>Surface mining: backhoes, bulldozers, excavators, screens, and conveyors</td>
</tr>
<tr>
<td>different</td>
<td>different</td>
</tr>
<tr>
<td>No underground mining</td>
<td>Underground mining and bench mining</td>
</tr>
<tr>
<td>Washing plants tend to not use flocculants</td>
<td>Washing plants may use flocculants</td>
</tr>
<tr>
<td>Does not require blasting</td>
<td>May require blasting</td>
</tr>
</tbody>
</table>

With hardrock mining (e.g. taconite, granite, and quartzite), blasting and crushing are used to fracture and break rocks into smaller, manageable pieces, which produces angular, freshly broken rock faces. In silica sand mining, blasting and the use of crushers are used to loosen weakly cemented sandstone, while keeping the individual, round grains intact. When the grains break, it lowers the performance for use as frac sand. After processing, much of the silt and clay is removed and very few grains would have freshly exposed surfaces.
• **Processing of Silica Sand**

Frac sand must be of uniform size and shape. Raw sand must be processed to be used for oil and gas drilling.

The sand is washed to remove fine particles. Washing is done by spraying the sand with water as it is carried over a vibrating screen. The fine particles are washed off the sand and the coarse particles are carried along the screen by the vibration. An alternative method uses an upflow clarifier, where water and sand flow into a tank. Fine particles overflow the tank while the washed sand falls by gravity to the bottom.

After washing, the sand is then sent to a surge pile where water adhering to the sand particles infiltrates back into the ground. From the surge pile the sand is sent to the dryer and screening operation where the sand is dried in a drum with hot air blasted into it. Then the sand is cooled and often further sorted to separate sand that is suitable for fracking from sand that is not suitable. Some specialized processing plants may further treat the sand by applying a resin coating to the sand particles. This coating helps the sand to flow as a slurry and increases the crush strength. ("Silica Sand Mining in Wisconsin", Wisconsin Department of Natural Resources, January 2012.)

Nonmetallic mining processors use 4500 to 6000 gallons of water per minute. Local aquifers cannot provide this much water, so reuse of water is necessary. Typical operations used unlined sedimentation ponds for water clarification and source water for processing. More sophisticated techniques reduce the amount of water being used. This is advantageous both economically and environmentally. Water quality concerns arise from the use of chemicals. There is a need to establish baseline water quality prior to the startup of processing as well as ongoing monitoring to ensure chemical usage has not contaminated local aquifers. ("Silica Sand Processing—Water quantity and Quality", Scott E. McCurdy, Conference on Silica Sand Resources of Minnesota and Wisconsin, October 1-3, 2012, Precambrian Research Center, University of Minnesota, Duluth, and Society of Mining, Metallurgy, and Exploration.)

While sand that is not suitable for fracking has other industrial uses, it may be difficult to sell it due to the remote locations of many processing plants. ("Wet Frac Sand Processing", Christopher Kelley, Conference on Silica Sand Resources of Minnesota and Wisconsin, October 1-3, 2012, Precambrian Research Center, University of Minnesota, Duluth, and Society of Mining, Metallurgy, and Exploration.)

• **Proppant Alternatives to Silica Sand**

There are three types of proppants used for hydro fracking: silica sand, resin-coated silica sand, and man-made ceramic beads known as manufactured proppants. Unlike frac sand and resin-coated proppants, which are primarily industries based in North America, ceramic proppant manufacturers are distributed throughout the world. Here is a shipment of manufactured silica sand that made the Duluth Shipping News.
This barge came from Russia and unloaded in Duluth harbor in 2011. Instead of sand mines, ceramic proppants are made from kaolinite or nonmetallurgical bauxite, or clay mines, and are being mined in places like China, Brazil, and India. To make the proppant, the clay undergoes a process called sintering where high temperature kilns bake the clays to form well rounded, strong sand-sized particles. An article in the Journal of Petroleum Technology indicated there currently is a global shortage of proppants. (“Proppants: Where in the world”, Journal of Petroleum Technology, April 2011, Society of Petroleum Engineers.)

- Fragmented Industry Elements: Mining, Processing, Transporting of Silica Sand

The silica sand industry comprises several locational elements: mining, processing, and transporting. The location of the mine is determined by geology: the location of the sand resource. Mining and processing may or may not occur at the same location or even in proximity to one another. When they are at different locations, transporting the sand from the mine to the processing facility is one stage of transportation. This typically occurs by truck. Once the sand is processed, it must be transported from the processing facility to the oil or gas fields. This typically occurs by rail or barge. Processing facilities may be sited near rail or barge terminals. When this is not the case, trucks bring the processed sand to the rail or barge loading site.

The economic impacts on an area such as increased employment and tax revenues can be great. At the same time, the multi-phase, fragmented nature of the industry increases the complexity of
addressing questions and challenges. The potential for impacts on existing landscapes, land uses, and sensitive resources can vary greatly from one site to another. A great increase in the number of trucks between facilities may have little effect in an unpopulated area. Those same trucks will have a much greater impact when traveling on a road passing near a neighborhood or down the main street of a small town dependent on tourism.

**Mining, Processing, Transportation Variations**

sand mine → truck → processing facility → truck → rail or barge loading facility → rail, barge → oil/gas field

sand mine processing facility → truck → rail or barge loading facility → rail, barge → oil/gas field

sand mine processing facility rail or barge loading facility → rail, barge → oil/gas field
II. **Market and Economics**

- **Background on U.S. Shale Gas and Shale Oil Plays**


The use of horizontal drilling in conjunction with hydraulic fracturing has greatly expanded the ability of producers to profitably recover natural gas and oil from low-permeability geologic plays—particularly, shale plays. Application of fracturing techniques to stimulate oil and gas production began to grow rapidly in the 1950s, although experimentation dates back to the 19th century. Starting in the mid-1970s, a partnership of private operators, the U.S. Department of Energy (DOE) and predecessor agencies, and the Gas Research Institute (GRI) endeavored to develop technologies for the commercial production of natural gas from the relatively shallow Devonian (Huron) shale in the eastern United States. This partnership helped foster technologies that eventually became crucial to the production of natural gas from shale rock, including horizontal wells, multi-stage fracturing, and slick-water fracturing. Practical application of horizontal drilling to oil production began in the early 1980s, by which time the advent of improved downhole drilling motors and the invention of other necessary supporting equipment, materials, and technologies (particularly, downhole telemetry equipment) had brought some applications within the realm of commercial viability.

The advent of large-scale shale gas production did not occur until a private firm experimented during the 1980s and 1990s to make deep shale gas production a commercial reality in the Barnett Shale in North-Central Texas. As the success of this became apparent, other companies aggressively entered the play, so that by 2005, the Barnett Shale alone was producing nearly 0.5 trillion cubic feet of natural gas per year. As producers gained confidence in the ability to produce natural gas profitably in the Barnett Shale, with confirmation provided by results from the Fayetteville Shale in Arkansas, they began pursuing other shale plays, including Haynesville, Marcellus, Woodford, Eagle Ford, and others.

Although the U.S. Energy Information Administration’s (EIA) National Energy Modeling System (NEMS) and energy projections began representing shale gas resource development and production in the mid-1990s, only in the past 5 years has shale gas been recognized as a “game changer” for the U.S. natural gas market. The proliferation of activity into new shale plays has increased dry shale gas production in the United States from 1.0 trillion cubic feet in 2006 to 4.8 trillion cubic feet, or 23 percent of total U.S. dry natural gas production, in 2010. Wet shale gas reserves increased to about 60.64 trillion cubic feet by year-end 2009, when they comprised about 21 percent of overall U.S. natural gas reserves, now at the highest level since 1971. Oil production from shale plays, notably the Bakken Shale in North Dakota and Montana, has also grown rapidly in recent years. (“Review of Emerging Resources: U.S. Shale Gas and Shale Oil Plays.” July 2011, U.S. Energy Information Administration.)
Dry natural gas is natural gas which remains after the liquefiable hydrocarbon portion and nonhydrocarbon gas has been removed. Wet gas has hydrocarbon compounds and small quantities of various non hydrocarbons existing in the gaseous phase or in solution with crude oil. (U.S. Energy Information Administration Glossary, http://www.eia.gov/tools/glossary/index.cfm?id=A)

Map of U.S. Shale Gas and Shale Oil Plays

In 2009 shale gas production amounted to more than 8 billion cubic feet (Bcf) per day, or about 14% of the total volume of dry natural gas produced in the United States and about 12% of the natural gas consumed in the United States. Production from the Barnett Shale has leveled off, but volumes of gas from the Marcellus, Haynesville, Fayetteville, and Woodford shales are growing as more wells are drilled in these plays and as other emerging plays are developed. The EIA projects that the shale gas share of U.S. natural gas production will continue to grow, reaching 45% of the total volume of gas produced in the United States by 2035. (http://www.netl.doe.gov/technologies/oil-gas/publications/brochures/Shale_Gas_March_2011.pdf)
Sand Production

The following is extracted from an article by the Federal Reserve Ninth District Davies, Phil. –Sand Surge,” Fedgazette, July 16, 2012. Available online at bit.ly/O4gKhW.

Nationwide, frac sand production almost doubled from 2009 to 2010, to 12.1 million tons, according to the U.S. Geological Survey. Logistics has a bearing on where sand mining is likely to prosper and grow. In Minnesota, transportation bottlenecks, in particular a lack of rail capacity, may prove as big a barrier to mine development as pushback from mining opponents.

High-grade frac sand commands a premium in the marketplace: $60 to $80 per ton, over five times the price of construction sand and gravel. Oil companies and oilfield service firms can pay over $300 per ton for processed sand delivered to the wellhead. No wonder that large mining firms, many of them based outside the region, have invested hundreds of millions of dollars in mines and processing facilities.

The typical frac sand mine is much larger than a traditional sand mine, ranging in size from 50 acres up to several hundred acres. Mining companies build big to take advantage of economies of scale. Most mining operations include processing and shipping facilities either onsite or nearby—sand washing and drying plants, and loading docks for trucks or railcars. These facilities are expensive—construction costs for a new processing plant average $50 million—but they can be up and running in a matter of weeks once building and
environmental permits are secured. Mining is simply a matter of excavating a pit or biting into sandstone bluffs with backhoes and front-end loaders.

Many new, large mines are situated on rail lines, the most economical shipping method. (Rail patterns dictate that most frac sand mined in the region goes to shale oil and gas fields in the eastern and southern United States, rather than to the Bakken.) For example, mines in Chippewa and Barron counties (Wisconsin) ship sand on small, rural rail lines to connect to the networks of Canadian National, BNSF and other continental railroads.

In Minnesota, the frac sand industry is less developed, with only a few known mines in operation. One large national producer of industrial minerals owns two of the biggest mines, north of Mankato. The sand surge rolled into Minnesota later than it did in Wisconsin—new mine proposals by large mining firms started cropping up in 2010. That's partly due to geology; accessible deposits of high-grade sandstone are less extensive in Minnesota than in Wisconsin, found mainly in a handful of southeastern counties and the Minnesota River Valley. Another impediment to mine development in Minnesota is logistics—the task of getting millions of tons of sand to distant markets.

In contrast to Wisconsin, southeastern Minnesota has little rail capacity to ship sand to transportation hubs such as Winona and the Twin Cities. Hundreds of miles of rural rail lines have been abandoned since the 1970s, leaving trucks as the only viable means of moving sand overland. In addition, much rail and barge capacity in Winona is already taken up by agricultural commodities.

Despite these limiting factors, several new mines have been developed or proposed over the past couple of years. The 110-year-old Biesanz Stone Co. quarry in Winona began mining frac sand in 2011, and last fall several mines were on the drawing board in the southwestern corner of Winona County, an area with outcrops of St. Peter sandstone. Another proposed mine in Scott County southwest of the Twin Cities would cover 1,000 acres along the edge of the Minnesota River Wildlife Refuge—including the grounds of the Minnesota Renaissance Festival held each fall.

New sand mines are likely to appear on bluff tops and in valleys across the region as mining companies seek to satisfy high demand for frac sand in shale oilfields. There’s no sign of a letup in shale oil drilling; in March, increased production in the Bakken oilfields made North Dakota the country’s second-biggest oil producer, edging it ahead of Alaska. And rising energy prices in a rebounding global economy can only stimulate more drilling—and more digging in the nation’s sandbox.

As the price of oil goes up, the need for things related to oil mining likely will increase. However, within a few years, mining development may slow if frac sand production increases to the point where demand is satisfied and proppant prices fall. Or if transporting frac sand proves too cumbersome and expensive in some areas. Industry sources believe that frac sand mining in southeastern Minnesota will remain small in scale until more rail and barge capacity is developed to ship sand to oil and gas fields.
And especially in Minnesota, uncertainty reigns about what will happen when moratoriums expire—a surge of development, renewed bans or something in between. Governments are seeking solutions to allow mining to expand while satisfying critics and protecting government assets and budgets. Winona County let mine development resume under revised regulations that include a road impact fee charged to new businesses that transport frac sand by truck. The impact fee—22 cents per mile for each ton of sand—will help fund ongoing repairs to county roads that suffer excessive wear and tear from sand hauling. New and expanded mining operations must also comply with county rules on dust monitoring, noise abatement, hours of operation and other matters.

Some Wisconsin townships have negotiated development agreements with mining companies intended to address the concerns of constituents and safeguard public resources. For example, one town negotiated an agreement with a mining company that sets out rules of operation for the mine over the next 20 years. Among the requirements are a ban on mining operations from May 1 through October 15 and a provision for offering fair market value to nearby residents who wish to sell their land. The pact has become a model for other Wisconsin townships seeking to forge their own agreements with mining firms.

The debate is not over, though. It will take awhile for frac sand mining to blend into the economic and political landscape—for communities in the region to figure out how to reap the economic rewards of mining while minimizing its societal costs.


- Employment

In just a few years, frac sand mining has lifted local economies—mostly in Wisconsin—by providing well-paying jobs, raising household incomes and pumping revenue into area businesses. Mining companies offer badly needed jobs to rural areas. No official job numbers exist for sand mining in the district—the industry is too new. But it’s evident that expanded mining has contributed to rising private employment since the recession. On average, one frac sand mine employs between 10 and 20 people, while 40 to 50 people work at a typical processing plant, according to industry sources. So over the past five years, new mines and processing plants—not counting existing, expanded mines—have created roughly 500 jobs in the Ninth Federal Reserve district portion of Wisconsin. At many mines, large numbers of trucks are needed to haul frac sand to processing plants and rail terminals, creating job openings for truck drivers and crews. (Davies, Phil. “Sand Surge,” Fedgazette, July 16, 2012.)

- Local Economy, Land Values, Tax Revenue, and Costs of Impacts on Infrastructure, Tourism

The following is excerpted from (Davies, Phil. “Sand Surge,” Fedgazette, July 16, 2012):

Besides jobs, sand mining has created a “wealth effect” in rural communities—lucrative payments to landowners who sell or lease their land to mining companies. Last year, Windsor Permian, a Texas oil and gas firm, paid over $16,000 an acre—well above market value—for
a potential mining site near Red Wing, Minn. In west-central Wisconsin, farmers have been offered six-figure mineral rights fees, plus royalties of $1.50 to $3 per ton for their frac sand, said Gerald Duffy, a Twin Cities attorney who has represented landowners in the area.

Spending by sand millionaires—along with purchases of goods and services by mining companies, mining-related businesses and their workers—percolates through local economies, benefiting enterprises with little connection to mining.

Local governments and taxpayers in rural areas also benefit from increased economic activity linked to mining. Lodging tax revenue could increase, and school district mill rates may decrease as new processing plants begin paying property taxes.

Economic gains from frac sand mining don’t come without costs; mining activity can damage infrastructure and the natural environment, and compromise public health and safety. Many of these costs are borne by taxpayers, or by society at large in the form of extra personal expense or forgone benefits.

Truck hauling from sand mines exacts a heavy toll on rural roads and bridges, for instance. A recent Winona County study on the impact of sand mining on county roads found that daily truck traffic to and from two average-sized mines would wear out pavement at 10 times the rate of normal, mixed traffic.

As a rule, mining activity raises residential property values by increasing average household income; people can afford more expensive housing. But studies of gravel and coal mining in other parts of the country show that homes situated near a mine or major sand truck route lose value.

Although silica sand mining is not considered as environmentally harmful as metallic mining, it’s an extractive industry that strips away vegetation and topsoil. Storm water runoff from mines can muddy wetlands and streams (as occurred in May 2012, when sand-laden water from a frac sand mine near Grantsburg, Wis., leaked into the St. Croix River). Reclamation of the site typically is required, but this depends on the location.

Some of this fallout from mining may affect other industries, such as agriculture, outdoor recreation and tourism.

Communities known for their scenic attributes draw great numbers of regional visitors, which has created a tourism economy. Removal of bluffs that contain silica sand or the creation of large mines in scenic areas, along with the associated noise, traffic, dust, and other disruptive elements may significantly reduce the attractiveness of these areas for visitors. Residents and business owners in such areas fear that the mining economy will over run the tourism economy. An additional fear is that a mining economy is limited to the time during which the sand is available and profitable to mine. As has been noted regarding communities elsewhere in the state that relied on mining, once the mining resource is gone,
so is the economy. In addition, the landscape has been altered, which may severely and permanently reduce the viability of tourism as an option.


- **What We Don’t Know, What Might Be Useful**

  **Future market for silica sand for hydrofracking:** Data from industry and government sources could be assembled and compared to consider market projections of demand. This likely will involve market projections for oil and gas.

  **Economical depth for mining:** We know where the sand is, but the depth at which mining is economical is unknown. In the past, it was not economical to mine sand beyond certain depths. With the surge in demand due to hydrofracking, the economic picture changed.

  **Impacts on property values:** Data could be assembled for properties near mines, processing sites, and transportation facilities to see what, if any, property value changes have occurred and if the changes are correlated to those activities and facilities. Such studies have been conducted to address question of the impacts other land uses. However, the sand facilities may be too recently created for any such analyses to be possible.

  **Potential effects on tourism:** Determining potential effects on tourism would be very useful. Determining what data and methodology would be needed in order to conduct such a study is a challenging question in itself.

  **Tax revenues available:** Minnesota Statute 298.75 establishes a tax on aggregate mining, including silica sand. Property taxes apply as well. It may be useful to assemble information to describe the potential revenues from these sources and determine what other tax or fee revenue sources are available.
III. AIR QUALITY

- Health Impacts

Potential Health Impacts of Crystalline Silica

Silica exists in two forms: amorphous and crystalline. The toxicity of crystalline silica to humans has been well characterized. In occupational settings where exposures tend to be higher than ambient exposures, silica is capable of causing a number of diseases. The best known disease is silicosis (silicotic nodules and fibrotic scarring of the lung), but exposure to crystalline silica is associated with other health concerns. Silica exposure contributes to other diseases of the lung including emphysema, chronic obstructive pulmonary disease, tuberculosis, and lung cancer. Silica exposure has also been associated with several diseases of the immune system.

When discussing the toxicity of silica, the real concern is with respirable crystalline silica particles with a diameter of 4 micrometers (4 μm or 4 microns) or smaller. Particulate matter 4 microns or smaller is referred to as PM₄. Particles this small are invisible to the naked eye. PM₁₀ is respirable but only reaches upper levels of the respiratory system when it’s larger than PM₄. PM₄ can travel much deeper in the lungs and reach the lower respiratory surfaces (alveoli) where the changes that produce silicosis take place.

source: http://www.epa.gov/pm/basic.html

Disease risk is related to both the levels and duration of silica exposure and the onset of disease may occur long after the exposure has ceased. The U.S. Occupational Safety and Health
Administration (OSHA) recently issued a “Hazard Alert” on worker exposure to silica during hydraulic fracturing operations. “Worker Exposure to Silica During Hydraulic Fracturing”, OSHA-NIOSH Hazard Alert, Occupational Safety & Health Administration, National Institute of Occupational Safety and Health, U.S. Dept. of Labor, June 2012.

Mining activities create a lot of fine silica dust. As noted above, exposure to silica dust has been shown to cause a number of lung diseases, including silicosis and cancer, although there’s no conclusive evidence linking these conditions to sand mining. (Davies, Phil. “Sand Surge,” Fedgazette, July 16, 2012.)

However, there have been studies identifying non-occupational silicosis due to elevated ambient exposures to silica particulate. There also are studies identifying silicosis in exposed animals downwind of peak sources of respirable crystalline silica. (Bridge, I. (2009) Crystalline silica: a review of the dose response relationship and environmental risk. Air Quality and Climate Change 43(1): 17-23) More study is needed, but there is evidence of potential health risks in areas of elevated silica concentration. We don’t know what health impacts silica has at lower concentrations such as those typically found in ambient air.

Exposure Limits for Crystalline Silica

The OSHA permissible exposure limit (PEL) for crystalline silica is 0.100 parts per million (ppm) (which is the same as 100 micrograms per cubic meter or μg/m³) for an 8-hour time-weighted average exposure. Adjustment of the OSHA PEL for a 24-hour exposure gives a level of 24 μg/m³. The National Institute for Occupational Safety and Health (NIOSH) recommended exposure limit is 0.05 ppm (50 μg/m³) for a 10-hour time-weighted exposure which would be adjusted to 15 μg/m³ for a 24-hour exposure.

The California Environmental Protection Agency’s Office of Environmental Health Hazard Assessment (OEHHA) has developed a chronic reference exposure limit for silica in ambient air of 3 μg/m³. This value is eight-fold lower than the time adjusted OSHA limit and five-fold lower than the time-adjusted NIOSH recommendation. The OEHHA value for the general population is therefore more protective than federal recommendations for occupational exposure. The differences between acceptable risk levels for occupational settings and those for the general population are typically much greater than five- to eight-fold.

The MPCA has requested that MDH develop an exposure limit for respirable crystalline silica in air.

Are the occupational exposure limits adequately protective?

A number of studies suggest that silicosis is underdiagnosed when X-ray is used as the diagnostic tool, and that there is significant risk to workers exposed to silica concentrations lower than the occupational levels. OEHHA reports that —silicosis is still being diagnosed at autopsy following death in workers who were supposed to be exposed to occupational levels of 50-100 μg/m³.”

Ambient Levels of Crystalline Silica Associated With frac Sand Mining
The Minnesota Department of Health (MDH) has little or no information on the levels of respirable silica generated by frac sand mining or processing. MDH has not been provided with any information on the ambient levels of silica that result from frac sand mining operations. MDH has been told that there are plans to monitor ambient silica associated with frac sand mining in Wisconsin.

Other Possible Health Concerns Associated With Frac Sand Mining

Because frac sand mining operations are expected to operate for many hours a day, some 24 hours per day for 7 days a week, the increase in truck traffic could be a problem. Increased dust, noise, risk of accidents and increased levels of engine exhaust will present health and nuisance issues. Emissions from the mining process – blasting, digging equipment and fixed machinery--will result in more dust and chemicals being placed into the air.

- **Air Quality Permits and Standards**
  - MPCA always regulates a silica-sand-related facility if they meet any of the following descriptions:
    - Has a dryer that was constructed after April 23, 1986
    - Has a stationary crusher capable of processing 25 tons per hour of non-metallic minerals (i.e. sandstone), and that crusher was constructed after August 31, 1983
    - Has potential PM10 emissions of 25 tons per year or more
  - The MPCA regulates particulate matter in three size ranges: Total Suspended Particulate, PM10, and PM2.5
  - There is not a silica standard for ambient air (PM 4); ambient air is defined as the portion of the atmosphere, external to buildings, to which the general public has access. We cannot build a specific limit in our permits for PM4 without a standard although we can request practices to mitigate emissions and exposure.
  - There are health benchmarks (agreed upon by MDH and MPCA) for respirable crystalline silica. Health benchmarks are similar to air standards in that they are health based, but they are less enforceable within the permitting process. They may be used to inform air permitting and respond to public comments. The MDH is currently reviewing other states’ health benchmarks to compare to Minnesota’s.
  - Silica sand primarily falls into the Total Suspended Particulate size category, but can also be found in PM10 and PM2.5 size categories.
  - Local units of government may also have air-quality-related ordinances and requirements that apply in addition those found in MPCA-issued permits. However, MPCA does advise local units of government on ways to mitigate potential health and environmental concerns (e.g. advice on how to limit fugitive dust).
OSHA regulates air quality in occupational settings to protect the health of workers through a respirable crystalline silica standard. OSHA defines respirable as particles below 4 micrometers, or PM4.

MDH and the MPCA have found that the majority of the silica exposure data are collected for the PM4 size category.

There are no federal reference methods for ambient air monitoring of the PM4 size category.

The MPCA has ambient air monitors for all three sizes of particulate matter arranged in a state-wide array; these locations are not intended to represent any specific facility, but are intended to represent neighborhoods or larger geographic areas such as regions.

A paper was published by Richards, et. al., in 2009 in the Journal of Air and Waste Management Association regarding a method in which a PM2.5 monitor was modified to collect PM4 data. This data was collected at several sand and gravel facilities in California. The published data includes emission factors for silica and ambient monitoring of silica. The results of the study suggest that the monitored levels are below the Recommended Exposure Level. It is important to note that the silica content of the California sand and gravel was approximately 30% by weight and that the silica sand found in Minnesota is nearly 100% silica by weight. This silica content difference makes it difficult to directly apply the findings of the California study to Minnesota sands.

Monitoring is a reactive tool; modeling is a predictive tool.

In order to predict (i.e. model) the ambient impacts of a silica-sand facility, the MPCA needs additional information such as:
  o An acceptable PM4 monitoring method
  o A set of silica emission factors for PM4-sized material for processes that occur at silica sand facilities

Certain industries in Wisconsin, of their own initiative, have hired the above-mentioned Richard et. al in an attempt to monitor for PM 4. This data will be further analyzed in order to assess what portion of the collected PM4 material is composed of silica. Due to the nature of the project’s funding, it is unclear if the data will ever be published or peer reviewed.

A proposed facility in Scott County has agreed to monitor for Total Suspended Particulate, PM10, and silica. The data from these sites will inform whether or not there are exposure risks to the general public. The MPCA will receive this data.

MPCA Air Compliance and Enforcement staff need to determine how to more effectively regulate the existing and planned processing facilities that include drying.
What We Don’t Know, What Might Be Useful

Concentrations of crystalline silica associated with frac sand mining: As noted above, there is little or no information on the amount of silica in the air that results from frac sand mining, processing, and transportation operations. There are plans to monitor ambient silica associated with frac sand mining in Wisconsin. However, MPCA reports that the Wisconsin study is being funded by industry and therefore the results may or may not be made public. A study funded by the State of Minnesota would ensure public availability of the results. Such a study might provide a basis for new state air quality standards for silica.

Health Impact Assessment: A Health Impact Assessment (HIA) is a research and community engagement process that can be used to help ensure that people’s health and concerns are being considered when decisions on infrastructure and land use projects are being made. The National Research Council defines HIA as "a structured process that uses scientific data, professional expertise, and stakeholder input to identify and evaluate public-health consequences of proposals and suggests actions that could be taken to minimize adverse health impacts and optimize beneficial ones."

HIAs have been used to provide important health information to decision makers on a wide range of projects outside the typical health arena, including comprehensive plans, brownfield redevelopment, transportation projects, energy policies, and housing projects. Over 100 HIAs have been performed in the US to help improve public health. Ten HIAs have been completed in Minnesota, mostly on comprehensive plans and transportation projects.

To date, no HIA has been used to evaluate frac sand mining in the US, but HIAs have been used to inform decision makers about additional health effects in projects that have some similarities, including oil and gas leasing, coal mine proposals, and copper, zinc and gold mining. These HIAs may review health issues that are typically included in an Environmental Impact Statement (EIS), such as water and air quality, but they also review additional health effects that are related to the specific site and community. Some health effects considered in these HIAs include reviewing the health effects of newly built infrastructure and traffic to support mining, the influx of migrant workers, and the disturbance of food sources relied upon by subsistence cultures.

An HIA on silica sand mining could provide additional health information for policy makers in determining how to balance health and citizens’ concerns with the economic benefits of silica sand mining. The HIA would need to include an air monitoring study. It also could include additional primary data collection and analysis of other issues, such as the economic impacts on tourism, to be most helpful. Also, the HIA should provide a quality public process that helps to articulate and clarify citizens’ concerns. An HIA could provide recommendations to policy makers to support possible positive health outcomes and to mitigate or prevent possible negative health outcomes to improve the public’s health and to inform zoning, permitting, monitoring, and reclamation policies. Performing an HIA on silica sand mining is beyond the scope of a standard agency project and would require dedicated funding.
Alternative proppants: Proppants other than silica sand exist that are used for fracking. Are other proppants, such as manufactured ceramics or resin coated proppants, viable alternatives to silica sand that will avoid the air quality and other potential environmental impacts generated by the silica sand industry elements? Should the State consider the availability of non-sand proppants in policy decisions regarding sand mining, processing, and transporting in Minnesota?
IV. Water Quality

- Ground Water

Potential Impacts to Groundwater from Mining

Any mine may create a pathway for pollutants (chemicals and/or bacteria) to more easily reach the groundwater, especially if the bottom of the mine is near or below the water table. Typical mining activity involves the use of heavy equipment and the potential exists for leaks or spills of petroleum products and solvents related to that machinery, although these tend to be fairly infrequent and small in volume. Runoff from contaminant sources near the mine or waste illegally dumped in the mine may also be potential concerns. Additional information regarding potential risks to drinking water associated with mining activities and actions required by the state to minimize or eliminate those risks can be found in the August 2009 MDH whitepaper titled: “Wellhead Protection Issues Related to Mining Activities.” (available online: http://www.health.state.mn.us/divs/eh/water/swp/mining.pdf)

In some areas where frac sand mining is planned, particularly southeastern Minnesota, the underlying bedrock is prone to karst formation (i.e. dissolution of the bedrock creating caverns, sinkholes, and other features). Groundwater is particularly vulnerable to contamination in karsted regions, due to highly interconnected vertical and horizontal pathways and high flow velocities within the bedrock. Mining activities that remove the protective cover above karsted bedrock formations may help to accelerate movement of surface contaminants to the groundwater. Even after reclamation, a covered mine pit remains as a depression on the surface of the bedrock where infiltrating water may collect, potentially concentrating infiltration in a small area, accelerating the formation of karst features and increasing the potential for groundwater contamination.

Potential Water Quality Impacts Associated with Frac Sand Mines

Some frac sand mines use chemicals called flocculants to remove silt and clay in the sand washing process. Two commonly used flocculants are polyacrylamide and polydiallyldimethylammonium chloride. While these chemicals are generally considered to be environmentally safe, they often contain low concentrations of related chemicals (acrylamide and diallyldimethylammonium chloride, or DADMAC) which are of concern. The US Environmental Protection Agency (EPA) classifies acrylamide as “likely to be carcinogenic to humans” and has set a National Primary Drinking Water Regulation of 0.5 parts per billion. DADMAC, in the presence of water disinfectants, may lead to the formation of N-nitrosodimethylamine. The EPA has just begun to evaluate nitrosamines as possible drinking water contaminants and has not established any drinking water standards for them. Although the concentrations of these chemicals in the sand wash water is likely to be low, MDH recommends monitoring of the groundwater at facilities where these chemicals are to be used to ensure safe drinking water levels are not exceeded.
There have been anecdotal reports that groundwater near frac sand mines becomes slightly more acidic (lower in pH) as a result of mining. It is not known whether this is typical of all sand mining operations, frac sand mines in general, or specifically related to the geology of the particular mines that were studied. MDH conducted a preliminary review of water quality literature but was unable to verify or refute these reports. Increasing the acidity of groundwater may cause naturally occurring minerals such as iron and manganese to more easily dissolve into the water. While generally not a health concern, these minerals can cause water to have unpleasant taste and odor and may cause staining, resulting in the need for treatment to make the water potable. Until the relationship between frac sand mines and water chemistry is better understood, MDH recommends that, among other water chemistry measures, pH be monitored in the groundwater near frac sand mining operations.

Potential Mining Impacts on Nearby Water Supply Wells

Any activity, such as mining, which removes large volumes of groundwater has the potential to impact nearby wells. The most likely impact is lowering of water levels, possibly even causing a nearby well to go dry. The Minnesota DNR Waters Division reviews large water removal activities to ensure such groundwater use will not harm wells in the area and MDH Source Water Protection Program evaluates whether there are any potential risks to community water supply wells.

- **Surface Water: Permits and Standards**
  - MPCA regulates a facility or site through general and individual National Pollutant Discharge Elimination Systems/State Disposal System (NPDES/SDS) water permits. The permits regulate wastewater and stormwater discharges to ground and surface waters from sites.
  - Frac facilities that have a surface water discharge are required to monitor their discharge. Depending on whether the facility has an individual or general permit, the discharge will be monitored for Total Suspended Solids (TSS), Potential of Hydrogen (pH), Flow and Turbidity at a frequency determined within the facility/site’s NPDES/SDS permit. The results of the monitoring will be submitted to the MPCA.
  - Currently, sediment related permits do not carry the same weight in the inspection program as chemical, biological, toxic, or high volume waste discharge facilities that the program is also charged with oversight. The MPCA has and will continue to respond (usually reactive, from complaints) to events at these facilities and the MPCA has had and continues to have enforcement cases with sand and gravel operations throughout MN.
  - Chemical use: With the literature available at this time, MPCA does not anticipate specific or unique environmental or health risks from use of polyacrylamide in sand processing facilities that are not already addressed through the current water permitting
process. If newer and better information comes along in regards to polyacrylamide, this assessment could change and will be addressed at that time.

- **What We Don’t Know, What Might Be Useful**

**Cumulative Impacts:** The cumulative impacts to water quantity and quality of multiple frac sand mines in relatively small areas are not well understood – monitoring wells should be required at mines to measure groundwater elevations, flow directions and water quality.

**Guidance for Drinking Water:** No state or federal drinking water standards exist for chemicals of potential concern associated with frac sand operations (i.e. flocculants). If these chemicals are detected in groundwater, MDH could evaluate whether drinking water guidance can be developed.

**Testing Methods:** No commonly accepted analytical testing methods have been developed for the chemicals of potential concern and very few commercial laboratories offer testing for these chemicals – MDH Public Health Laboratory could explore the feasibility of developing analytical test methods for acrylamide, DADMAC and NDMA.

**Long Term Effects in Karst Regions:** Need more information on the long-term implications for groundwater quality of reclaimed mines in karst-prone regions of the state – water quality monitoring should be required following mine closure. The University of Minnesota and Minnesota Geological Survey are actively researching karst and groundwater in Minnesota and should be consulted regarding additional mining-related research needs/opportunities.
V. TRANSPORTATION

As a transportation commodity, silica sand is considered a common non-metallic mineral. It is normally handled as a dry bulk commodity, easily transferred by mechanical means including bucket loaders, clamshells, and conveyors. Silica sand is transported both packaged and in bulk by all modes; truck, rail, barge, and intermodal container. It is a chemically inert material included in the non-hazardous USDOT hazmat classification.

While Wisconsin already has 10 times the silica sand mining activity of Minnesota, state residents here have concerns around the rapid expansion of non-metallic mineral production and its transport. Transportation safety is a significant issue resulting from frequent heavy truck and rail trips, and is being addressed in road design, traffic safety, and grade crossing safety initiatives. Local, light duty roads are being most rapidly and directly impacted by concentrated truck traffic. Local jurisdictions have limited resources to react to the damage, but are negotiating through use permits for private sector compensation.

- Trucking and Road Systems

Federal, State Trunk, and State Aid Roadways and Bridges

The average silica sand mining operation will move from 250,000 to a million tons of sand per year to a processing and shipping facility. (‘Transportation Impacts from Non-Metallic Mining in Wisconsin’, Figure 2, ‘Production Projections Per Mine-Based on Proposed Facilities’. WisDOT Northwest Region Systems Planning, Nov. 19, 2012) This equates to a concentrated flow of heavy trucks totaling 70-250 truck trips per day, with half loaded to a full 80,000 pounds GVW. Traffic routes and volumes are determined in consultation with local road authorities and MnDOT. Factors include the most direct route as well as highway condition and capacity. Road capacity to handle the new traffic and current traffic levels is derived from existing data.

MnDOT and county engineers have authority over road designs, safety configurations, and programmed maintenance. Engineers have developed benchmark wear impacts and costs. Wear produced by concentrated traffic is determined based on design standards and life of a specific road versus the new traffic.

The Federal and State trunk highway system is generally able to handle the increased traffic without significant immediate impact. Because these are public thoroughfares with users engaged in traffic crossing jurisdictional boundaries, including interstate commerce, specific commodity or industry-targeted user fees are normally not allowed for non-permit loads. Funding thus is usually attached to mining and conditional use permit fee structures. Non-programmed funding for sand-associated repairs on light duty roads is most commonly negotiated between mining interests and local officials.
Local Roads Designed for Lower Capacity and Loading

The greatest immediate impacts due to mine operations and concentrated heavy truck traffic occur on local township and county roads designed for low traffic volumes and 5-9 ton axle loadings. Normal highway funding available to these governmental units is far from adequate to offset the new and immediate needs for road repair and rebuilds. Serious road degradation may occur in the first 1-3 years, versus a life of the mining operations that is expected to extend for 5-30 years.

Regulation of Trucks (Commercial Vehicle Operations)

MnDOT is charged with administering and enforcing both state and federal commercial vehicle safety regulations, including inspections and audits. Regulatory and statutory direction also covers several areas that directly apply to silica sand transport.

All trucks hauling commodities subject to blowing or dust production, including sand and gravel, must be covered by full tarps at all times on Federal and State highways, and at any speeds over 30 MPH on local Minnesota roads, compliant with M.S.169.81.

Condition of equipment must be maintained by the operator at all times to ensure safe operations of the vehicle and to minimize risk and impacts to other traffic. This includes condition of tires, brakes, signals, operating controls, installed safety equipment, and potential for spill or leakage of commodities.

Legal weight loadings must be observed at all times, to minimize and control wear on roads and bridges. Sand transporters are limited to the default weight limits of 80,000 pounds GVW on five axles without exception. The Department of Public Safety (DPS) may enforce these limits through ticketing and fines, and both DPS and MnDOT provide safety data to the national driver and carrier data bases, which may trigger probation or suspension of driver and carrier licensing. MnDOT maintains strategically located Weigh-In-Motion scales and cameras to provide observation and protection of key infrastructure, including major bridges, to monitor operations within legal limits.

General Highway Safety: Motorized Vehicle and Non-Motorized Shared Use on Identified Mine-Haul Routes

MnDOT and local authorities have a direct responsibility for the safety of all highway users. Heavy truck traffic on a historically light-use road has the potential to significantly increase safety risks for other users, in particular non-motorized use.

Pedestrian, bicycle, and horse & buggy conflicts have been identified in the potential mining areas. This is due to the presence of heavy recreational uses in the region and to local communities such as the Amish, who by choice use horse and buggy for normal transportation. Unless specific allowances are made in traffic routing or road design, such as adequate shoulder widths, these conflicting uses may increase the incidence of serious or fatal accidents.
MnDOT and local engineers and road authorities are pursuing safety mitigation by design. This may include truck climbing lanes, turn and queuing lanes, shoulders, use separations (trails and paths), and proper signage and signaling. All these need to be considered to maintain or improve the highway safety environment. Signage and awareness campaigns, trucker advisements, and other educational efforts also fall under the responsibility of MnDOT and local partners to mitigate possible impacts.

- Rail and Rail Systems

Rail Grade-Crossing Safety, Particularly at Processing Plants or Trans-load Sites

Besides commercial truck traffic, major frac sand operations ship virtually all of their production by railroad to the end users in the oil fields. By rail, raw sand typically is shipped in open hoppers while processed frac sand typically is shipped in covered hoppers to prevent loss of the commercial product during transport. A single site may generate one to five full unit trains of 100-125 cars per week, plus return trips. “Production and Logistics of Frac Sands”, Rick Schearer, Pres. & CEO, Superior Silica Sands, Wisconsin Rail Freight Conference, October 26, 2012. This can significantly raise the level of road/rail conflicts in many of the affected rural areas and add noticeable rail traffic in urban areas. MnDOT administers the state and federally funded rail grade crossing safety program.

MnDOT is responsible for determining the adequacy and the selection of grade crossing warning devices throughout the state. Additional tracks through existing crossings and creation of new highway rail grade crossings must receive approval from MnDOT prior to use. Significant additional truck traffic over existing crossings may warrant consideration of additional warning devices such as flashing lights and gates, cantilevers and traffic signal.

Rail Safety and Operations Regulation

MnDOT has been granted limited authority for rail safety inspection and regulation by statute and by agreement with the Federal Railroad Administration (FRA). FRA and state inspectors coordinate on safety inspections, hazardous materials handling, infrastructure condition, highway overpass and grade crossing construction, and accident investigation. Regulation of commodity handling, safety, and rates defers to Federal jurisdiction due to its status as interstate commerce. This includes Surface Transportation Board federal commerce regulation, design and safety regulation, and all OSHA and EPA regulations that apply.

Branch and Short Line Rail Upgrades and Funding to Improve Rail Condition and Safety

Minnesota, along with Wisconsin and Iowa, have a record of proactively working to preserve and upgrade local, low-volume rail lines to ensure market access for rail-oriented and bulk materials. This supports the economic vitality of rural communities. New mine operations and processing plants require rail access to be economically viable.

The Minnesota Rail Service Improvement (MRSI) program has been the state’s vehicle for offering low-interest loans and earmarked grants to local shippers and railroad short lines to
maintain and upgrade lines and promote rail shipping. It is administered by MnDOT Office of Freight & Commercial Vehicle Operations.

The above map, published in a July 2012 article by the Federal Reserve, shows several sand facilities. The number of facilities may have changed since the map was created. More relevant to this transportation discussion is the mapping of railroads—and lack thereof—serving the mining and processing areas.

source: Federal Reserve Ninth District, in “Sand Surge”.

The above map, published in a July 2012 article by the Federal Reserve, shows several sand facilities. The number of facilities may have changed since the map was created. More relevant to this transportation discussion is the mapping of railroads—and lack thereof—serving the mining and processing areas.
● **Barge and Barge Systems**

Silica sand is hauled by barge in applications similar to rail, open or closed depending on condition of sand. Environmental Protection Agency air and water rules apply. Normal payload is 1,500 tons per barge. A river tow (collection of barges under control of a single towboat) may carry 22,500 tons or more.

There are over two dozen intermodal freight terminals located on the Mississippi and Minnesota Rivers in Minnesota. *(MnDOT map on website)* Port activities, like commercial truck, rail, and barge transport, constitute interstate commerce and cannot be materially restricted by local & state jurisdictions.
What We Don’t Know, What Might Be Useful

Air quality issues (ambient air and impacts) created by transportation:

loading and transporting
   by truck
   by rail
   by barge.

near mines
near processing sites
near loading sites

How many barge terminals are there that currently are dealing with frac sand? Might there be more?

Do publicly owned terminals have management or regulatory options not available to privately owned facilities? If so, which terminals are owned by public entities (port authorities, cities, etc.) versus privately owned?

What EPA air and water rules apply for barge facilities? (referred to in text)

Funding options for local road jurisdictions: Local, light duty roads are being most rapidly and directly impacted by concentrated truck traffic from sand mining industry operations. Local jurisdictions have limited resources to address this. Are the funding means available to local and state government adequate to address the needs?
VI. Governance

- Local Government Land Use, Planning

The following summary of a discussion found in an article by the Federal Reserve Ninth District is a good description of the land use planning challenges faced by residents, local governments, and the mining industry.

Sand mining has sparked protests from residents who have formed groups to monitor mining activity and challenge projects at normally uneventful township and village board meetings. Many of these are small communities where controversy was rare at their meetings. Local governments across the region have responded to the controversy around frac sand mining by imposing bans on new mining operations or expansions. Federal and state governments have some oversight of nonmetallic mines but sand mining in Minnesota and Wisconsin is mostly regulated at the local level. This includes zoning codes and land use permits that require mining companies to fulfill specified conditions. Moratoriums on sand mining enacted by municipal, town and county boards are intended to provide a chance for community leaders and planners to consider stricter regulations for sand mining. *(Sand Surge, Fedgazette)*

Air quality and water quality regulation is described in the respective sections of this report, but in Minnesota and other states, land use planning and regulatory authority rests primarily with local government: county, municipality, township. Such authorities are granted by enabling acts in Minnesota Statutes. There are similarities across the planning and regulatory powers of these three types of local government. However, there also are differences.

Comprehensive planning, or planning that addresses a local government's decision making for the future, is required only in seven county metropolitan area around Minneapolis and St. Paul. This includes the following counties: Anoka, Carver, Dakota, Hennepin, Ramsey, Scott, and Washington. The comprehensive plan of communities in these counties must include specified elements such as land use, housing, parks and opens space, transportation, surface water management, utilities, capital improvements, and the like. In other areas of the state, communities are not required to prepare comprehensive plan (often called general plans) but have the authority to do so. One of the important purposes of a comprehensive plan is to avoid land use conflicts caused by incompatible uses locating in near proximity to one another. A large sand processing facility next to a retail or residential area might be an example. Unfortunately, many communities choose not to plan based on costs, nonchalance, or ideology. The lack of a long range, comprehensive plan often leaves the county, city, or town without guidance or policies on how to deal with issues that arise.

Once policies are established by a comprehensive plan, they are implemented by official controls such as a zoning code, subdivision regulations, or other ordinances. Local government approval of a mining and/or processing facility typically is granted through a conditional use permit or
special use permit as well as other elements of a zoning ordinance or official control. There might be a site plan approval, building permit, or others, depending on the specifics of the official controls of the government unit. These official controls, or regulations, are best when written and administered to promote and implement the policies established by the long range plan.

Planning and regulatory questions become more complex when considering transportation issues. Major roadways fall under several jurisdictions. A municipality has jurisdiction over its own roads, but access onto a county highway requires approval by the county. Access to a state highway requires review and approval by MnDOT. Different roads are intended for differing types and volumes of traffic. —Main Street” in many small cities is a state highway. What might seem normal for a state highway—for example, dozens or hundreds of sand trucks in a day—often is considered disruptive and destructive to a small town’s main street character. While it is easy in retrospect to say that such conflicts could or should have been foreseen and avoided through good land use and transportation planning, the fact is that such situations are common and cannot be shrugged off.

The conflicts are not limited to _main street_ locations or transportation issues. As described earlier, communities known for their scenic attributes draw great numbers of regional visitors, which has created a tourism economy. Removal of bluffs that contain silica sand or the creation of large mines in scenic areas, along with the associated noise, traffic, dust, and other disruptive elements may significantly reduce the attractiveness of these areas for visitors. An additional fear is that a mining economy is limited to the time during which the sand is available and profitable to mine. Once the landscape has been altered, tourism may no longer be an option.

Local governments with mining experience typically require reclamation of a mining site. This will include landscaping, adequate water management design, ensuring stable land on slopes, and other elements. This ensures a site will not be left in an unstable or unsightly condition. However, it does not avoid the changes discussed above—elimination of bluffs or other scenic features, impacts on small town economies, unknown air quality issues, etc.—that have raised concerns among many residents of areas potentially affected by the changes.

The spectrum of planning and regulatory knowledge and experience is vast. Though there are issues with silica sand mining that don’t apply to aggregate mining, there are common elements. A governmental unit that has been reviewing and regulating aggregate mining for decades will have a greater ability to deal with silica sand mining than a governmental unit that has no history with mining of any kind. Nonetheless, because of the separate elements of mining, processing, and transportation, the nature of sand mining is posing new challenges even for experienced governmental units.

These complexities and conflicts point out the need for inter-governmental, multidisciplinary cooperation, coordination, and planning. A plan and official controls based on understanding the missions and requirements of other jurisdictions will better accommodate real world situations.
● **Environmental review categories**

Minnesota Rules 4410 were prepared to implement the environmental review program established by Minnesota Statutes Chapter 116D, the Minnesota Environmental Protection Act (MEPA). The Rules include mandatory categories for environmental review and the responsible governmental unit (RGU) for each category. Each category included a threshold, usually based on project size, the crossing of which places the project in the mandatory review category. The review might be an Environmental Assessment Worksheet or an Environmental Impact Statement. The following mandatory review categories do or may apply to silica sand mining facilities:

**4410.4300, Mandatory Environmental Assessment Worksheet**
- Subp. 15. Air pollution. RGU: Minnesota Pollution Control Agency
- Subp. 24. Water appropriation and impoundments. RGU: local government
- Subp. 27. Wetlands and public waters. RGU: local government
- Subp. 36. Land use conversion. RGU: local government
- Subp. 36a. Land conversion in shoreland. RGU: local government

**4410.4400, Mandatory Environmental Impact Statement**
- Subp. 9. Nonmetallic mineral mining. RGU: local government
- Subp. 11. Industrial, commercial, and institutional facilities. RGU: local government
- Subp. 20. Wetlands and public waters. RGU: local government
- Subp. 27. Land conversion in shorelands. RGU: local government

The rules also give governmental units, including the EQB, the authority to require an EAW for projects that may have the potential for significant environmental effect even if the project does not cross a mandatory review threshold.

The various elements of the silica sand industry (mining, processing, transporting) create a significant challenge in determining if a proposed project crosses a size threshold established by the mandatory categories and thus requires environmental review. The concepts of ‘phased project’, ‘connected actions’ will apply. The rules require that multiple projects and multiple stages of a single project that are connected actions or phased actions must be considered in total when comparing the project or projects to the thresholds” of the mandatory review categories. For example, several mines operated by the same firm often are phased actions. A new mine and its new processing facility located off site may well be connected actions.

● **Noise**

Minnesota Rules 7030 establish maximum noise levels in noise area classifications. These standards may or may not be an issue near sand mining or processing facilities. Noise monitoring to ensure the standards are met requires specialized expertise.
Quality of Life

There are intangibles that should not be overlooked. The rural character of an area and the small town character of a city are examples. Many people believe these extend beyond discussion of specific regulatory authorities or rights. In fact, planning, regulations, and property rights established by law are tools for identifying, promoting, and protecting these intangibles.

The noise, dust, and light created by industrial activities can and should be considered when planning the future of a community.

What We Don’t Know, What Might Be Useful

Guidance and Best Management Practices for Local Governmental Units: The nature of sand mining with its varied elements is posing challenges even for experienced governmental units. A multi-discipline study resulting in a guidance document would be useful for local governments. This effort would examine and provide guidance on such things as:

- statutory authorities
- review topics
- information needs
- provision and maintaining necessary infrastructure
- how to address the different elements: mining, processing, transporting
- best management practices for local governments in permitting and ongoing monitoring
- best management practices for facility operators for planning and managing facilities
- reclamation requirements

Additional Review and Guidance on Connected Actions and Phased Actions in Environmental Review: Further examination of these concepts as they apply to the varied elements of the silica sand mining industry would be useful to local governments.

Mineral Rights vs. Surface Rights: Questions have arisen regarding whether or not subsurface rights owned by one person would allow sand mining on private property where the surface rights are owned by another person. Because sand mining usually is done by surface mining or bench mining, the surface of the land would be affected.
VIII. POTENTIAL IMPACTS ON SENSITIVE RESOURCES AND MAPPING PROJECT

Areas with the potential for silica sand mining extend across large areas of the state. Processing sites and associated transportation facilities exist and may be proposed for locations not in direct proximity to mines. Many sensitive resources exist in these areas and could be subject to significant impacts. Planning for the different elements of the industry would benefit from identifying what other resources could be affected. Assembling currently held information will allow for studying the potential impacts. It also will help determine what information is not available but that would be useful to obtain. The overall purpose would be to provide information on the potential impacts on habitat, impacts on threatened and endangered species, and on other sensitive resources.

Summarized below is a mapping project proposal that would pull together these data layers to create a tool that would be usable or available to state and local government units. This is not a standard agency project and therefore would require dedicated funding.

• Proposed Mapping Project Scope of Work

Purpose: Develop GIS based mapping project for counties that contain silica sand resources for local governments and potential project proposers as a planning tool for siting mines and to help scope out potential issues that would need to be addressed with specific proposals.

Deliverable: 1) An ArcMap project that contains prebuilt data layers of interest that would be converted to an interactive map available on the internet. The maps would be organized by county. A series of static maps would also be prepared for silica sand resources in each county. The interactive map and static map would provide text, interpretation, and data for potential users.

2) As a separate but related project, several hydrogeological settings could be identified for further evaluation. A three dimensional depiction of setting will be provided to assist in development of conceptual models for better understanding impacts from mining proposals.

Map Content: ArcMap Data including:
• Geologic Atlas
  o Houston – in progress
  o Winona – in progress
  o Wabasha – complete pdf and GIS
  o Goodhue – complete pdf and GIS
  o Dakota – complete pdf, limited GIS
  o Washington – GIS only
  o Scott – complete pdf and GIS
  o Carver – complete pdf and GIS
  o Sibley – complete pdf and GIS
- Nicollet – complete pdf and GIS
- LeSueur – no atlas
- Blue Earth – complete pdf and GIS

- Silica sand resources within 50 feet of the ground surface
- Karst features
- Trout streams
- Public waters
- Wetlands
- Official Fens
- Sites of Biodiversity (moderate, high, and outstanding)
- Numbers of known occurrences of threatened and endangered species within a Section (Township?). Separate numbers for plants and animals

- Land cover data
- Railroads
- Highway corridors
- Population Centers
- Prevailing wind
- Wind speed

- Potential Additional Data: These data layers would need to be assembled from a variety of sources, including individual local governments. Some work has been accomplished on this but the data is varied and requires verification and updating. These layers would be useful in considering cumulative potential effects, connected actions, and phased actions.

  - silica sand mines and processing facilities.
  - Sensitive populations:
    - schools
    - licensed daycare centers
    - nursing homes
    - hospitals
    - clinics

Example Map Output:
Example Three Dimensional Figure:

Level of Effort:

Production of a web based interactive map and static county maps would require the following tasks:

- Compilation and verification of data (meta data)
- Map production
- Development of web instructions, caveats, and data limitations
- Development of scripts or analysis tools
- Development of hydrogeological settings (4-6)
- Web design and testing
- Data maintenance