SUPPLEMENTAL INFORMATION REGARDING
NONMETALLIC MINING IN GOODHUE COUNTY, MINNESOTA

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Goodhue County

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INTRODUCTION

Summit Envirosolutions, Inc. (Summit) assembled a team of geologists, engineers, hydrogeologists, planners, biologists, archaeologists, and landscape architects (Summit Team) to work with the Goodhue County Mining Study Committee (GCMSC) over the past several months to answer questions, review technical data, review suggested revisions to Article 14 of the Goodhue County Zoning Ordinance, and review the “Goodhue County Mining Study Committee Summary Report July 2012” (herein “GCMSC Report”). The Summit Team has prepared this report to provide relevant data and information on nonmetallic mining, particularly with respect to best management practices, that have not previously been provided to GCMSC.

Primary team members and areas of expertise include:

- Summit Envirosolutions – Geology, Hydrogeology, Water Quality, Geographic Information Systems, Cultural Resources
- de maximis Data Management Solutions – Geographic Information Systems
- Bruce Kramer – Geology, Hydrogeology, Mining and Processing Methods
- TKDA – Planning, Engineering, Architecture, Landscape Architecture
- EcoSmith Consulting – Planning, Biology, Ecological Resources
- Kestrel Design Group – Landscape Architecture, Horticulture

A copy of “Silica Sand Mining in Wisconsin” prepared by the Wisconsin Department of Natural Resources (January 2012) is included as Appendix I, incorporated by reference, and herein referred to as the “WDNR Report.” The WDNR Report contains information specific to the silica sand mining in Wisconsin and presents information regarding mining methods, potential environmental impacts, and regulations. The WDNR Report is valuable to Goodhue County because it provides a comprehensive description of the environmental issues specifically associated with nonmetallic mining. The Summit Team generally agrees with the overall conclusion in the WDNR Report that the existing regulatory framework, at both the county and state level, is sufficient for protecting public health and the environment. There are two specific areas where the WDNR Report acknowledges that more data, information, and/or regulation are needed:
1. Data are lacking on the amount of respirable crystalline silica, known to cause silicosis in mine workers, contained in dust from mines, and there are no state or federal regulatory standards for silica dust in ambient air.

2. Data are lacking for the fate and transport of linear anionic acrylamides (LA AMD) in groundwater. These compounds are used as flocculants in the water recycling steps for sand processing.

The Summit Team recognizes that most of WDNR’s analysis was qualitative based on their knowledge and experience as of January 2012. As the development of the mining of this valuable mineral resource evolves, it is expected that quantitative data regarding the environmental impacts will be collected, analyzed, and reported. Goodhue County has the opportunity to encourage the collection of monitoring data that will allow a more quantitative analysis of environmental issues in the future.

This draft report supplies background and supplemental information to the GCMSC Report and WDNR Report. Section 1 discusses the geology of Goodhue County, the Geographic Information Systems (GIS) data and tools developed by our team, and the current status of permitted mining facilities in the County. Section 2 provides a brief overview of environmental regulations not included in the GCMSC Report. Section 3 supplies supplemental information for environmental impacts not covered in depth in the WDNR Report, GCMSC Report, and for areas not currently addressed in Article 14 of the County Zoning Ordinance. Section 4 presents reclamation concepts and a review of successful components for reclamation plans.

1.0 MINING ASSESSMENT

1.1 Background

A basic understanding of geologic terms is important to distinguish between various kinds of mineral resources and mineral mining. The following paragraphs give background information for the County’s nonmetallic mineral resources.

The earth’s crust is predominantly composed of the elements of oxygen (55%) and silicon (27%). The remaining 18% of the earth’s crust contains over 92 elements that are found in nature. Different elements combine to form different minerals. Quartz, for example, is a compound of silicon and oxygen. Feldspars are minerals that are also made up of silicon and oxygen, but they also contain aluminum, calcium, potassium, and sodium. Quartz and feldspars, as well as other minerals, fall into a category of minerals known as silicates.
While elements are the building blocks of minerals, minerals are the building blocks of rocks. The three types of rocks are igneous, metamorphic, and sedimentary. Igneous rocks are associated with volcanic activity. Metamorphic rocks have igneous or sedimentary origins but have been subjected to enormous amounts of heat and pressure from the shifting of plates over the earth’s mantle. Sedimentary rocks are usually the result of erosion and can be formed from igneous, metamorphic, or other sedimentary rocks.

Layers of rock that have been laid down over long periods of time underneath today’s topsoil are known as bedrock. Bedrock can have different components depending on the location. The three broad types of bedrock are listed below; these types are often interbedded with each other, meaning that one type of bedrock can contain a thin layer of another type.

1) Limestone Beds. Limestone is a sedimentary rock made up of the mineral calcite. Calcite is also known as calcium carbonate, because it is made up of calcium plus two other elements (carbon, and oxygen) that form carbonate. Dolomite is another sedimentary rock; it is a magnesium carbonate. Both limestone and dolomite can contain other minerals, such as quartz and feldspar, as well as trace amounts of other mineral oxides and sulfides.

2) Shales. Shales are composed of silt- and clay-sized particles that often have very complex chemical formulas and often contain silicates.

3) Sandstones. Sandstones are composed of sand-sized grains of quartz, feldspars, and numerous accessory minerals and are often cemented by calcite or quartz.

The geologic setting in Goodhue County is characteristic of a large portion of the north central United States. Geologic evidence indicates that large oceans covered this area of North America for tens of millions of years. Different rock types were formed based on the depth of the ocean and the climate at the time rocks were deposited. Limestone and dolomite can form in warm, shallow water (where reefs of animals having calcium carbonate structures accumulate) or in deep oceans (as microscopic organisms die and accumulate on the ocean floor). Shale forms offshore from beaches (as fine particles accumulate from the land) or in deep water (as ocean “mud” accumulates on the ocean floor). Sandstone forms in beach environments, where wave action “rolls” particles until they become rounded and wind activity creates dunes.

Bedrock units in the upper Midwest have been catalogued by geologists since the 1800s. In general, bedrock units are named for the “type section,” or the place where they were first characterized in detail. That is why the names Decorah (Iowa), St. Peter (Minnesota), Platteville
(Wisconsin), and Jordan (Minnesota), among others, are used as the names of rock formations in this area.

The geologic section presented in the GCMSC Report illustrates a “rhythmic interbedding” of sandstone, shale, and limestone in eastern Goodhue County. This rhythmic interbedding resulted from seas that transgressed (got bigger) and regressed (got smaller) during the Cambrian Period (550 to 490 million years ago) and Ordovician Period (490 to 450 million years ago) of geologic time. The environment in which sandstones were deposited is particularly important for the silica sand mineral resource in Goodhue County. The beach and wind processes of the St. Peter Formation, Jordan Formation, and Ironton/Galesville Formations resulted in the relatively large grain sizes, sorting, and rounding that characterize these formations.

Grain size is an important concept in understanding geologic terms. The word “sand” refers to a grain size, not a type of rock or mineral. Natural forces like water, wind, gravity, and glaciers can erode rocks into loose deposits of various grain sizes. The general categories of these deposits are boulders, cobbles, pebbles, sand, silt, and clay. The Wentworth Scale of grain sizes is presented in Appendix II. This scale shows the various sizes of particles and the numerous ways geologists measure the grain sizes (e.g. sieve size, millimeters, inches).

Sand sizes are critical to the process of hydraulic fracturing described in the WDNR Report. “Frac sand” is used to prop open the fractures (hence the term “proppant”) used in oil and gas extraction, and there is an optimal size that enables oil and gas to flow through the fractures. Petroleum geologists and reservoir engineers determine the sand size that will optimize production efficiency for a particular well. In general, the oil and gas industries currently purchase three main proppant products to increase production by injecting the sand under high pressure into fractures. These products, from coarse to fine, include:

- 20/40 – sand sizes are between the #20 and #40 sieves (see Appendix II),
- 30/50 – sand sizes are between the #30 and #50 sieves, and
- 40/70 – sand sizes are between the #40 and #70 sieves.

1.2 Nonmetallic Mineral Framework of Goodhue County

The nonmetallic mineral resources in Goodhue County, and how those resources are used, are as follows.

1. Kaolinite, Illite, and Montmorillonite (clay): pottery and sewer pipe
2. Peat (organic, fibrous material): soil amendments, filtration, and fuel
3. Industrial sand and gravel (glacial- or fluvial-derived (river deposited) sand and gravel deposits made up of igneous, metamorphic, and sedimentary rocks eroded and redeposited): road base aggregate, concrete, asphalt, engineered fill, traction control, filtration, landscaping, sand blasting, and bedding sand

4. Calcium and Magnesium Carbonates (limestone and dolomite): road base aggregate and surfacing, cement, concrete, rip rap, agricultural lime, foundation backfill, and landscaping rock

5. Silica sand (pure quartz sand): proppant, glass, foundry molds, optical fibers, water purification/filtration, architectural and engineered coatings, and bedding sand

The distinction between aggregates and silica sand is important. Aggregate is a general term for both #2 (crushed limestone/dolomite bedrock) and #3 (industrial sand and gravel) above. Aggregate is used in multiple industrial, building, and construction applications. Silica sand is a deposit that contains a high percentage of pure quartz sand that has properties used for specialty manufacturing processes such as glass and foundry operations, water filtration, and as proppant for the oil and gas production industries.

The geologic units that are associated with potential silica sand mining in Goodhue County include:

- St. Peter Formation,
- Coon Valley Member of the Prairie du Chien Group,
- Jordan Formation, and
- Ironton and Galesville Formations.

The St. Peter Formation is known within the silica sand industry as “Ottawa Sand,” among other names. It has been mined extensively from Illinois to Minnesota in areas where the formation is close to the surface. In Goodhue County, the St. Peter ranges up to 150 feet thick and is relatively close to the surface in the area shown on Figure 1. While a potential proppant source, the average grain size within the St. Peter is not as large as the Jordan Formation or Ironton and Galesville Formations. In the current market, this grain size will not be sought as a primary source of proppant. The finer grain sizes are used more in the gas production industry, and a decrease in gas prices over the past six months has lowered the demand for finer grain sized proppant products (e.g. 40/70).

The Coon Valley Member of the Oneota Formation has been the source of geologic debate over the past several decades regarding the geologic period when the rocks were deposited. Based on
work by Mr. Anthony Runkel with the Minnesota Geological Survey, among others, the Coon Valley Member is considered to be Ordovician aged and part of the Prairie du Chien Group. It is variable in thickness but is generally approximately 25 feet thick. Testing indicates that high quality silica sand may be present locally. The Coon Valley Member is present between the Hagar City Member of the Oneota Formation and the Jordan Formation and contains interbedded sandstone and shale. The lower portion of the Coon Valley is extremely hard, and forms the top, or “back,” of the underground mines in western Wisconsin.

The Jordan Formation averages 100 feet in thickness where it has not been eroded and is comprised of two members, the Van Oser and the Norwalk. Only the Van Oser Member contains sand of the size and quality for use as proppant. This unit can vary in thickness from 10 to 75 feet across the upper Midwest. The Jordan sandstone will be the primary target of silica sand producers in Goodhue County, therefore, our efforts were concentrated on evaluating this bedrock unit.

The Ironton and Galesville Formations, known in Wisconsin as the Wonewoc Formation, are commonly over 100 feet thick and contain sand of the quality suitable for use as proppant. However, these formations are deeply buried in Goodhue County and will not likely represent a significant source of silica sand in the area.

The non-silica sand geologic units throughout Goodhue County include the Galena Dolomite, Decorah Shale, Platteville Limestone and Glenwood Shale, Prairie Du Chien Group (except the Coon Valley Member), St. Lawrence Formation, and the Franconia Formation. The dolomite and limestone units that are interbedded with the sandstones are currently being used, or could be used, for construction aggregate, rip rap, or landscape stone. The Cretaceous-aged rocks present in the west-central portion of the County are generally comprised of sandstone, clay, and shale and are less than 30 feet thick; while used historically for clay, they are not currently considered significant nonmetallic resources. The outwash/alluvium along with the sand and gravel associated with glacial till are currently used for construction aggregate, concrete, and landscape stone.

1.3 Status of Existing Mining

Goodhue County has excellent GIS resources and staff. GIS data were obtained from Goodhue County and the Minnesota Geological Survey (MGS) regarding mining related layers. These layers included Light Detection and Ranging (LIDAR) data, aerial photography, additional geologic and hydrogeologic data, and the locations of permitted quarry/extraction sites. Additional data layers were obtained relating to the Goodhue County Environmental Constraints Land Use Evaluation (ECLUE) Model prepared by 1000 Friends of Minnesota in 2009. The
ECLUE data are high-quality GIS layers of numerous physical and environmental data that will be a valuable resource for future analysis. Layers in the GIS include, but are not limited to, the following.

- County Boundary
- Civil Divisions
- Township, Section, Range
- Roads and Railroads
- Soils
- Slopes
- Surface Water Features
- Sensitivity to Groundwater Pollution
- Watersheds
- Wetlands
- Color Aerial Photography
- Digital Elevation Models
- Goodhue County Geologic Atlas
- County Well Index
- Permitted Mines
- Bluff Lands
- Shoreland
- Sinkholes
- Forested Areas
- Aggregate Resources
- Natural Resource Inventory
- Cannon River Wild and Scenic Designation
- Registered Feedlots
- Floodplains

The GIS data were used to:

- Evaluate the existing permitted nonmetallic mines;
- Evaluate the potential presence of other mines that may exist as unpermitted or abandoned mines;
- Identify (and describe) strata above and immediately below target sand layers and assess the marketability and feasibility of mining those strata;
- Identify bluff areas as defined by Goodhue County Ordinance Chapter 12 and vertical faces that may be natural cliff areas or mine walls; and
• Delineate areas where Jordan sandstone deposits are near the surface and are not excluded from mining due to current regulatory setbacks.

Figure 1 shows the existing permitted mines in Goodhue County using the bedrock geology layer as a background.

Note: It is important to understand that the figures in this supplemental report are not intended to be used by readers to evaluate specific areas or parcels. The figures generally show either the entire dataset or examples of the data set at smaller scales. The Summit Team will deliver GIS layers and tools developed as part of this study to County staff for future use.

Table 1 presents information in the County database and information obtained by County staff for this study. This table summarizes the bedrock formations or other minerals mined, the bedrock formations above and below the mined mineral, estimated depth to silica sand below the current mine floor, information regarding the mined product uses, market, mining method, amount of annual production, water use, traffic, blasting, and processing equipment. The information represents a combination of geologic interpretation by the Summit Team, the County’s database for registered mines, and a survey conducted for this study. The geologic interpretation involved the use of GIS layers described below for the Jordan sandstone, the Goodhue County Geologic Atlas, and the County Well Index (CWI) maintained by the Minnesota Department of Health (MDH). In the case where the St. Peter sandstone was the first silica sand deposit below the existing mine floor, the elevation of the top of the St. Peter (and corresponding estimated depth to reach it) was estimated from drilling logs of nearby wells. Highlights of the analysis include the following observations.

• Over half of the operations are mining limestone from the Prosser, Cummingsville, Platteville, Shakopee, and Oneota Formations and supplying crushed aggregate to the state, county, townships, construction companies, and concrete producers, mainly for use in roads.

• Of the remaining mines, the majority report sand and gravel mining from Quaternary deposits and supply aggregate to the state, county, townships, construction companies, and concrete producers, mainly for use in roads and buildings.

• Twelve limestone and dolomite mines have Jordan Sandstone beneath the mine floor. Of these, the depth to Jordan Sandstone is less than 50 feet at four of the mines.

• Crushed aggregate (limestone and dolomite) produce significantly more product than industrial sand and gravel operations.
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- None of the mining operations report that dewatering is necessary to remove the mineral resource.

- Approximately 30% of the facilities report using water for washing and dust suppression.

- Truck traffic is reported to range from 3 to 150 trucks per day.

- Over 40% of the operations report using blasting techniques.

Summit received 2011 LIDAR-sourced elevation data (supplied to the County from the Minnesota Department of Natural Resources (MDNR)) from the County on June 24, 2012. The data contain elevation values for square-meter cells across the County. Figure 2 presents the digital elevation model (DEM) which shows shading of the various elevation ranges. A branch-like drainage pattern caused by erosional processes is evident across the County.

A statistical analysis was performed on the DEM to evaluate the cells for the potential for vertical walls. The technique, called a neighborhood analysis, uses a moving window of nine cells to calculate the value of the center cell of the nine-cell block. A filter was applied for values less than two standard deviations. The result of this effort is a new GIS layer of “high slopes” that depicts areas with near-vertical high walls, whether fabricated (quarries, road cuts, etc.) or natural (erosional). A crescent-shaped group of cells, forming a “signature” that indicates a mine, was observed for existing mines in the County. When used in conjunction with the historic aerial photography and historic LIDAR data, it becomes feasible for an analysis of the change in topography within the County. The tools can be used for future LIDAR data sets for ongoing change analysis. Rough estimates of the amount of material mined are also possible using these tools. Figure 3 presents an example of the comparison between the high slopes layer and the aerial photograph at two existing mines.

In order to estimate the distance between the floor of an existing mine and an industrial silica sand layer, several new layers of data were necessary. The elevation of the top of the Jordan Formation was not available in digital format. Therefore, Summit obtained a hand-drawn map showing the depth to Jordan that represents work performed by Mr. Anthony Runkel of the Minnesota Geological Survey predominantly in the 1990s. Summit digitized the contours drawn by Mr. Runkel based on his work and converted the contours to a digital grid. This grid was then subtracted from the 2001 digital elevation values to obtain elevations of the top of the Jordan across the County. It should be noted that these are estimates for the purposes of the study and should not be used for prospecting, reserve analysis, or construction purposes. Figure 4 presents the end result of the shaded elevation ranges for the top of Jordan Formation.
A database and shapefile were then created in GIS to document the observations at the permitted mines. Aerial photography and LIDAR data were used to estimate the acreage and square footage of the mine footprint. Vertical distance to the Jordan Sandstone from the floor of the existing mines was then estimated at each applicable mine. These values are presented in Table 1.

Finally, the GIS tools were tested to evaluate different permutations of the accessibility of the Jordan Sandstone under different mining scenarios and the existing and proposed ordinances ("accessible Jordan"). The depth to Jordan was used to evaluate whether companies could economically remove various thicknesses of overburden (predominantly Oneota Formation) to excavate Jordan Sandstone. Stripping ratios are used by mining companies to evaluate the amount of overburden economical to remove for a given mineral reserve. A stripping ratio is the amount of overburden that needs to be removed versus the amount of product mined. For example, if 90 feet of Prairie du Chien rocks need to be removed to reach 30 feet of economically viable Jordan Formation, the stripping ratio would be 3 to 1 (3:1). Figure 5 presents a County-wide view of this analysis using ranges of the depth to the Jordan Sandstone. The analysis excluded areas due to bluff slopes, soils, and setback distances contained in the County Ordinance.

Under current proppant pricing, and dependent on fluctuating aggregate demand for crushed Oneota Formation, the economical stripping ratios for the Jordan sandstone could vary significantly. The availability of high-quality proppant elsewhere in the region where stripping ratios are less than 1:1 (i.e. there is more proppant than overburden) could reduce the amount of overburden that companies are willing to strip. The stripping ratios in areas of accessible Jordan could also drive mining companies to evaluate the feasibility of underground operations.

1.4 Future Mining in Goodhue County

1.4.1 Mining Decisions

The economic value of a nonmetallic mineral resource is variable based on natural abundance and the current demand. In the case of industrial sand (e.g. sand and gravel), the value continues to rise as sources are depleted. In the case of silica sand, its relative rarity has been the primary driver of its historically higher value. This difference in value has been recognized for over 50 years by the United States Tax Code, which treats industrial sand and gravel differently than silica sand from the perspective of depletion allowances. Historically, industrial sand has a depletion allowance of 4 percent, while silica sand has a depletion allowance of 14 percent. The result is that silica sand producers can deduct an additional 10 percent from their federal tax burden. While silica sand has historically been more valuable than industrial sand, the current
demand for use as proppant for hydraulic fracturing in the oil and gas production industry continues to fuel fluctuating yet elevated prices.

A mining company usually starts exploration long before making any mining decision. Sand mining is no exception. Mining companies initially use independently acquired data; published and unpublished documents; and county, state, and federal geologic resources to begin evaluation of a resource. Consultants, when hired by private landowners or mining companies, use similar information.

Mining companies decide on investments in mining projects using projections of costs of mining and processing and then comparing the anticipated rate of return they might receive on any one investment to other investment opportunities or mining projects available. This is generally true for metallic mining prospects, industrial minerals prospects, silica sand prospects, and construction aggregates including industrial sand and gravel.

Once an area or location is identified as having mineral resource potential, mining companies will use land acquisition specialists to identify parcels for acquisition or leasing. In some cases, large landowners may approach a mining company to evaluate their property for determination of resource value. A first right of refusal may be given to the mining company with prior negotiated lease and royalty rates, given successful exploration, permitting, and production. Potential exploration sites are prioritized by the mining company using internal criteria. In many cases, some sacrifice of the “cost of mining” is accepted if the exploration site is located near state or federal highways or rail transportation corridors.

In areas that are not state or federal lands, two types of acquisition strategies are usually used prior to on-site exploration: 1) if the site is a large area with many small parcels, a gradual land acquisition strategy is usually used to acquire parcels using a third-party acquisition strategy; or 2) if the site consists of a single or a small number of larger land holders, lease arrangements are negotiated. In almost all cases where multiple parcels are needed to accomplish a particular mining strategy, some combination of outright acquisition and leasing is required.

### 1.4.2 Mining Methods

Once a mineral deposit has been identified, it is delineated by geology, mineralogy and/or property ownership. It is then explored with data from soil and rock borings. After these steps, the mining company will choose a mining method that is physically, economically, and environmentally best suited to allow maximum recovery of the resource.

Factors affecting this mining method choice are: 1) special characteristics of the deposit (size, shape, attitude (horizontal, inclined, or vertical), and depth below the surface); 2) the mechanical
properties of the deposit itself and the rock surrounding the deposit; 3) groundwater and hydraulic conditions; 4) economic factors, including the quality of the mineral deposit, comparative mining costs, and desired production rates; and 5) environmental and regulatory factors affecting the mine site. Environmental and regulatory factors may include: a) the desire to maintain visual and esthetic quality of open space in the local environment; b) the desire to maintain current surface uses; c) the potential for subsidence of the surface above near surface underground workings; d) groundwater drainage issues and the prevention of any degradation of groundwater or surface water quality.

**Surface Mining**

Surface mining involves open-air excavation for removing mineral resources and is common in Goodhue County. The currently permitted mines in the County are surface mines. Surface mines can be categorized into three types: 1) Placer mines, which involve panning and sluicing, hydraulicking (or large placer), and dredging; 2) Open Pit mines, which may include single bench, multiple bench, strip, or quarry mining; and 3) Glory Hole mines, which is an open pit method that utilizes underground access.

Placer operations on small scales are common in most states. Goodhue County has some permitted placer mines in the Mississippi riverbed. These mines are used for the extraction of industrial sand and gravel for use in various local applications including concrete for roads and building materials.

Open pit aggregate mines are common in the County. These mines operate on a single or multiple bench method where each bench is a production location. The maximum stable bench height and bench slope depend on the rock materials that form the bench and high wall. Strip mining is the mining method that is used to mine near-surface seams of coal. This type of mining is not used in Goodhue County.

In glory hole mining, mineral from the mine is removed by open pit methods and allowed to fall by gravity or is deposited in a shaft or “glory hole” to a tunnel underground. The material is subsequently loaded out at an underground drawpoint and transported via truck or rail to the surface. This mining method is not currently used in Goodhue County, but it may have some application in the future.

**Underground Mining**

If the depth of a mineral deposit is excessive and precludes economic extraction due to the cost of overburden removal, or if other conditions exist where open pit mining is not feasible, the mining company will usually select an underground method if the company determines that
mining the resource is still feasible. For underground mining, the challenge for the company is selecting or developing a mining method that provides adequate ground support for temporary or permanent support of the subsurface openings. The selection criteria are based on which method results in a safe environment, including pillar stability, the minimization or prevention of surface subsidence, and creating a portal (entrance area) that is non-obtrusive and safe.

The geology of Goodhue County could allow Self-Supported Openings mining methods. These methods may involve the use of stopes, which are excavations in the form of steps. Variations on the stope theme include: open stope mining with isolated openings; pillared open stopes; open stope mining with random pillars; and open stope mining with regular pillars. Also included in this category of Self-Supported Openings mining methods is room and pillar mining. Room and pillar mining is likely to be selected by a mining company for underground mining in Goodhue County. This type of mining is used in the underground mines near Maiden Rock, Wisconsin. The geology at both locations is similar.

Room and pillar mining is used for flat-lying deposits in which the mineral is of uniform grade, quality, and thickness – similar to the conditions for silica sand mining in Goodhue County. The mined area looks like a grid of pillars and rooms. The rooms are made as wide as safety permits, and this dimension is dependent on the properties of the immediate roof rock. Pillar stability is vital to roof support. Rock mechanics evaluations are integral to the engineering success of this type of mining.

Supported Openings mining methods are less likely to be needed in Goodhue County, but some use may be desired in certain situations. This type includes cut and fill stoping and various timbered fill stoping.

Caving methods are not likely to be used but include sublevel caving and block caving methods.

**Discussion of Mining Methods**

Comparing the two mining methods (surface and underground), surface mining allows a greater flexibility in production, which may include selective mining and the potential for a removal of a larger percentage of the mineral deposit. Fewer workers are needed in surface mining, and worker safety is generally better. Underground mining has a smaller surface footprint; however, mineral resource material will still need to be processed and stockpiled for shipping.

Silica sand would be mined in a manner consistent with best-practice mining operations across the County. For open pit mining, best practices include developing a series of high walls and benches in a quarry. This series is accomplished through the application of drilling and blasting.
technology used in small sections of an operating bench or benches. In many cases, the mined material would be processed at the primary processing plant located at the mine site.

Topsoil and overburden would be the first to be removed through the use of large scraper machines or bulldozers. This material is usually stored on-site for reclamation or used near the boundaries of the site for visual, dust, and noise screening or as safety berm construction material.

Bedrock overburden would be mined and stored or immediately processed through primary and secondary processing for sale. Aggregates are processed for the purpose of developing very specific sizing and usually sold for local use. Some aggregates may be loaded on trains for regional sale if this is an option for the mining location. All overburden mining and sales have a purpose of opening the opportunity to develop the actual mineral of choice – in this case, silica sand. Sometimes, if the site warrants, development of silica sand deposits may be totally dependent on market conditions for these overburden aggregate materials.

Sandstone would be further processed on-site or transported to a secondary processing and loadout area. Secondary processing could be designed as a dry or wet process depending on the methods chosen by the mining company. The entire object and goal of processing the sandstone is to disaggregate the sandstone into the individual sand grains that make up the poorly cemented sandstone.

In some situations, a sandstone or alluvial (water deposited) sand may be located below the water table, and the mining process could be designed as a dredging or dewatering operation. The hydrogeology of dewatering is presented further in Section 3.1.

2.0 REGULATORY SUMMARY

2.1 Federal and State Regulations

To the extent that mining operations generate tailings, waste rock, wastewater discharges, and/or air emissions, mining can adversely impact the environment. Nonmetallic mining activities are regulated by the U.S. Environmental Protection Agency (EPA) and involve every major EPA program. All point source discharges from mining operations must be authorized under a National Pollutant Discharge Elimination System (NPDES) permit, as described in Section 402 of the Clean Water Act. The construction of surface water impoundments is regulated by Section 404 of the Clean Water Act, and Section 402 applies in the case of discharges from these impoundments into waters of the United States.
In general, EPA Regional offices have used statutory authority granted by the Clean Water Act to regulate mining activities through the NPDES permits program since the 1970s. Although permits relating to water quality in Minnesota are issued by the Minnesota Pollution Control Agency (MPCA), EPA’s Office of Water may review state-issued permits to ensure compliance with water quality criteria and effluent guidelines.

Minnesota regulates mining under a variety of laws, statutes, and rules. Minnesota Statutes 84, 93, 103G, 116, and 273, along with Minnesota Rules 4410, 6115, 6125, and 6132, contain many of the requirements that apply to nonmetallic mining activities.

2.2 Environmental Review and Goodhue County’s Ordinance

The Minnesota Environmental Policy Act (MEPA) governs environmental review procedures in Minnesota. Minn. Stat. 116 and Minn. Rules 4410 include the requirements for environmental review that apply to nonmetallic mining activities. Environmental review is a formalized way of gathering information about a project to identify potential adverse environmental effects as well as measures that may be taken to avoid or minimize those effects. State rules require that an Environmental Assessment Worksheet (EAW) be completed for any operation that will excavate 40 or more acres of land to a mean depth of 10 feet or more during its existence to extract or mine sand, gravel, stone, or other nonmetallic minerals (other than peat). The rules require an Environmental Impact Statement if the mining operation will excavate 160 acres or more of land to a mean depth of 10 feet or more during its existence.

Goodhue County regulates mining activities through its Zoning Ordinance, particularly Article 14. Article 14 establishes permitting requirements, environmental review procedures, and performance standards that regulate mineral extraction activities. The current Article 14 contains a rigorous information submittal requirement that exceeds most counties where silica sand is mined. Minnesota’s environmental review rules and Goodhue County’s Zoning Ordinance require owners and operators of proposed new nonmetallic mining activities to submit detailed information regarding the proposed mine. A comparison of the information required to be included by Article 14 of the County Zoning Ordinance and the EAW process indicates that the majority of the information is the same. The main pieces of information required by an EAW but not by the County’s current Ordinance include: (1) nearby sensitive ecological resources (e.g. threatened and endangered species); (2) nearby cultural resources (i.e. archaeological, historical, or architectural resources); and (3) an analysis of cumulative effects.
2.3 County Comprehensive Plan

Goodhue County’s Comprehensive Plan provides the legal basis for the County’s Zoning Map and Ordinance (including Article 14). The Ordinance and Zoning Map must be consistent with the Comprehensive Plan. The Comprehensive Plan identifies the County’s vision for the future and serves as a guide to decision-making related to land use and infrastructure systems.

The County’s current Comprehensive Plan includes goals related to aggregate resources and mining in Elements 1, 3, and 5. Goal 7 in Element 1 includes a goal to manage and maintain aggregate resources in future growth zones. The policies related to this goal discourage mining in environmentally sensitive areas and prime farmable agricultural areas. Policies require that mines have a reclamation plan and that the preservation of aggregate deposits be considered when approving housing development.

Element 3, Goal 2 of the plan addresses water quality protection. This section does not address issues related to mining directly, but it provides general goals for water resource protection that apply to all land uses. Element 5, Goal 2 addresses the compatibility of mining with surrounding urban land uses.

This report may be used to update the Comprehensive Plan, in order to set the stage for future updates to the County’s Zoning Maps and Ordinance. This report and its maps could be added as attachments to the plan. The plan could be updated as follows:

- **Element 1, Goal 7 and Element 5, Goal 2**: The mapping completed for this study may be used to identify more specifically where nonmetallic mining will be permitted in the County. Identification of specific areas or zoning districts in the County where mineral extraction is most appropriate would be consistent with Section 1, Subdivision 1 of Article 14 of the Zoning Ordinance.

- **Element 3, Goal 2**: This goal could be expanded to address protection of surface and groundwater from specific impacts of nonmetallic mining, if needed based on this study.

2.4 County Zoning Ordinance

The County’s current Zoning Ordinance includes detailed requirements for permitting, the permitting process, and performance standards for mining operations. The ordinance requirements are similar to those adopted by many communities in Minnesota. This section discusses some options for the County to consider, based on recent trends in mining ordinances in other Minnesota communities.
The County’s Zoning Ordinance currently permits mining throughout the A-1 and A-2 districts. These districts make up all or nearly all of the land within many townships in the County.

While mining has traditionally been allowed throughout Agricultural Districts in many counties and townships, some communities in Minnesota have created specific Mining Districts to limit this use to areas where mining is currently occurring or where significant resources have been identified. If new mines are proposed outside the designated Mining District, the proposer must apply to re-zone the area for the proposed mine. Communities have created specific Mining Districts for two reasons:

1. Landowners and residents are not usually aware that mining is an allowed use throughout Agriculture Districts, because mining is often considered an “industrial” use. Residents have concerns about the compatibility of mining with the traditional agricultural and rural residential uses in Agriculture Districts.

2. The designation of specific mining districts and requirement for re-zoning areas for mining when this use is proposed outside the mining districts allows for greater control of the locations of mining activities.

The mapping completed by the County, the ECLUE project, and this project may provide enough specific information for the County to designate specific Mining District(s) in Goodhue County. This designation could have a variety of impacts, such as those listed below.

- The identification of specific mining districts on zoning maps would provide specific information to surrounding landowners and project proposers about where this use will be allowed in the County.

- Designation of specific mining districts would help to implement the Comprehensive Plan goal of discouraging mining in environmentally sensitive areas, in prime farmable agricultural areas, and in areas where it is not compatible with current or future residential uses.

- The requirement to re-zone to allow mining outside of specific mining districts may increase the length of approval time for new mining activity and make it more difficult for project proposers to obtain approvals.

The County’s current Ordinance addresses many of the significant issues and performance standards needed to regulate mining operations. The current Ordinance uses a Conditional Use Permit (CUP) as the primary tool to regulate mining operations. The sections that follow suggest
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some options for the County to consider based on approaches that other Minnesota communities are using to regulate mining operations.

**Permit Type**

The County’s Mineral Extraction Ordinance currently requires that applicants obtain a CUP for mining operations. It also requires that mine operators file an annual registration form for all mineral extraction facilities. The annual registration is reviewed administratively by the Zoning Administrator but not by the County Board of Commissioners.

Some other Minnesota communities are using different permit processes for mining operations. One trend is to use an Interim Use Permit (IUP) or a Mining Permit rather than a CUP to regulate mining operations. These permits recognize that mining is usually a temporary use of the site and not the ultimate use. Another trend is to combine these the CUP, IUP, or Mining Permit with a formal annual review process or annual permit application that includes review and approval by the governing body.

Examples of permitting approaches used in other Minnesota communities include the following.

- **CUP with an AOP** Some communities use a combined CUP and Annual Operating Permit (AOP) process. The CUP process is similar to the process Goodhue County uses currently. After a mining operation has obtained the CUP, it is required to apply annually for an AOP. The AOP application is typically due early in the calendar year, well before the mining season begins. The AOP application requirements include the following.
  
  - An annual report summarizes operating conditions regulated by the ordinance during the past year, such as activity levels at the site, area of reclamation and type of reclamation, average haul trips, changes made to the site, and compliance with any other conditions in the CUP. It may require submittal of reports such as the annual water use information submitted to the MDNR and any air or water monitoring reports.
  
  - The applicant provides information about how operating conditions (such as traffic or dust control) for the coming year are expected to vary from the previous year, particularly in relationship to the CUP conditions; a site plan and aerial photos that show the active mining area and locations of stockpiles; and a description of reclamation that will occur.
  
  - The AOP process includes an annual inspection of the site by the local government to determine compliance with the CUP and the previous year’s AOP.
A fee is submitted and escrow is set up to cover the cost of the AOP review.

The AOP application is reviewed by city or county staff and consultants (if needed for specific technical issues). In some communities, the AOP application and staff report are presented to the planning commission and then to the council or board. In other communities, the application goes directly to the council or board for review. The council or board may approve or deny the AOP.

Some AOP review processes require notification of neighbors within a ½ mile of the mine site, so that they are aware of the review and may attend the planning commission or board meeting to provide comments. In other cases, the application is not noticed but does appear on the publicized agenda for the planning commission and/or council meetings.

Local governments have incorporated the AOP process into their ordinances for the following reasons.

- The AOP allows for public identification and review of any issues related to mine operations during the previous year. It also allows the community to adopt conditions for operation to address the issues. For example, if the operator has violated hours of operation, the AOP provides a forum for staff, residents, and the governing body to identify the issues and develop conditions to address them.

- The issues that most frequently arise during AOP reviews are related to noise (e.g. operations outside the allowed working hours), dust, and trucking operations (e.g. trucks using residential streets rather than the designated haul routes on county roads). In one case, the AOP review identified that the mine operator failed to report evidence of pollution in water monitoring samples. Two communities interviewed for this report believe the AOP process is a useful way to resolve such concerns by adding conditions to the AOP to address them.

- If there are serious problems or violations, the AOP is a mechanism that allows the community to document the problems and potentially to suspend operations for a partial or full year, without affecting the long-term status of the CUP or initiating the difficult process to revoke the CUP.

- The AOP process tracks progress in reclaiming the site, which is typically required to occur proportionately with the opening of new mining areas. If reclamation is not being completed in compliance with the CUP, the AOP is an opportunity to require compliance during the upcoming year.
Interim Use Permit or Mining Permit with Annual Review. Some communities use an IUP to regulate mining operations rather than a CUP. Classifying mining as an Interim Use recognizes that mining operations will end, and the site will have other uses in the future. IUPs require that the governing body specify a particular date or event when the permit will expire. These permits include conditions for operation like those included in CUPs.

Other communities have created specialized “Mining” or “Excavation” permits rather than requiring a CUP. These permits are renewed annually.

Local governments utilize IUPs or Mining Permits rather than CUPs for the following reasons.

- The IUPs do not “run with the land” in perpetuity like CUPs. The permit may end at a specified date or with a specified event, for example, when the current mining operation ends, or if the site is purchased by a new owner.

- Mining Permits in some communities are annual permits. The council or board conducts the annual review process and approves annual operation of the mine.

Levels of Permitting. Some ordinances reviewed for this report specify more than one level of permitting for mining operations and different requirements for each level of permitting. Some examples are as follows.

- Level 1 Permits are used for short-term projects where operations will not exceed 5 acres of excavated area or a depth of 20 feet and will be active for only one mining season. The permit requires the mining operation to comply with the ordinance’s reclamation standards, but an EAW may not be required.

- Level 2 Permits are granted for operations that will be active for more than one mining season, will not exceed 10 acres of excavated area, and will limit excavation to a maximum depth of 1-3 feet above the water table. This permit requires compliance with reclamation standards and an EAW.

- Level 3 Permits are granted for operations that will exceed 10 acres. The local government requires a technical review for this permit by the MDNR’s Division of Lands and Minerals and an EAW.

The ordinances reviewed for this report require that the permit applicant (typically the mine operator) pay all of the costs for review of the application, review of the annual permit, and
monitoring site activities required for the permit. This may include costs to the local government for hiring consultants or experts as needed to evaluate permit applications, complete site monitoring, or evaluate monitoring results.

### 3.0 NONMETALLIC MINING ENVIRONMENTAL IMPACTS

This section supplies supplemental information for nonmetallic mining environmental issues not covered in depth in the WDNR Report, the GCMSC Report, and for areas not currently addressed in Article 14 of the County Zoning Ordinance.

#### 3.1 Water Quantity

Water is used by mining operations primarily for dewatering, dust control, potable supply, and materials processing. The potential impacts of water quantity are presented first, and then strategies for minimizing those impacts are discussed. For background purposes, the breakdown of water use within Goodhue County is shown below (in millions of gallons per year).

![Goodhue County Water Use 2010](chart)

Source: Minnesota Department of Natural Resources Water Appropriation Permit Records

Industrial uses in 2010 comprised approximately 10 percent of water used for public water supply. Mining and processing would be considered industrial uses. Dewatering involves
pumping to lower the water table below the mineral reserve. If dewatering is necessary, it is common to depress the water table locally, and a Water Appropriations Permit process would apply (as discussed in the next subsection below). The most significant impact of dewatering would likely be off-site discharge of excess water, discussed under Section 3.2. Water used for dust suppression is normally deployed from water trucks with 500 to 10,000 gallon capacities, depending on the length and type of haul roads. Haul roads are generally comprised of crushed limestone and dolomite aggregate, similar to an unpaved county road.

Many proposers will request permits to put a wet plant at the mine site to remove the finer grains from the sand before trucking the sand to a dry plant. Smaller extraction projects will propose to haul raw sand without on-site processing. Wet plants at silica sand mines vary greatly in size and capacity. Smaller operations will process less than 100 tons per hour of raw material. Larger plants are designed to process over 800 tons per hour. The size of the plant is important because water usage will also be variable. Plants capable of processing 800 tons per hour will utilize over 16,000 gallons per minute (gpm) of water to wash and size the sand grains, however, these plants will recycle the vast majority of the water. See the WDNR Report in Appendix I for more detail on wet processing plants.

In Minnesota, consumptive use is defined as water withdrawn that is not directly returned to its original source. Under this definition, all groundwater withdrawals are consumptive unless the water is returned to the aquifer from which it was obtained (which is not permitted by MDH without a variance). The majority of water used by sand processing is reused by a series of filter presses or by a settling pond system. The “make-up” water, or water used to meet pumping requirements, is generally needed to replace water that evaporates from settling ponds or is transported off-site in the processed sand.

Typical processing plants at smaller mine sites will require 250 to 550 gpm of make-up water during processing hours. These rates are comparable to one city well in towns with populations of less than 2,500, less than most irrigation wells, and considerably more than most local dairy farms. Assuming a 550 gpm pumping rate and processing that operates 10 hours per day for 6 months a year, the total water pumped from groundwater aquifers or from surface water sources would be 60 million gallons on an annual basis. For a 100-acre parcel, this represents approximately 75% of the water that falls annually on the property (assuming 30 inches of precipitation) and 6% of the water that would be stored in a 100-foot thick aquifer with 30% porosity beneath the same parcel. Percentages would increase or decrease accordingly for higher pumping rates and larger parcels.

The plant design is an important consideration. Mine operators will put together a series of components that crush, screen, size, scrub, and separate the fine-grained waste material (herein
“fines”) from the water to enable water recycling. Figure 6 presents a typical wet plant layout under the assumption that a filter press is not used in the process. The number and size of ponds would vary greatly depending on the rate of material processing and the percentage of out-of-specification material that is produced.

The most significant water quantity impact of mining and processing is the creation of excessive “drawdown” of aquifers in the area surrounding the pumping well(s). Drawdown is created when water cannot enter the well borehole or well screen as fast as it is removed. In an aquifer that is unconfined (i.e. open to atmospheric pressure), drawdown also reflects the amount of dewatering in the aquifer. In an aquifer that is confined (i.e. separated from the atmosphere by low-permeability rocks or sediments), the drawdown reflects a decrease in pressure head, not actual dewatering in the aquifer.

The MDNR has regulatory authority over Water Appropriations Permits. The threshold for requiring a permit is 10,000 gallons per day, which will be exceeded at any processing site for nonmetallic minerals. The permitting process involves submitting an application. MDNR can require an aquifer test to demonstrate that drawdown will not adversely affect neighboring water supplies. The aquifer test is conducted at the same rate as the proposed appropriation, and it is conducted for sufficient time to evaluate the long-term effects of pumping from the aquifer.

Two best management practices (BMPs) are particularly effective for minimizing, monitoring, and mitigating water quantity issues associated with nonmetallic mineral processing. First, efficient design of water processing plants can significantly decrease water use. Filter presses can be used to remove fines from the water. In addition to water quality improvements discussed below, the use of filter presses removes fines without using settling processes and returns more water for processing faster than using only settling ponds, ultimately reducing the amount of make-up water. This BMP should be employed in areas where water withdrawals could impact neighboring water supplies.

Second, the use of pressure transducers, dataloggers, telemetry, and computer software to collect, transmit, store, analyze, visualize, and report water elevation data can provide two benefits. Initially, these tools can be used to characterize groundwater and surface water flow systems prior to mining. Subsequently, they can be used to monitor water levels throughout the mining and reclamation processes. The continuous data can be used to better understand the groundwater flow regime and to document impacts that require mitigation. Mitigation for excessive drawdown includes decreasing the amount of water use or drilling another well to replace an impacted well.
3.2 Water Quality

Nonmetallic mining operations can impact the quality of surface water or groundwater, or both. Impacts can result from existing and modified site drainage patterns, the hydrogeologic characteristics of the strata underlying the proposed mining or water treatment areas, the design of the mining and water treatment operation, and proximity to existing hydrologic features and groundwater. The most common physical and chemical constituents of concern (COCs) relating to nonmetallic mining in Goodhue County are listed and discussed below.

1. Total Suspended Solids (TSS) are silt- and clay-size particles that are in storm water runoff, water used for dust suppression on haul roads, and water used for sand processing. TSS are harmful to many aquatic species and can increase water temperature.

2. Total Dissolved Solids (TDS) are dissolved minerals in the same water as TSS. They are harmful to many aquatic species.

3. Temperature is a physical parameter that is an important factor in trout stream sustainability.

4. pH is a physical parameter that indicates whether the water is neutral, acidic, or basic. pH plays an important role in the chemistry of surface water and groundwater systems.

5. Volatile Organic Compounds (VOCs) are compounds usually associated with petroleum and cleaning solvents. They are used in mining equipment operation and maintenance and in ammonium nitrate and fuel oil (ANFO), a common explosive used in blasting.

6. Nitrate, nitrite, and ammonia are compounds of nitrogen that are harmful to humans, fish, wildlife, and plants at high concentrations. Nitrogen compounds are used in ANFO and are components of sanitary waste and agricultural fertilizers.

7. Polyacrylamide is a polymer used as a flocculant (i.e. an agent that facilitates separation of solids from water) for sand processing. Polyacrylamide is non-toxic; however, the unpolymerized form – acrylamide – is a nerve toxin.

At mine sites that do not have a wet processing plant, the main concerns for water quality are associated with storm water runoff and how it may impact surface water. The silt- and clay-size particles that are present in the topsoil, overburden, and silica sand have the potential to be carried off-site as suspended or dissolved solids in runoff. These impacts are similar to what is already occurring in Goodhue County; because of steep topography in the County, bluff erosion and storm water runoff in general from developed areas has resulted in the listing of the Cannon
River, Belle Creek, Hay Creek, and Spring Creek as “impaired waters” by the EPA. These waters are impaired for the most part due to high concentrations of TSS and TDS associated with storm water and agricultural runoff.

The best way to minimize storm water impacts at nonmetallic mining sites is to ensure that the mine is internally drained (i.e. no storm water runoff within the mine or plant areas leaves the property) and to follow the BMPs outlined in the Storm Water Pollution Prevention Plan (SWPPP) and Erosion Control Plan (ECP) required by state and local regulations. For cases where internal drainage cannot be achieved, MPCA has issued a general storm water discharge permit (NPDES/State Disposal System General Permit MNG490000) for nonmetallic mining activities. For the purpose of this assessment, it is assumed that new mines in Goodhue County will choose to be covered by the general permit. However, proposed mines could choose to negotiate an individual permit with MPCA based on site-specific considerations. The general permit does not authorize discharges from the mines to calcareous fens or to trout streams or Outstanding Resource Value Waters as designated by the MDNR.

For mine sites with wet processing plants, the use of flocculants and other water treatment chemicals is common. From the Summit Team’s permitting experience, the use of anionic and cationic flocculants is a concern for the public and may evoke alarm regarding the safety of the water supply. Polyacrylamide flocculants are widely used to separate finer materials from the process water stream. The use of flocculants is a water conservation measure, because it allows less make-up water to be used in the process. These flocculants are common treatment chemicals used in municipal drinking water systems. However, polyacrylamide can contain trace quantities of acrylamide, or it can de-polymerize to acrylamide which is a COC with the EPA. The EPA has set a discharge goal of zero for acrylamide as part of its Phase II 1992 revisions to the Safe Drinking Water Act. The EPA has set a groundwater standard of 0.5 parts per billion of acrylamide in drinking water.

The primary threat to water quality from nonmetallic mining is the unplanned release of processing water and mine tailings to off-site surface water. Recent spills of water containing silica sand mine waste in Wisconsin are examples where BMPs were not implemented or were not sufficient to prevent off-site discharge of these materials. The potential for releases of processing-related water and tailings can be reduced through proper design, construction inspection, and monitoring of engineered settling ponds that incorporate structural and operational BMPs.

Another potential threat to water quality involves the horizontal movement (i.e. migration) of mining-related water (storm water runoff or processing water) along bedrock layers. Migration is more of an issue at limestone/dolomite mines than at silica sand mines because of the fractures
(bedding planes, joints, faults) that characterize those mines and because of the relatively low permeability of the actual rock matrix. Although migration of water along bedding plane fractures does occur in Goodhue County (see the figure of groundwater movement in the GCMSC report), the poorly cemented nature of the Jordan Sandstone creates a flow regime more conducive to vertical infiltration. The fact that the Van Oser Member contains higher quality proppant material than the Norwalk Member indicates that 30 to 50 feet of sandstone will be likely be present beneath the floor of mines located in the Jordan Sandstone. The filtration capacity of this sand should reduce the potential for TSS issues for shallow aquifers and discharge zones near a silica sand mine.

There are several perspectives on what constitute mine design BMPs for minimizing impacts to groundwater resources. Some counties have required that settling ponds be lined with an impermeable layer (e.g. clay, concrete, geotextiles). From a sustainability perspective, it is unlikely that these layers will remain impermeable over time, which ultimately defers water quality issues to a time after the mine has been abandoned.

BMPs to minimize, monitor, and mitigate potential impacts to surface water and groundwater quality at nonmetallic mines include the following.

- Some potential BMPs to minimize water quality impacts begin at the site characterization phase.
  - Sufficient groundwater and surface water data should be collected to adequately characterize the migration of water on a proposed site. Processed LIDAR data should be used to predict surface water movement at various stages of the mine development.
  - Drilling programs to characterize the mineral reserve should also be used to evaluate the potential for karst features in overburden and sand deposits. Information on the groundwater elevation, gradient, and hydraulic conductivity should be used to create a site conceptual model and to estimate groundwater velocities. Average groundwater velocities within silica sand formations in Goodhue County likely range from 0.1 to over 15 feet per day; therefore, accurate characterization of the local groundwater velocities is important.

- As discussed in Section 3.1 continuous monitoring equipment can detect conditions requiring changes to the mining processes or mitigation for impacts. Sensor technology is developing rapidly given the advancements in solar power, fiber optics, telemetry, carbon fiber, and nanotechnologies. There are currently single-probe systems on the market that can monitor water level, temperature, and conductivity (which is related to
TSS and TDS). Other common probes include capabilities to record nitrate and dissolved oxygen concentrations.

- The key to any monitoring program is correct placement of the monitoring devices. Site characterization needs to be sufficient for an understanding of the correct number and location of monitoring devices. Another important consideration for a monitoring program is the installation, maintenance, and calibration of the monitoring equipment. Field readings should be made periodically to verify the sensor readings. Data should be submitted in digital format and used along with data from multiple mines and other sites for a time-series analysis of groundwater and surface water resources across Goodhue County.

- Plans for settling ponds and berms should be developed by registered engineers. The County should consider requiring independent engineering reviews of plans submitted as part of the permitting process. The County should also consider construction observation (as ponds and berms are built) and regular monitoring of these facilities after construction (during annual permit reviews).

3.3 Noise and Vibration

Noise and vibration impacts relating to silica sand mining operations are the result of the large machinery and occasional blasting required to excavate bedrock. Noise is generally considered to be unwanted sound. Sound is the result of small pressure fluctuations in the air. There are many ways in which pressure fluctuations are generated, but typically they are caused by the vibrating movement of a solid object. Noise is measured in decibels (dB) and can be described in terms of three variables: amplitude (loud or soft); frequency (pitch); and time pattern (variability).

Vibration is an oscillatory motion that can be described in terms of displacement, velocity, or acceleration. Displacement is the distance that a point moves away from its static position, velocity represents the instantaneous speed of the movement, and acceleration is the rate of change of the speed. Although displacement is easier to understand than velocity or acceleration, it is rarely used for describing ground-borne vibration. Most transducers used for measuring ground-borne vibration use either velocity or acceleration.

Blasting is a regulated activity. Hauling, storage, and usage of explosives and certification for blasting professionals are regulated by the federal government. Minnesota Administrative Rule
6132.2900 addresses air overpressure (noise) and ground-borne vibration from blasting at nonferrous mines. In general, noise levels on lands not owned or controlled by the permittee cannot exceed 130 dB, must be monitored by the operator at the nearest structure located on lands not owned or controlled by the permittee (where the MDNR considers necessary to investigate complaints), and the permittee must keep a blaster’s log. Ground vibration controls dictate that the maximum peak particle velocity from blasting should not exceed 1 inch per second at the location of a structure located on lands not owned or controlled by the permittee and that vibrations are monitored with an appropriate seismograph, among other requirements.

Noise is also regulated pursuant to Minnesota Rules Part 7030.

BMPs to minimize, monitor, and mitigate noise and vibration impacts at nonmetallic mines include:

- Taking into consideration local receptors during preliminary and final design of the mine plan (because the excavation of sand and the creation of high walls can greatly reduce noise behind the wall, but may amplify noise in the opposite direction);
- Leaving existing trees at the property boundary;
- Building berms between noise sources and receptors;
- Using strobe signals rather than audible systems for back-up alarms on heavy machinery (when permitted by the federal Mine Safety and Health Administration);
- Enclosing generators and other mobile equipment;
- Notifying nearby residents 48 hours prior to blast events;
- Using vibration monitors with sensors capable of measuring three mutually perpendicular peak particle velocities, with the peak particle velocity being the largest of these measurements; and
- Installing continuous noise monitors that meet the specifications in American National Standards Institute S1.4-1983.
3.4 Ecological Resources

Like other types of development, mining activities have the potential to impact certain fish and wildlife species, their habitats, and plant communities. Potential impacts include destruction or degradation of vegetation, noise levels, water and air pollutants, and traffic-related fatalities. These impacts, in turn, have the potential to affect human health in various ways, including quality of life, recreation, and economic opportunities. Impacts to ecological resources can also affect the long-term sustainability of Goodhue County’s natural resources and can have public relations implications or legal ramifications. Best practices for addressing potential impacts at proposed nonmetallic mining sites generally involve the following stepwise approach.

- **Submission of a Natural Heritage database request.** The Natural Heritage Information System (NHIS), administered by the MDNR’s Natural Heritage and Nongame Research Program, can be queried for known locations of “ecologically sensitive resources,” defined in the EAW Guidelines as “rare or unique natural features or features of special significance, including threatened and endangered species; habitats that are rare statewide such as prairie remnants or virgin timber; locally rare habitats; colonial waterbird nesting colonies; and high quality wetland complexes.” The program’s Web site has a data request form which involves a fee and requires a map of the proposed project area and other project information.

- **Review of listed species.** Species may be listed as threatened or endangered or have other legal status at the state and/or federal level.
  - As of June 2012, the distribution of species that are federally listed as threatened, endangered, proposed, and candidate species includes the following for Goodhue County:
    - Dwarf trout lily (*Erythronium propullans*), endangered (found on north-facing slopes and floodplains in deciduous forests);
    - Higgins eye pearlymussel (*Lampsilis higginsii*), endangered (found in the Mississippi River); and
    - Prairie bush clover (*Lespedeza leptostachya*), threatened (found on native prairie on well-drained soils).
  - As of June 2012, the MDNR’s Rare Species Guide identifies 79 species of plants, insects, mussels, fish, reptiles, birds, and mammals listed as threatened, endangered, or of special concern at the state level and potentially occurring in Goodhue County.

- **Review of habitat mapping.** The potential for areas of protected or sensitive habitats
within a proposed project site depends on various factors, such as land cover, ownership, and special designations. Ecologically sensitive resources may be present even though they haven’t been documented in the NHIS. The work completed for the ECLUE project is an invaluable source for the County. Even if designated areas or sensitive resources do not exist within the proposed project boundary, proximity to these areas may create the potential for impacts to species or habitats because of animal movements, seed dispersal, and pollination. The County may want to consider leveraging the GIS of ecological resources for ongoing consultation. A recommended addition is the GAP Stewardship 2008 data layer, which assesses the habitat protection status of every acre in Minnesota for both public and private ownership types. The following data may also be considered for addition to the County’s GIS if not currently in-house or part of the ECLUE data (note that this list is not intended to be all-inclusive).

- State, federal, and other designations, such as:
  - Minnesota Wild and Scenic River Districts
  - Reinvest in Minnesota Master Conservation Easements
  - Scientific and Natural Areas
  - State Forests and Parks
  - State Wildlife Management Areas
  - Trout Lakes and Streams
  - U.S. Fish and Wildlife Service Waterfowl Production Areas

- Land cover mapping and natural resource inventories, such as:
  - Calcareous Fens
  - Minnesota Land Cover Classification System
  - Minnesota County Biological Survey (Native Plant Communities, Railroad Rights-of-Way Prairies, and Sites of Biodiversity Significance)
  - National Wetlands Inventory
  - Public Waters Inventory

- **Site-specific habitat review.** It is recommended that the County’s ordinance require that a professional biologist visit proposed project sites if available databases and/or mapping tools indicate that rare species or habitats may be present. The biologist will look for evidence that ecologically sensitive resources occur within or near the project area. The field evaluation should include consideration of potential impacts to species inhabiting the site as well as surrounding areas that may be impacted by mining activity. The biologist should also assess the need for more in-depth surveys of specific species or habitats, with particular attention to the potential for occurrence of species listed as
threatened or endangered or having other legal status at the state and/or federal level.

- **Species- or habitat-specific surveys.** The methodology of in-depth surveys, if warranted by the site-specific habitat review, is highly variable, depending on the species or habitat of interest. Surveys should be conducted by professional biologists having demonstrable expertise with the species or habitat.

- **Mitigation measures.** According to the EAW Guidelines, mitigation measures for impacts to fish, wildlife, or ecologically sensitive resources “include avoiding, minimizing, and compensating for impacts. Examples include landscaping or revegetation with plant species of value to wildlife, retaining wooded travel corridors (especially along waterways), and construction or restoration of wetlands.” These methods are discussed in Section 4 of this report.

### 3.5 Cultural Resources

The archaeological record in Goodhue County includes preserved representations of every important cultural sequence known in the region of southeast Minnesota. The prevalence of burial mounds and large village sites adjacent to the bluffs above the Mississippi River are exceptional examples of those site types in Minnesota. These cultural resources would be threatened by silica sand mining if BMPs are not followed.

The National Historic Preservation Act of 1966 (as amended), the most comprehensive federal law pertaining to the protection of cultural resources, created the State Historic Preservation Offices, established the National Register of Historic Places, and created a federal-state-tribe-local partnership. The most essential provision is Section 106, which requires federal agencies to consider the effect of their undertakings on historic properties and, under 36 CFR 800, to consult with State and Tribal Historic Preservation Offices.

Minnesota Statutes, Chapter 138 places responsibility for Minnesota’s historic preservation program with the Minnesota Historical Society (MHS). The Minnesota Field Archaeology Act establishes the Office of the State Archaeologist (OSA), requires a license to engage in archaeology on nonfederal public land, establishes standards of data recovery, and requires state agencies to submit development plans to OSA, MHS, and the Minnesota Indian Affairs Council for review when known or suspected archaeological sites are present. The Minnesota Private Cemeteries Act (MS 307.08) protects all human remains and burials older than 50 years on either public or private lands or waters, and burial site authentication is conducted under the sole auspices of OSA.
The following paragraphs provide relevant historic contexts for the pre-contact period (before about 375 years ago) in North America in general and in Goodhue County in particular. These contexts are divided into a number of periods and sub-periods, and constitute research themes under which archaeological resources identified in Goodhue County can be evaluated for their National Register of Historic Places (NRHP) significance.

**Paleoindian Period (circa 9500 to 6000 B.C.)**

The Paleoindian period is the earliest period for which there is undisputed evidence that humans lived in North and South America. Paleoindian peoples entered Minnesota following the retreat of the Wisconsin Glaciation, and many of their sites were buried beneath thick sediment deposits. The excavation of Paleoindian sites has shown that these people were highly mobile hunters and gatherers, who pursued herds of large game including mastodon, bison, and woodland caribou, as well as a variety of smaller animals, into the tundra and open pine and oak forests that populated that landscape behind retreating glaciers. As they moved, probably in small bands, they obtained and carried, sometimes for hundreds of miles, the raw materials needed to make stone tools.

In Minnesota, the Paleoindian period is commonly divided into Early and Late stages. Sites dating to the Early Paleoindian period, between 9500 and 8000 B.C., are scarce, and evidence is largely limited to fluted spear points typical of the period without any associated features or artifacts. Sites dating to the later part of the Paleoindian stage, between 8000 and 6000 B.C., are numerous in Minnesota and have been found throughout the state, but these also have consisted largely of surface-collected spear points; therefore, little information is known regarding this time period in Minnesota.

**Archaic Period (circa 6000 to 1000 B.C.)**

Approximately 9,000 years ago, Minnesota experienced a “rapidly changing postglacial environment,” including warmer temperatures and a decrease in precipitation. New landscapes emerged from beneath the ice, and the state transitioned from a forested region to an expanse of prairie interspersed with large lakes and swiftly flowing rivers fed by glacial runoff. These changes brought about the extinction of the large prehistoric mammals, which were replaced with new complexes of animals and plants.

Inhabitants of this region were forced to adapt to this transformed landscape, altering their means of subsistence and lifestyles. The Archaic tradition is marked by an increased diversity of tool types, raw materials, and local resources. In response to the increased abundance and variety of game, fish, shellfish, and plant resources, the large arrowheads of the Paleoindian tradition were...
replaced by smaller notched and stemmed chipped-stone points, and chipped-stone axes were replaced by groundstone adzes, axes, and other groundstone tools. Other implements introduced into the tool kit during this period include atlatl darts, bone tools, and copper tools. Copper implements, found primarily in northern regions of the state, appeared about 7,000 years ago and were manufactured and used until approximately 3,500 years ago. Due to an increased dependence on regional resources resulting from the stabilization of the environment, Archaic peoples became less nomadic, establishing longer-term seasonal camps with temporary structures and storage pits.

**Ceramic/Mound Stage (circa 1000 B.C. to A.D. 900)**

Along with the advent of plant domestication toward the end of the Archaic stage came two major cultural developments, one technological (pottery manufacture) and one spiritual (the construction of earthen mounds in which to bury the dead).

**Late Precontact Stage (circa A.D. 900-1630)**

Between approximately A.D. 900 and 1630, American Indian populations established and inhabited semi-permanent villages, which were complemented by temporary campsites used for seasonal activities. This period saw “the intensification of food production, significant population increases, and the emergence of well-defined regional complexes”. Overall, however, the lifeways and environments of the peoples who lived during this time varied significantly, resulting in a number of temporally and regionally specific cultures over the Midwest. The most prominent of these is archaeologically designated as the Mississippian tradition. Mississippian sites are distinguishable from their Ceramic/Mound-stage counterparts by greater artifact density, highly distinct ceramic styles, corn and vegetable storage pits, and large semi-permanent village complexes located on river valley terraces. Complexes potentially associated with the Mississippian tradition in Minnesota have thus far been found in locations limited to the more southerly parts of the state.

In the area of Goodhue County, intensified maize horticulture became the dominant subsistence strategy as early as A.D. 1000, marking the onset of the Oneota cultural complex. The Oneota culture entered southern Minnesota around 1,000 years ago from the south, replacing the Mississippians, who had spread from the southeast United States into southeastern Minnesota, although the precise relationship between these archaeological cultures is difficult to determine. First appearing in the Red Wing area, the Oneota relied heavily on maize horticulture, hunting, and riverine resources. Evidence for 200 years of intense interaction between the Oneota and southern Middle Mississippian groups is present in and around Red Wing, and this interaction is followed by increased “regionalization” of the Oneota, who moved out from Red Wing to the
west and south. In Goodhue and Pierce counties, hundreds of habitation and domestic sites, and thousands of mounds have been identified in association with this culture.

Best practice for management of cultural resources, to ensure that they are adequately identified and protected, is to follow the steps defined in the Minnesota State Historic Preservation Office (SHPO) Standards and Guidelines for the entire Area of Potential Effect (APE) for the proposed project. This process of evaluation, which must be conducted by an archaeologist who meets the Standards of the Secretary of the Interior for conducting archaeological research, includes a Phase IA literature search and a Phase I archaeological reconnaissance survey. This scale of investigation includes comprehensive archival and record searches for a project APE followed by on-the-ground survey of areas within the APE that are deemed medium- or high-probability. If sites are identified or deemed to be potentially impacted by a project, then a Phase II (intensive survey) or Phase III (treatment measures) may be necessary. The way that this is currently done as part of an EAW, by completing a simple SHPO record search, is inefficient and may lead to the destruction of undocumented cultural resources, especially if a project occurs in high probability areas (e.g. bluff top adjacent to river, slopes less than 20%, within 500 ft of water or wetland, or on other prominent topographic features or sheltered areas on the landscape).

The potential for both direct effects and indirect effects of a project should be considered. While the majority of the archaeological record is primarily subject to direct effects (such as the destruction of artifacts by mining activities), burial mounds, effigy mounds, and above-ground historic structures may be subject to indirect effects such as viewshed disturbance, noise disturbance, or vibration disturbance.

4.0 RECLAMATION ISSUES

The third objective of this mining study was to research and report the benefits and challenges related to land reclamation from open pit mining, sub-surface mining, and contour mining operations. Generic versions of reclamation plans for these types of mines are summarized in the following sections. The rationale and the philosophies behind the reclamation plan designs are discussed along with concepts for “template” development to enable the County and mine proposers to apply consistent approaches for sustainable mining and mine reclamation.

4.1 Benefits and Challenges of Mine Land Reclamation

Unreclaimed mines often become eyesores, safety hazards (e.g. steep slopes, deep pits), and magnets for unauthorized activities such as illegal dumping, target shooting, off-road vehicle use, and parties, as well as noxious weeds. To avoid such problems, mine reclamation is required
in Goodhue County while mining activities are on-going and after mining activities are completed. Reclamation can transform mining sites to a wide variety of valuable, attractive land uses, including, for example:

- agriculture (row crops, orchards, pasture)
- native plant communities and wildlife habitat, such as prairie, wetland, savanna or forest
- green space, passive recreation area (hiking, biking, skiing, or nature trails)
- residential development
- public parks
- recreational uses (soccer, baseball, football, etc.)
- lake or pond for swimming and/or stocked for fishing
- land uses permitted by Goodhue County.

Developing a reclamation plan before mining activities begin is crucial to maximize reclamation success, to minimize costs and maximize efficiency, and to ensure enough resources are budgeted for reclamation. Planning ahead can, for example, allow for mining operations to be performed in a way most conducive to achieving the proposed final land use and minimize double handling of materials. For example, topsoil, i.e. native O and A soil horizons, can be stockpiled and protected for re-use in site reclamation, grading during mining operations can be done in a way that contributes to the final proposed land use, materials to be re-used on site can be stored close to where they will be re-used, volume of materials available from mining operations on the site can be balanced with volume needed for the reclamation plan, cleared trees can be stockpiled for future use (to create brush piles for wildlife if desired, for habitat in ponds, for use in stream stabilization, or shredded for mulch), and if existing native vegetation is to be restored on the site after mining is complete, the site can be mined in a way that allows for native plant propagules to be preserved for future reclamation.

The challenging scale and site conditions of mine reclamations make it all the more crucial to plan ahead to maximize efficiency and success. Without planning ahead to salvage topsoil and protect sites from erosion, mine sites often present the following challenges for revegetation:

- anoxic subsoils
- exposed gravel with short supply of topsoil
• lack of organic matter and nutrients
• droughty and windy conditions
• erosion

Creating a reclamation plan before mining activities begin can match topsoil preservation and storage needs to the proposed land use, prescribe appropriate erosion and sediment control to protect site resources, and match final land use and vegetation to the post mining growing conditions. The diverse palette of plant communities native to Goodhue County includes communities that can grow and thrive in a wide variety of growing conditions, including moist and dry cliffs, as well as exposed ridgetops with shallow topsoil and exposed bedrock.

4.2 Reclamation Plan Contents

The mine permitting process should include electronic submittal of a reclamation plan with the components described below. A Stormwater Pollution Prevention Plan (SWPPP) and Erosion Control Plan (ECP) should also be completed after the Conditional Use Permit is approved.

To be most successful, a reclamation plan needs to be prepared before mining activities begin. The basic components of a reclamation plan include, but are not limited to:

A. Site analysis
B. Photographic inventory of pre-mining site conditions
C. Plan for re-use of nonmetallic mining refuse
D. Waste consolidation, containment, and removal and disposal plan for other wastes
E. Footprint of area to be disturbed
F. Phasing plan
G. Sediment and erosion control plan during and after mining
H. Stormwater management plan during and after mining
I. Soil salvage plan: include protection from erosion, compaction, and weeds
J. Proposed land use after mining
K. Site preparation plan, including, but not limited to, grading, clearing, grubbing, marking, development of staging areas, debris removal, amendment stockpiling, access road construction, installation of sediment and erosion control measures, protection of vegetation to be preserved
L. Reclamation plan: grading plan with 2 foot or less contour intervals, soil restoration plan, re-vegetation plan
M. Quantified reclamation performance standards
N. Quantified performance standards for maintenance of reclaimed areas.
Site analysis informs all the other parts of the restoration plan, and should include, at a minimum:

A. Current land use on site  
B. Adjacent land uses  
C. Existing soils, including distribution, thickness, and type of topsoil and subsoil  
D. Existing surficial geology  
E. Geologic composition and depth of mineral deposit  
F. Existing topography with contour lines at 5 foot or less intervals  
G. Existing structures  
H. Existing roads (paved and unpaved)  
I. Wetlands and streams  
J. Existing vegetation, including plant community, evaluation of condition of plant community, dominant species  
K. Threatened and endangered species and plant communities within ¼ mile radius: see http://www.dnr.state.mn.us/eco/mcbs/maps.html for general county overview, contact the Minnesota Biological Survey at the Minnesota Department of Natural Resources for more site specific information.  
L. Groundwater elevation  
M. Wells and wellhead protection zones (public and private)  
N. Location of recharge zones  
O. Location of areas previously affected by mining on site, including location of stockpiles, wash ponds, and sediment basins

The three parts of the implementation of a reclamation plan are (1) land shaping, (2) soil restoration and stabilization, and (3) revegetation.

4.3 Best Management Practices for Mine Reclamation in Goodhue County

Minnesota law and county policies require that all mining operations obtain approval of a plan to reclaim the site to a productive use subsequent to mining. This "Reclamation Plan" ideally would be implemented as mining progresses and areas are completed. Reclamation could return portions of the site to open space or agriculture use consistent with existing surrounding lands. Infrastructure improvements such as any processing and load out areas, rail spur/siding and access road(s) could remain as valuable post-reclamation land use. Re-vegetation ideally would occur concurrently with development of the mining areas. If native plant community restoration is the goal for the mine reclamation, native tree, shrub and grass species ideally would be used to re-vegetate benches to shield high walls and the mine floor and primary processing plant areas. Mine reclamation could include wetland creation, reservoir or lake construction, wild land
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restoration, trail development, etc. Best management practices for land reclamation are presented in the following sections.

4.3.1 Return Agricultural Land to Agriculture

It is recommended that land in agricultural land uses be reclaimed to agricultural uses, including row crop agriculture, pasture, or woodlots, after mining. NRCS agricultural conservation practices, such as contour strips, should be used on steep slopes.

4.3.2 Reclaim Land not in Agriculture Prior to Mining to Match Regional Presettlement Landforms, Soils, and Vegetation

For land not in agriculture prior to mining, it is recommended that each of the components of mine reclamation - (1) land shaping, (2) soil reclamation and stabilization, and (3) revegetation - be designed to mirror the pre-settlement character of the area. Matching local landforms and vegetation communities celebrates regional identity and maximizes ecological function. Resources for learning more about landforms and vegetation typical of the area of the site to be reclaimed include: Minnesota DNR’s *Field Guide to Native Plant Communities: Eastern Broadleaf Forest Province*, and Goodhue County Natural Resource Inventory (NRI) published in 2001. Observing landforms, soils, plant species composition, and species abundance in nearby high quality natural areas is also an invaluable tool to inform reclamation plans. High quality natural areas can be found, for example, from:

- The Minnesota Biological Survey Native Plant Community and Rare Species County Map for Goodhue County
- List of areas designated Scientific and Natural Areas (SNA) by the Minnesota Department of Natural Areas

As Goodhue County was bypassed by the last glaciation, its landscape is generally very dissected, with many streams and bluffs, and very few lakes. Because of the great diversity in habitat and microclimatic conditions in this dissected landscape, pre-settlement vegetation of Goodhue County included a great diversity of plant communities. The *Field Guide to Native Plant Communities: Eastern Broadleaf Forest Province* summarizes the pre-settlement vegetation of a large part of Goodhue County this area as follows:

“The most important factors influencing the pattern of vegetation in the historical landscape were slope, aspect, flooding, and the likelihood of burning; variation in substrate was important only locally, with most of the section covered by rather uniform deposits of loess or alluvium. Prairies occupied the flat, fire-prone remnants of the plateau in the western part
of the section. Steep slopes in dissected areas were sufficiently protected from fire for woody vegetation to develop, although dry prairies were common at the tops of southwest-facing bluffs, with oak woodland developing downslope and northward and eastward along these slopes. Mesic forests were prevalent on north- and east-facing slopes, usually dominated by oak on the upper slopes, with basswood and then sugar maple increasing in importance downslope. Wet-mesic forests of basswood, sugar maple, black maple, elm, bur oak, black ash, and walnut were present on level, silty valley bottoms in dissected terrain. Sandy valley bottoms supported dry prairies, black oak woodlands, and, rarely, jack pine savannas and woodlands. The alluvial bottomlands of broad valleys such as that of the Mississippi River were covered with floodplain forests of silver maple and river birch and terrace forests of silver maple, elm, green ash, hackberry, cottonwood, basswood, and swamp white oak. River shore communities were present on sand bars and shorelines. Steep rock walls and rocky colluvium provided habitat for development of cliff and talus communities.”

According to the Goodhue County NRI study, which includes natural community inventories for 655 natural areas in Goodhue County, the most frequently encountered natural community types in Goodhue County today are Oak Woodland-Brushland, Lowland Hardwood Forest, and Oak Forest. Bedrock Bluff Prairies are common along south and west facing bluffs. Other natural communities found in Goodhue County include floodplain forest, shrub swamp, white pine mixed hardwood forest, and moist and dry cliffs. The graphic below shows typical landscape positions of these communities. Table 2 shows a summary of the natural communities left in Goodhue County in 2002. For descriptions of these communities, see the Goodhue County NRI, and the Minnesota DNR’s Field Guide to Native Plant Communities: Eastern Broadleaf Forest Province.
The Minnesota County Biological Survey has created a map of high quality natural areas and rare species for each county in Minnesota. The map they created for Goodhue County shows the high quality natural areas and rare species heavily concentrated along bluffs and river corridors, especially along the Mississippi River and Cannon River. Numerous occurrences of rare species are shown in the mesic oak forest, maple basswood forest, floodplain forest, and bedrock bluff prairies. Many other areas of the county have no high quality natural areas and rare species left at all. The County should consider prohibiting mining activities in areas that could negatively impact the few areas that still have high quality natural areas and rare species. While the upland plant communities delineated in the County Biological Survey are not protected by State and Federal regulations, the County can require a higher level of protection. It is recommended that mining be prohibited in natural communities identified in the Goodhue County Biological Survey or in the Goodhue County Natural Resource Inventory where high quality natural areas and rare species are demonstrated through field studies to exist and where mitigation is inadequate to replace or restore habitat, and that these communities be protected with buffers when mining occurs adjacent these communities. If mining is allowed in these communities, mitigation replacement should be required. State and federal regulations for wetlands and rare, threatened and endangered species prevail.
Reclamation plans for sites where creation of native vegetation communities is the goal of the restoration plan should consider the following:

- Choose a target plant community that has growing conditions similar to the growing conditions of the post mining site. For example, a ridgetop with shallow soil would be an ideal growing site for bedrock bluff prairie. See Table 2 for more examples of how to match target plant communities to post mining growing conditions.

- Choose a target plant community that complements the surrounding land uses.

Tools for developing plant lists and a planting strategy to restore these communities include:

- *Native Seed Mix Design for Roadsides*: tool for developing seed mixes for native plant communities in Minnesota.


- Minnesota DNR’s *Field Guide to Native Plant Communities: Eastern Broadleaf Forest Province*: includes description of habitat and growing conditions of native plant communities in southeastern Minnesota, lists of dominant plants, and abundance of dominant species in each community.

### 4.3.3 Visually Match Landforms Typical of Goodhue County

Tools for matching the visual character of the region are provided below.

A. The following show typical unnatural mining landforms that are to be avoided.
Uniform steepness not acceptable
Steep wall not acceptable
Steps not acceptable
Piles of rock not acceptable
Break up length of windrow stockpiles
Uniform steepness not acceptable
Rubble piles
B. The following are images of landforms typical of Goodhue County, which provide a visual vocabulary, or templates, to guide mining operations and reclamation.

Wooded groves

Typical agricultural landscape in Goodhue County, image source: lakesnwoods.com/images/Goodhu37.jpg

Restored treatment wetlands with sinuous rather than rectangular shapes
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Bedrock bluff prairies typical of Goodhue County

Rounded slopes   Slope breaks here

Uneven slopes

Rolling hills, slopes not uniform

Typical dry sand-gravel prairie in Goodhue County, image source:
minnesotaseasons.com/Destinations/Large/River_Terrace_Prairie_SNA_04.jpg
Proper bluff treatment  Bends in paths  Wooded and stabilized banks

Typical river valley in Goodhue County, image source: cannonvalleytrail.com/

Break up straightness  Swale  Large woody debris

Typical river valley and trail in Goodhue County, image source: minnesotaseasons.com/Destinations/Large/Cannon_River_Turtle_Preserve_SNA_01.jpg
4.3.4 Use Landscape Ecological Principles to Maximize Ecological Value of Reclaimed Areas

How reclaimed plant communities are shaped and relate to each other and to adjacent land uses affects their value to the plants and animals that live in them or use them as sources of food or water. Three examples of these principles are summarized below.

Maximize Core Habitat Patch Area

Landscape ecology divides landscapes into a matrix with patches and corridors (see below). The matrix is the dominant cover type in the landscape; patches are nonlinear landscape elements in the matrix, and corridors are linear elements within the matrix.
A habitat patch is an area where a group of plant and animal species live. The greater the core of the patch – i.e. the smaller the edge to core ratio of the patch – the more valuable a patch is for many plants and animals. A larger patch normally has a larger population size of a given species than a smaller patch, making it less likely that the species will go locally extinct in the larger patch (Dramstad et al. 1996). Also, while the more common generalist wildlife species can live in a wide variety of environmental conditions, some “specialist” wildlife species have much more specific habitat requirements, and some of these will only nest in large core habitat patches of a minimum size. Such large habitat patches are becoming more and more rare and invaluable to specialist species that need such patches to survive.

When evaluating how to maximize core habitat area, analyze potential post mining land uses in relation to surrounding land use. If, for example, a large patch of mesic prairie borders the mining site, consider restoring prairie next to the mesic prairie on the neighboring property, to enlarge the existing prairie and its value to wildlife. This could be more valuable than restoring mesic prairie on the same mining site elsewhere on the mining site, away from the neighboring prairie.

**Minimize Ratio of Edge-to-Core Habitat**

Minimizing ratio of edge-to-core habitat also maximizes ecological value. Edges have different conditions, and therefore different species composition, than core interior habitat. For example, forest edges have more light and wind exposure than forest interior. Edges are also more subject to human influences and invasive species, and can also negatively influence habitat value in
other ways. For example, Neotropical migrant birds (birds that nest in North America but winter in Mexico or further south) that nest near forest edges typically suffer more from nest predation and brood parasitism than those in the forest interior. Animals that eat their eggs, such as raccoons, blue jays, and opposums, are more numerous along forest edges than in the interior. Cowbirds, which are nest parasites, i.e. they lay their eggs in nests of other birds, such as Neotropical migrants, are also more numerous along edges than in the interior, further decreasing neotropical nesting success near forest edges.

Habitat fragmentation increases edge to core habitat and therefore reduces habitat value (see below). Reclaiming larger patches, conversely, can improve habitat value by decreasing ratio of edge to core habitat.

Effect of Habitat Fragmentation on Amount on Ratio of Edge-to-Core Habitat (Dramstad et al 1996)

Maximize connectivity.

Connections between natural communities allows plants and animals to move between patches and reproduce and may help maintain diversity. Connectivity is also crucial to the survival of species that need several habitat types to survive, such as endangered Blanding’s turtles that need both upland and wetland habitat to complete their lifecycle. When evaluating how to maximize connectivity, analyze potential post mining land uses in relation to surrounding land use.
4.3.5 Additional Best Management Practices for Land Reclamation

Plan Operations and Final Grades to Maximize Sustainability

Plan operations and final grades to maximize sustainability, for example, by planning operations and final grading to (1) minimize erosion, (2) minimize double handling and hauling distances, (3) protect regional scenic beauty by mirroring local landforms. Rock mechanics, cementation, stability, and fracture orientation will ultimately dictate high-wall design.

Minimize Area Disturbed At One Time

The mine reclamation plan should be sequenced to keep the number of un-reclaimed acres to a minimum at any given time by mining in phases and promptly reclaiming land as soon as practical after extraction is complete. This will (1) minimize the amount of land exposed to erosion at one time, and (2) minimize the amount of financial assurance needed at one time.

Protect Cold Water Fisheries from Increase in Suspended Solids or Increase in Temperature due to Mining Activities

Temperature of surface water fluctuates with air temperature, and becomes too warm for trout streams in hot summer temperatures, whereas water infiltrated into the ground remains a constant 54 to 55 degrees Fahrenheit. In trout stream watersheds, process water discharged from basins should therefore never be discharged directly into trout streams, but should be infiltrated into the ground as close as possible to the discharge site, so it can flow underground and be cooled before it reaches downstream trout streams.

Subsurface wastewater wetlands are particularly well suited as a BMP to clean non-metallic mining wastewater. Subsurface wastewater wetlands have a substrate of washed gravel, with plants that are highly efficient at cleaning wastewater via biological processes on the plants’ roots. A subsurface flow wetland is distinguished from lagoon style wastewater ponds by the fact that no water is visible, but is held twelve inches below the top of the gravel bed so that only the plants are visible. They can therefore function not only as a wastewater wetland, but also as a visual amenity and wildlife habitat. They are also particularly well suited for frac sand mines in Goodhue County because aggregate needed for the wetlands is readily available, and treating water underground will cool the water before being discharged so it does not harm trout habitat. Numerous opportunities exist for private companies to “adopt a watershed” and build these structures near the discharge points to Goodhue County streams. This concept could be a powerful tool toward delisting impaired waters within the County.
Influent and effluent from subsurface wastewater wetland

*Preserve and Protect all Topsoil for Re-Use on Site*

If needed, topsoil or engineered soil can be brought onto the site, but topsoil from the site should not be sold for use off site. All topsoil harvested on site should be preserved, protected, and reused on site. Adequate topsoil characterization should be required prior to mining. The following guidelines should be considered for site characterization:
• A minimum of 5 soil profile samples per acre should be collected and classified by a Minnesota licensed soil scientist;

• The thickness of the O, A, E, B and C Horizons should be mapped and contoured;

• Volumes of O and A, B, and C Horizons should be calculated;

• Earth moving equipment should be equipped with coordinate and depth controls (GPS).

A maximum stockpile size of 1-acre footprint, 20 foot high, and maximum side slope of 3:1 should be enforced.

Topsoil should be protected from erosion and compaction before, during and after mining activities. Topsoil should not be handled when wet. Topsoil types should be kept separate from each other at all times, divided to the level of soil order. There are 5 soil orders in Goodhue County:

• Inceptisols: young mineral soils that have started to develop soil layers

• Entisols: young mineral soils that have little or no evidence of development of soil horizons

• Mollisols: formed under grasslands and have a deep, dark colored surface layer

• Alfisols: have a clay enriched B horizon that is low in base saturation

• Histosols: organic soils

USDA Natural Resources Conservation Service (NRCS) Soil Survey for Goodhue County provides soil maps and data for Goodhue County.

**Scarify Soil Prior to Topsoil Re-distribution**

All grading should be completed and resulting surfaces scarified prior to topsoil redistribution. Soil should be loosened with a paraplow or approved equal to a minimum depth of 30 inches.

**Re-Use Woody Debris from Trees and Shrubs Cleared from Site**

Non-lumbered trees and shrubs removed from the site during grubbing should be left whole and stockpiled for use in reclamation or run through a chipper or otherwise converted into mulch and then stockpiled for use in reclamation activities. Wood chips can be used, for example, as a soil amendment or for erosion control. Non-shredded trees and shrubs can be used, for example, to
create wildlife habitat improvement structures such as brush piles or woodpecker snags, for soil bioengineering for stream restoration, or to control site access. Logs should not be cut small or sold as firewood.

**Re-Use Organic Wastes on Site as Compost Soil Amendment**

Organic waste, including all vegetation cleared from the site that is not used for any of the above uses, should be composted on or off site, and compost should be used on site for site reclamation. Net balance of organic matter should not decrease due to mining activities. Compost can be used, for example, for erosion control and as a soil amendment.

**Re-Use Boulders from Site Where Practical**

Boulders can be stockpiled and re-used, for example, to create wildlife habitat enhancement structures, for soil bioengineering for stream stabilization, to control access, to mark boundaries, to create sitting areas, and to enhance aesthetics.

**Keep Post Process Sand Separate from Topsoil**

Post process sand should be protected from wind and stockpiled separately from topsoil, and should be either disposed of off-site, or re-used on site without negatively impacting site. Post process sand can be re-used, for example, to enhance wildlife habitat by creating sand wallow baths for birds and turtles.

**Include Quantifiable Performance Standards for the Mine Reclamation and Maintenance**

Clear performance standards are crucial to enable all parties to objectively evaluate whether or not the reclamation and maintenance are satisfactory. Standards typically include minimum required percent cover of acceptable vegetation, minimum species diversity, and maximum percent undesirable vegetation at completion, and percent survival of woody vegetation, at specified maintenance intervals (e.g. 0-2 years after completion, 2-5 years after completion, and more than 5 years after completion).

Sample performance standards are shown below. These should be adjusted based on project conditions and goals.

Sample Native Prairie Seeding Performance Standards:

- End of Year 1 (note: for Fall seeding, end of year 1 is end of following growing season, for Spring seeding, end of year 1 is end of year seeded):
  - Less than 10% invasive species cover
>90% vegetative cover; minimum 80% acceptable, live vegetation cover

Minimum 3 seeded native grass species and 3 seeded native forb species germinating

Minimum 1 native seedling germinating per square foot

• End of Years 2, 3, and 4:
  o <5% invasive species cover
  o >90% vegetative cover; minimum 80% acceptable, live vegetation cover
  o Minimum 50% of seeded species present

• End of Year 5:
  o <5% invasive species cover
  o >85% acceptable native species cover
  o >50% seeded species cover
  o Minimum 70% of seeded species present
  o Minimum Floristic quality index of xxx (project specific depending on what was seeded)

4.4 Estimating Mine Land Reclamation Costs

An example mine reclamation cost estimate worksheet is presented as Table 3. It includes line items that are part of typical mine reclamation, along with estimated unit costs. These estimated costs will vary depending on site conditions, ease of access, project scale, contractor, and many other factors. Cost estimates in the worksheet in Table 3 are based on bids from projects in Minnesota and Wisconsin, as well as RS Means Construction Cost Data.

The Summit Team also built a GIS-based tool for County staff for ongoing use during review of proposals. The tool requires that proposers submit separate GIS layers of the mining area extent and each proposed land cover type presented in Table 2. The tool calculates the area of each cover type, calculates the cost on a per acre basis, sums the costs, and enables the County to compare the total costs submitted by the proposer to costs calculated by the tool.
5.0 ADDITIONAL REFERENCES

See GCMSC Report for complete bibliography. Additional references include:


Minnesota DNR Ecological Land Classification Program, Minnesota County Biological Survey and Natural Heritage and Nongame Research Program. 2005. Field Guide to the Native Plant Communities of Minnesota: The Eastern Broadleaf Forest Province.


FIGURES
Mine Sites and Geology
Goodhue County, Minnesota

Mine ID, Company Name
1. Bruening Rock Products
2. Roberson Lime & Rock
3. Anderson Lime & Rock
4. Anderson Lime & Rock
5. Todd Angelstad
6. Milestone Materials
7. Milestone Materials

17. Jerry & Maria Swanson
18. Kielmeyer Construction
19. Kielmeyer Construction
20. Fitzgerald Excavating Co
21. Terry Lacanne
22. Luhman's Construction
23. Kielmeyer Construction
24. Randall Peine
25. Persson Inc

26. Skyline Materials
27. Skyline Materials
28. Skyline Materials
29. Charles Savage
30. Schumacher Excavating
31. Schumacher Excavating
32. Schumacher Excavating
33. Schumacher Excavating
34. Howard Strenerson
35. Midwest Asphalt
36. Dean Whitmore
37. Wojcik Construction

Legend
- Prosser Limestone (Galena)
- Cummingsville Fm (Galena)
- Decorah Fm (Galena)
- Platteville Fm
- St. Peter Sandstone
- Shakopee Fm (Prairie Du Chien)
- Oneota Fm (Prairie Du Chien)
- Jordan Sandstone
- Eau Claire Fm
- Mt. Simon Sandstone

Figure 1
File: 20120702_Goodhue_Fig1
Summit Proj. No.: 2155-0001
Plot Date: 07-02-2012
Arc Operator: RRE
Reviewed by: BDJ
Legend

- **High Slopes**

Map adapted from Goodhue County, Minnesota. Remote-sensing imagery originated from Ayres Associates.
Elevation Range in Feet

- 536 - 550
- 551 - 600
- 601 - 650
- 651 - 700
- 701 - 750
- 751 - 800
- 801 - 850
- 851 - 900
- 901 - 950
- 951 - 1,000
- 1,001 - 1,050

Legend

Elevation of Jordan Formation
Goodhue County, Minnesota

Figure 4
File: 20120702_Goodhue_Fig4
Summit Proj. No.: 2155-0001
Plot Date: 07-03-2012
Arc Operator: RRE
Reviewed by: BDJ
Accessibility of Jordan
Outside Bluffs and Setbacks
Goodhue County, Minnesota

Depth to Jordan
Feet

-47 - 0  91 - 120  151 - 180
1 - 90    121 - 150  181 - 210

Figure 5
File: 20120702_Goodhue_Fig5
Summit Proj. No.: 2155-0001
Plot Date: 07-02-2012
Arc Operator: RRE
Reviewed by: BDJ
Figure 6
Typical Wash Plant
TABLES
### Table 1
**Existing Mine Inventory**
**Goodhue County, Minnesota**
**July 2012**

<table>
<thead>
<tr>
<th>Company Name</th>
<th>Address</th>
<th>County Mine Number</th>
<th>Property Addresses</th>
<th>Acct Status</th>
<th>Approximate Depth to Silica Sand (below mine floor)</th>
<th>Average Daily Truck traffic</th>
<th>Blasting and Frequency</th>
<th>Product uses</th>
<th>Who Purchases Product</th>
<th>Mining Methods</th>
<th>Geologic Formations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anderson Lime &amp; Rock</td>
<td>15065 Sherwood Trail, Zumbrota MN 55992</td>
<td>NR</td>
<td>115236 1 County 6 Blvd, Wanamingo, MN 55983</td>
<td>Active</td>
<td>90</td>
<td>1-2 times/year</td>
<td>1-3 times per year</td>
<td>Lime</td>
<td>10663 County 30 Blvd, Wanamingo, MN 55983</td>
<td>Qcl</td>
<td>Cl=Clay</td>
</tr>
<tr>
<td>Anderson Lime &amp; Rock</td>
<td>1000 Michigan Street, Zumbrota MN 55992</td>
<td>NR</td>
<td>10742 182nd Ave, Zumbrota, MN 55992</td>
<td>Active</td>
<td>90</td>
<td>Yes/frequency unknown</td>
<td>1-3 times per year</td>
<td>Lime</td>
<td>10484 County 18 Blvd, Welch, MN 55089</td>
<td>Qcl</td>
<td>Cl=Clay</td>
</tr>
<tr>
<td>Anderson Lime &amp; Rock</td>
<td>28510 Highway 19 Blvd, Red Wing, MN 55066</td>
<td>NR</td>
<td>29750 150th Ave, Welch, MN 55089</td>
<td>Active</td>
<td>90</td>
<td>Yes/frequency unknown</td>
<td>1-3 times per year</td>
<td>Lime</td>
<td>29805 County 6 Blvd, Red Wing MN 55066</td>
<td>Qcl</td>
<td>Cl=Clay</td>
</tr>
<tr>
<td>Berman Materials</td>
<td>28670 187th Ave, Zumbrota, MN 55992</td>
<td>NR</td>
<td>15065 Sherwood Trail, Zumbrota MN 55992</td>
<td>Active</td>
<td>90</td>
<td>Yes/frequency unknown</td>
<td>1-3 times per year</td>
<td>Lime</td>
<td>29900 County 6 Blvd, Red Wing MN 55066</td>
<td>Qcl</td>
<td>Cl=Clay</td>
</tr>
<tr>
<td>Blue Ridge Aggregates</td>
<td>29900 County 6 Blvd, Red Wing MN 55066</td>
<td>NR</td>
<td>28510 Highway 19 Blvd, Red Wing, MN 55066</td>
<td>Active</td>
<td>90</td>
<td>Yes/frequency unknown</td>
<td>1-3 times per year</td>
<td>Lime</td>
<td>30260 County 1 Blvd, Red Wing, MN 55066</td>
<td>Qcl</td>
<td>Cl=Clay</td>
</tr>
<tr>
<td>Bumble Bee Quarries</td>
<td>30000 County 1 Blvd, Red Wing, MN 55066</td>
<td>NR</td>
<td>29805 County 6 Blvd, Red Wing MN 55066</td>
<td>Active</td>
<td>90</td>
<td>Yes/frequency unknown</td>
<td>1-3 times per year</td>
<td>Lime</td>
<td>30260 County 1 Blvd, Red Wing, MN 55066</td>
<td>Qcl</td>
<td>Cl=Clay</td>
</tr>
<tr>
<td>Goodhue County</td>
<td>15065 Sherwood Trail, Zumbrota MN 55992</td>
<td>NR</td>
<td>15065 Sherwood Trail, Zumbrota MN 55992</td>
<td>Active</td>
<td>90</td>
<td>Yes/frequency unknown</td>
<td>1-3 times per year</td>
<td>Lime</td>
<td>29900 County 6 Blvd, Red Wing MN 55066</td>
<td>Qcl</td>
<td>Cl=Clay</td>
</tr>
</tbody>
</table>

**Notes**: The additional information was supplied by Goodhue County or the mining company or both.
<table>
<thead>
<tr>
<th>Typical Landscape Position and Growing Conditions</th>
<th>Plant Community Native to Goodhue County adapted to these conditions</th>
<th>Description</th>
<th>Estimated Cost Per Acre*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steep south or west facing slopes above Mississippi River and tributaries; thin sandy or gravelly soil</td>
<td>Bedrock Bluff Prairie</td>
<td>Open grassland community consisting of patches of very drought tolerant prairie grasses and forbs growing around bedrock outcrops and exposed soils</td>
<td>$9,000-$12,000</td>
</tr>
<tr>
<td>Full sun exposure, level to steeply sloping sites, dry soils</td>
<td>Dry prairie</td>
<td>Open grassland community consisting of drought tolerant prairie grasses and forbs</td>
<td>$2,000-$5,000</td>
</tr>
<tr>
<td>Full sun exposure, deep, moderately moist, well drained but not excessively dry, level to rolling topography</td>
<td>Mesic Prairie</td>
<td>Open grassland community on deep, generally rich soils, typically has rich forb diversity</td>
<td>$2,000-$5,000</td>
</tr>
<tr>
<td>Full sun exposure, deep, wet soil; water table typically remains 12” to 24” below the surface for much of the growing season but the surface is usually not saturated except during brief periods of snow melt or heavy rains; typically in slight depressions.</td>
<td>Wet Prairie</td>
<td>Open grassland community with rich forb diversity on deep, wet soils</td>
<td>$7,000-$10,000</td>
</tr>
<tr>
<td>Nearly level to steeply sloped sites with dry soils</td>
<td>Dry Savanna</td>
<td>Sparsely treed community with grass dominated herbaceous ground cover, trees are open grown and typically small and gnarled</td>
<td>$5,000-$10,000</td>
</tr>
<tr>
<td>On steep, exposed, south to west facing bluffs, often adjacent to bedrock bluff prairies</td>
<td>Oak-Hickory Woodland</td>
<td>Dry-mesic or dry deciduous woodlands, typically 75-100% canopy cover</td>
<td>$8,000-$15,000</td>
</tr>
<tr>
<td>Most often on north and east facing slopes on thin, wind deposited silt on crests and upper slopes of bedrock bluffs</td>
<td>Oak Forest</td>
<td>Hardwood forests with 50-100% canopy cover</td>
<td>$11,000-$15,000</td>
</tr>
<tr>
<td>On loamy soils, in sites protected from fires like hummocky stagnation moraines, till plains along the Minnesota Rivers, and middle and lower bedrock bluff slopes</td>
<td>Maple Basswood Forest</td>
<td>Closed canopy deciduous forest community of shade-tolerant, trees sensitive to fire, shrub layer typically sparse, diverse ground layer</td>
<td>$11,000-$15,000</td>
</tr>
<tr>
<td>Typical Landscape Position and Growing Conditions</td>
<td>Plant Community Native to Goodhue County adapted to these conditions</td>
<td>Description</td>
<td>Estimated Cost Per Acre*</td>
</tr>
<tr>
<td>--------------------------------------------------</td>
<td>----------------------------------------------------------</td>
<td>-------------</td>
<td>------------------------</td>
</tr>
<tr>
<td>On sand deposits along valley floor and on very steep generally north facing slopes of the Mississippi River and tributaries</td>
<td>White Pine Hardwood Forest</td>
<td>Dry mesic pine hardwood community, typically 25-75% canopy cover</td>
<td>$11,000-$15,000</td>
</tr>
<tr>
<td>In active river floodplains, on low, level, annually flooded sites along medium and large rivers, sandy or silty soils</td>
<td>Floodplain forest</td>
<td>Deciduous forest tolerant of prolonged seasonal inundation, sediment deposition, erosion and ice scouring, understory is typically open</td>
<td>$11,000-$15,000</td>
</tr>
<tr>
<td>On mineral soils near margins of lakes and wetlands, in ravines, on the lower portions of north facing slopes.</td>
<td>Lowland Hardwood Forest</td>
<td>Deciduous forest, typically 50-100% canopy</td>
<td>$11,000-$15,000</td>
</tr>
<tr>
<td>Shady areas of north facing slopes or narrow ravines in mesic forests in deeply dissected bluffs along the Mississippi River and its side valleys</td>
<td>Moist Cliff</td>
<td>Open, lichen and moss dominated community; vascular plants are restricted to crevices and ledges</td>
<td>$17,000</td>
</tr>
<tr>
<td>Dry, steep cliff faces, typically south to west facing</td>
<td>Dry Cliff</td>
<td>Open, lichen dominated community, vascular plants are restricted to crevices and ledges</td>
<td>$12,000-$17,000</td>
</tr>
<tr>
<td>Soils are saturated to flooded following spring thaw or heavy rains; water level often slowly recedes during growing season but water table remains at or near soil surface</td>
<td>Wet Meadow</td>
<td>Open shallow wetland communities dominated by grasses and sedges.</td>
<td>$12,000-$17,000</td>
</tr>
<tr>
<td>Typically on slight slopes where cold, oxygen poor groundwater rich in calcium and magnesium carbonates discharges to the surface and drains away, and surface water inputs are minimal; soils typically shallow to deep peat</td>
<td>Calcareous Fen</td>
<td>Open graminoid dominated community; rare community protected by law</td>
<td>$20,000+</td>
</tr>
<tr>
<td>Along margins of rivers and lakes</td>
<td>Emergent Marsh</td>
<td>Open wetland community dominated by grasses and forbs</td>
<td>$12,000-$17,000</td>
</tr>
</tbody>
</table>

*estimated cost per acre includes cost for seeding herbaceous species, planting liner stock of trees and shrubs for woody plant communities, and temporary irrigation for those plant communities that need it. Estimated cost range does not represent absolute lowest or highest rates, costs will vary by site and market rates will apply.

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Table 3
Reclamation Cost Worksheet
Goodhue County, Minnesota
July 2012

<table>
<thead>
<tr>
<th>Item</th>
<th>Unit</th>
<th>Cost per Unit – low end of estimated range</th>
<th>Cost per Unit – high end of estimated range</th>
<th>Number of Units</th>
<th>Amount ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mobilization</td>
<td>Lump Sum</td>
<td>Variable</td>
<td>Variable</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Demolition</td>
<td>C.f.</td>
<td>$21</td>
<td>$21</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Demobilization</td>
<td>Lump Sum</td>
<td>Variable</td>
<td>Variable</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Landfill disposal of demolition</td>
<td>Ton</td>
<td>$20</td>
<td>$50</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temporary erosion and sediment control</td>
<td>Lump Sum</td>
<td>variable</td>
<td>variable</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grading</td>
<td>Cubic Yard</td>
<td>$3</td>
<td>$5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Loosen subsoil: paraplow to 30” depth</td>
<td>Acre</td>
<td>$1,000</td>
<td>$1,200</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Re-apply stockpiled topsoil</td>
<td>Cubic Yard</td>
<td>$3</td>
<td>$5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Herbicide unwanted species</td>
<td>Acre</td>
<td>$800</td>
<td>$1,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Controlled Burn</td>
<td>Acre</td>
<td>$200</td>
<td>$500</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Procure and install mulch</td>
<td>Cubic Yard</td>
<td>$125</td>
<td>$125</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Install mulch chipped from woody plants cleared from mining site</td>
<td>Cubic Yard</td>
<td>$30</td>
<td>$60</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soil amendments: mycorrhizae</td>
<td>Acre</td>
<td>$1,000</td>
<td>$2,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soil amendments: superabsorbent polymer</td>
<td>Acre</td>
<td>$1,000</td>
<td>$2,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Procure and install native seed</td>
<td>Acre</td>
<td>$2,000</td>
<td>$15,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Procure and install native plant plugs</td>
<td>Each</td>
<td>$3</td>
<td>$5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Procure and install bare root tree</td>
<td>Each</td>
<td>$75</td>
<td>$150</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Procure and install 1.25” tree</td>
<td>Each</td>
<td>$200</td>
<td>$200</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Procure and install bare root shrub</td>
<td>Each</td>
<td>$15</td>
<td>$30</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Procure and install 1 GAL shrub</td>
<td>Each</td>
<td>$20</td>
<td>$40</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 years of start-up maintenance</td>
<td>Acre</td>
<td>$8,000</td>
<td>$12,000</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Estimated cost range does not represent absolute lowest or highest rates, costs will vary by site and market rates will apply.*
APPENDICES
1.0 Introduction
Sand mining has occurred in Wisconsin for hundreds of years; however, recently there has been a dramatic increase in the number of mining proposals. This increase is attributed to a surge in hydrofracking, a technique used by the petroleum industry to extract natural gas and/or crude oil from rock formations, which requires a certain quality of sand in the process. Wisconsin possesses high-quality sand resources and therefore is seeing a substantial rise in mining permit requests to mine for frac sand. Consequently, the topic of sand mining in Wisconsin has generated interest from regulators, legislators, local government, and the general public.

2.0 Purpose of this document
This is an informational document that summarizes our best current information on the mining process, possible environmental impacts, and applicable regulations. There are no oil or gas wells located in Wisconsin, thus this document does not address the effects of the hydrofracking technique. This document is intended to be a dynamic document and will be updated periodically as new significant information becomes available.

3.0 Background Information Hydrofracking, Frac Sand and Frac Sand Mining in Wisconsin

3.1 What is Hydrofracking?
Hydrofracking is also referred to as hydraulic fracturing or fracing. The technique involves drilling a typical oil or natural gas well thousands of feet below the earth’s surface and using explosives to create small cracks in the rock. Then water, frac sand, and chemicals are pumped under high pressure into the well for the purpose of expanding the cracks and holding them open. By fracturing the rock and then holding these fractures open it is possible to more easily remove the resources sequestered in the rock. Hydraulic fracturing has been around for over 60 years but recent developments in directional boring and other technologies in combination with hydraulic fracturing now allow for the extraction of natural gas and oil that was previously not extractable. Use of these techniques has also made it more economical to extract oil and gas from formations that were previously too expensive to mine. Because of this, there has been a large increase in hydraulic fracing and thus an increase in demand for frac sand. Most of the natural gas shale rock wells are located in Texas, Oklahoma, Mississippi, Arkansas, New York, North Dakota and Pennsylvania.
Figure 1. Clockwise: Trailers of sand and compressor trucks around a well during a hydrofrac job. Lower right, well rounded pure quartz sand typical of Wisconsin Cambrian sandstones. Lower left, basic principles of hydrofracking. Fracturing low permeability gas bearing shale with fluid pressure, sand is injected as a proppant to hold fractures open and allow gas to flow from rock.

Figure 2. Locations of major shale gas resources (American Petroleum Institute)
3.2 What is Frac Sand?

Frac sand is silica sand or silicon dioxide (SiO₂), also referred to as quartz. Silica sand has been mined for thousands of years as it has many uses, from paving roads to filtering drinking water. It is also used in the hydrofracking process: fluid pressure fractures the rock and opens natural fractures and pores that would normally be closed due to the weight of the overlying rock, the sand grains are then carried into these fractures and prop them open after the fluid pressure is released. Hence the name proppant; a term commonly applied to frac sand.

Not all silica sands can be used for hydrofracking. To meet the industry specifications, frac sand needs to be nearly pure quartz, very well rounded, and must meet tight size gradation standards. The sand must also have a high compressive strength, generally between 6,000 psi and 14,000 psi. Sands that meet these specifications are mined from poorly cemented Cambrian and Ordovician sandstones and from unconsolidated alluvial sands locally derived from these sandstones. Sands derived from Quaternary glacial deposits, and most beach and riverbank sands are too impure and too angular to be used as frac sand. Wisconsin has areas which contain high-quality silica sands which are desirable for use in hydrofracking.

3.3 Sand Mining in Wisconsin

Wisconsin has abundant resources of sand that range in age from Quaternary glacial deposits to marine sandstones of Cambrian age (500 million years). Sand has been mined in Wisconsin since the arrival of the first permanent settlers. The oldest continuing use has been as fine aggregate for mortar and concrete. Molding sand has been mined since the beginnings of the foundry industry in the 19th century. Sand has also been mined for filter beds for drinking water and wastewater treatment, well screen packing, glass manufacture, and bedding sand for dairy operations.

Frac sand for use in the petroleum industry has been produced in Wisconsin for over 40 years. However, the demand for frac sand has increased exponentially in the past two to three years. Wisconsin has approximately 60 mining operations involved in extraction of frac sand and approximately 30 processing facilities operating or under construction. Current mining operations are primarily located in West Central Wisconsin but there are also facilities in Burnett, Green Lake and Waupaca Counties. This does not include very small operations or the frac sand being removed and sold as a result of excavations associated with cranberry culture.

A conservative estimate of Wisconsin frac sand mining capacity based on existing mines, mines under construction, and processing plants would be in excess of 12 million tons per year. Currently there are approximately 20 new mining operations being proposed and the impacted counties report considerable interest and many mine and processing plant proposals are under consideration.
3.4 Location of Frac Sand in Wisconsin

Sand that will meet frac sand specifications is found in the Cambrian: Jordan; Wonewoc; and Mt. Simon Formations; and in the younger Ordovician-age St. Peter Formation (Figure 4 and 5).

Principal areas of interest for sand mining have been in western Wisconsin, from Burnett and Chippewa Counties in the north to Trempealeau, Jackson and Monroe Counties in the south.

Activity in the north, primarily in Barron and Chippewa Counties has concentrated on mining Jordan Sandstone from exposures on hilltops, and on mining Wonewoc Sandstone on lower hillsides. The lower part of the Jordan Formation, the Norwalk Member, and the underlying St. Lawrence dolomite and Tunnel City sandstones are too fine grained and contain impurities such as feldspar which make them unsuitable for use as frac sand.

In Pierce County, Jordan Sandstone (the upper coarser grained Van Oser member) has been mined underground for many years from tunnels driven into the bluffs beneath the Prairie du Chien Dolomite. The fact that the Van Oser Member is near the top of the Jordan has created interest in mining it from the floor of depleted Prairie du Chien dolomite quarries on ridge tops in Dunn, St. Croix, and Buffalo Counties.
BEDROCK SAND RESOURCES

**Cambrian Wonewoc Fm.**
Important producer and potential resource in west, not exposed elsewhere.

**Cambrian Jordan Fm.**
Extensive potential in west, currently important source of frac sand from underground mines. Poor exposure in east.

**Ordovician St. Peter Fm.**
Long production history and good potential in south and east. Channels can make prospecting a challenge in the northeast.

Figure 4, Stratigraphic column for Wisconsin showing position of Cambrian and Ordovician sandstones mined for frac sand. *(WGNHS Educational series 51, 2011)*

Figure 5, Regional geologic map showing Cambrian sand outcrop area in yellow and St. Peter Sandstone in green in west-central Wisconsin. *(From USGS Geologic Map of USA)*
Figure 5 shows the distribution of the formations that are targets for frac sand development in western Wisconsin. The rocks are essentially flat lying, with a slight dip to the west. The pattern on the map is due to erosion that has cut down through the layers, exposing the older rocks in the valleys. This is the coulee topography typical of the Driftless area, a region of Wisconsin not covered by the Quaternary glaciers.

The Jordan Formation forms a narrow outcrop band on the upper slopes of the ridges, and is exposed in the valleys of southern Pierce County and along the western side of the Chippewa Valley. The Wonewoc forms a wider outcrop area on the lower slopes.

Most new mines under development or proposed in Trempealeau, Dunn, Buffalo, Jackson, and Monroe Counties are in the Wonewoc. The Wonewoc is finer in average grain size than the Van Oser Member of the Jordan, but high purity makes some of the material that is too fine for frac sand suitable for the glass industry. Although the Wonewoc has more material not suited for frac sand, it is easier to mine in the southern region because of the much greater surface exposure, which eliminates the need to mine underground.
4.0 A Typical Sand Mining Operation

Although there is a great amount of variability in how sand is mined, this section describes a typical sand mine and sand processing plant. Note there are several mining facilities in operation and several proposed that mine or would mine below the groundwater level utilizing hydraulic dredging to remove the sand. The overview of the sand mining process provided below is descriptive of a more common dry mine although in both cases many of the same additional processing steps would take place with both mining methods.

4.1 OVERBURDEN REMOVAL/EXCAVATION

Prior to any actual mining being done at a site, it is necessary to remove overburden from the top of the sand formation. Overburden is topsoil or subsoil that is mainly composed of silt, loam, clay, or combinations of the three. Overburden thickness is highly variable, but as has been stated above, a desirable trait of Wisconsin’s frac sand formations is that they are close to the surface, meaning there is little overburden to remove.

Removal is performed by scrapers or tracked excavators and off-road haul trucks. The overburden is often hauled to the perimeter of the mine site and piled into berms. Topsoil is kept separate and used on top of the berms once they have reached their final elevation. Finally the berms are seeded and mulched. The berms have multiple purposes; they provide storage for overburden until the mine is reclaimed, they provide a visual barrier between the active mine and roads or adjoining properties, they screen light pollution should the mine be operated after dark, and they act as a noise barrier.

4.2 EXCAVATION

Once the overburden has been removed, the sand is excavated. Depending upon the geological formation, blasting may be used to make the sand containing material more amenable to excavation. Excavation is typically performed by large tracked excavators or rubber-tired front end loaders. The excavated material may be taken directly to the washing process, stockpiled on site for later processing, trucked to a processing facility or trucked to a rail load-out where it would be taken by rail to a processing plant. Stockpiles may be formed by conveyors, or trucks may deposit the sand in a pile and a dozer or rubber-tired loader will push the sand, gradually building a large pile that the trucks drive on top of to deposit more sand.

4.3 BLASTING

In situations where the sand-bearing geological formation is tightly cemented it may be necessary to utilize blasting to make the sand more amenable to removal. Blasting practices can result in noise, vibration, and fugitive dust emissions. Blasting at mines will vary with site specific geology. It may be conducted as frequently as every day or only once every few months.
It is difficult to describe an average blast scenario since it is specific to each mining operation and the particular geological formation. An example of typical sand mine blast might consist of drilling 40 holes, 2 to 3 inches in diameter into the formation to be blasted. The holes could be 50 to 150 feet deep and located in a grid 20’x 20’ (example only). A charge of explosive (types of explosive vary depending upon the intended result of the blast) is placed at the bottom of the hole. A detonation cord is connected and run to the top of the hole. The space between the charge and the top of the hole is filled with stemming material. Stemming material is an inert material used to backfill a borehole for the purpose of containing the explosive energy. The stemming material also acts to minimize fugitive dust (airblast) emissions from the explosion. The type of stemming used is dependant on what is readily available at the mine site and may be composed of such things as sand or crushed rock. After the stemming material has been placed a blasting cap is attached to the detonation cord and all of the blasting caps are connected to a detonator. In modern blasting techniques the detonators are typically electronically sequenced to detonate individual blasting caps milliseconds apart. This sequencing improves the effectiveness of the blasts and reduces off site vibrations, minimizing impacts to nearby structures.

Federal Mine Safety and Health Administration (MSHA) rules require the use of water injection when drilling the blasting holes in order to control drilling dust. Prior to drilling, sand mine operators usually remove overburden, which also lessens the amount of fine material that can become airborne by blasting. If needed during summer periods, water may also be sprayed onto blast areas to minimize fugitive dust emissions.

Impacts to nearby neighbors from blasting can be minimized by using proper blasting techniques, notifying neighbors of blasts, and limiting blasting to daylight hours.

The Wisconsin Department of Safety and Professional Services regulates blasting activities. Blasting regulations in Wisconsin are found in SPS 307, Wis. Adm. Code. SBS 307 regulates licensing of individuals involved in blasting activity, allowable blasting explosives and methods, recordkeeping of blasts, notification of neighbors, monitoring of seismic and airblast energy and sets allowable seismic and airblast energy limits .This code applies to all nonmetallic mines including frac sand mine sites

The State Mine Safety program is also administered by the Department of Safety and Professional Services. Their charge is to inspect mining operations, training, complaint response enforcement of state code and liaison with federal Mine Safety and Health Administration (MSHA).

4.4 CRUSHING

If the formation is of such a nature that it requires blasting, it is likely that the material will then need to be crushed to reduce the size of the particles for later handling. After blasting, the sand is in a mix of rocks and boulders on the floor of the mine. This material is often referred to as shot rock. A mobile crushing unit is brought to the mine and is placed close to the blast area in order to minimize the distance the shot rock needs to be hauled to be loaded into the crusher. Larger mines may have a permanently placed crushing plant. In these cases the shot rock is either conveyed or hauled to the crusher by haul trucks loaded by front end loaders or large excavators.
Crushing plants are usually composed of a primary crushing unit and a secondary crusher with a screen plant. Crushing plants are powered by either a large diesel engine, or by a generator. The shot rock is picked up by front end loaders from the blast area and carried to the primary crusher. The primary crusher breaks the shot rock into what is referred to as \textit{breaker run}. Breaker run is conveyed to the secondary crusher where it is further broken down. The resulting material is fed to a screen plant where it is sorted by size. Smaller particles of a targeted size are carried away to stockpiles. Larger particles are recycled within the plant to the secondary crusher and screens until they have reached the desired size.

\section*{4.5 PROCESSING}

To be used for the hydrofracking technique, sand usually has to undergo further processing. Frac sand, as has been stated above, must be of uniform size and shape. To achieve this uniformity the sand is run through a processing plant. The plant will wash, dry, sort, and store the sand.

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. Some processing operations also use what is called an upflow clarifier to wash the sand. An upflow clarifier is essentially a tank where water and sand are continuously directed into the tank. The water washes the sand and the overflow water along with the fines overflow the tank while the washed sand falls by gravity to the bottom of the tank and is sent for further processing.

After washing the sand is then sent to a surge pile where much of the water adhering to the sand particles infiltrates back into the ground. In Wisconsin the wet portion of the processing facilities typically runs from April to mid November. The drying portion of the process can operate year round thus necessitating stockpiling of washed sand adequate to last through the winter processing months.

From the surge pile the sand is sent to the dryer and screening operation. The sand may be dried by feeding it into a large rotating drum. This drum has hot air blasted into it by burning natural gas or liquid propane. Fins inside the drum agitate the sand and carry it forward through the dryer. When it reaches the end of the drum the sand is cooled and may be further sorted by screening. Another newer drying technology is the fluidized bed dryer. Sand is introduced into the dryer and heated gas from combustion of natural gas or propane is introduced through holes in plates in the bottom of the dryer. This gas lifts or fluidizes the sand and the heated gas dries the sand. Once the sand is dried it is cooled and may be further sorted by screening. This sorting is performed so that sand particles of similar sizes may be selected and stored. Sand that is suitable for fracing is kept, and sand that is not suitable may be sold to industry for other uses that have been listed above.

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.
Processing plants may be located on the same site as the mine or in some cases the processing plant is located separate from a number of mines which support the processing facility. In the later scenario the sand is transported to the processing plant by dump trucks or tractor-trailer units.

### 4.6 TRANSPORTATION

Transportation of sand from the time it is mined, processed, and eventually delivered to the location where it is going to be used can take many forms depending upon the location of the mine, the processing facility and the destination where the sand will ultimately be used. Within the mine the sand may be transported by front end loaders, large open-topped off-road trucks, or dump trucks. Open-topped dump trucks and closed gondola compartmentalized trucks (similar to grain trucks) are currently being used to transport sand directly to rail spurs for shipment or to processing facilities.

Vehicular traffic on local roads will have an impact on the service life and condition of the roads. The degree of road deterioration will depend on the amount of traffic, the type of vehicles, and the design of the road.

Rail currently seems to be the preferred method of transporting sand from the mine or from the processing plant to the location of final use. Most of the rail cars being used are open-topped, while some are compartmentalized bottom unloading gondola type cars. Reportedly one operation is trucking sand to Minnesota where it is being processed, then this sand is loaded onto barges and transported to market down the Mississippi River.

### 4.7 RECLAMATION

NR 135 Wis. Adm. Code requires all counties in the state of Wisconsin to implement a nonmetallic mining reclamation permit program including adoption of an ordinance and administration of a mining reclamation program. The purpose of this program is to assure mining sites are reclaimed to a post mining land use. Nonmetallic mining permits are subject to uniform reclamation standards that are provided in NR 135 Wis. Adm. Code.

NR 340 Wis. Adm. Code is administered by WDNR and it also has reclamation requirements. This law applies to a mine or portions of a mine that are adjacent to navigable waterways.

Because large frac sand mines are designed to be mined and reclaimed in phases there will, in most cases, be on-going contemporaneous reclamation. In any case, when the supply of sand at the mine site has been exhausted, the mine owner/permittee is required to reclaim the mine area. Mine reclamation is administered by the county regulatory authorities (RA) where the mine is located. There is some variation in what counties require for reclamation, but generally the site will be graded so that slopes do not exceed a 3:1 slope. This generally applies to slopes that will receive topsoil or substitute plant growth material but steeper slopes may be approved by the RA based on test plots or other justification. Vertical or near vertical highwalls may be approved by the county RA, if shown to be safe and stable, or if the highwall was in existence before NR135. Once grading is complete the site will have topsoil applied, and then be seeded and mulched. In some instances a mine will be converted to a building site or a farm field.
Mine owners are required to provide the RA with a bond or some other form of financial assurance as a condition of the NR 135 permit. The financial assurance must be in place prior to initiating mine development activities and must be payable to the county RA. This ensures that should an operator fail to fulfill their obligation under the reclamation plan that the County will have sufficient funding available to carry out the approved reclamation plan. It is important that County RAs periodically check to ensure that the dollar amount continues to be adequate to perform all reclamation activities necessary to comply with the uniform statewide reclamation standards in NR 135, the county reclamation ordinance, and the approved reclamation plan.
5.0 Environmental Impacts

The environmental impacts of a sand mining facility will vary by location and type of operation. This document summarizes the types of impacts that could occur.

5.1 AIR IMPACTS

Nonmetallic mining sites and frac sand processing facilities have two types of air emissions. The first is from dust that may be emitted during the mining and handling of sand. The second is from various pollutants emitted from equipment used to mine, handle, and/or process the sand.

Each mine and/or processing plant may differ within the industry. An industrial sand mine may consist of the following operational equipment:
- Blasting
- Overburden Removal and Excavation
- Backfilling
- Crushers
- Pumps
- Washing
- Stockpiles
- Conveyors
- Loading/Unloading
- Mobile Equipment Traffic
- Generators (Electrical Generating Units)

The processing of sand may consist of the following operational equipment, which could also include those processes identified above for mining operations:
- Conveyors
- Dryers
- Screening
- Storage Bins/Silos
- Loading/Unloading

Each subsection below includes an evaluation and explanation of air emissions and potential regulations as it applies to each part of the construction phase or operation.

5.1.1 Construction Impacts

No major air impacts are expected during site development. Excavation and earth work is anticipated for planned new facilities. Fugitive dust during construction would be minimized by BMPs which include paving or placing gravel on access roads and watering down roads or work areas with tanker trucks as needed. Diesel emissions from construction equipment would be temporary and minor.

5.1.2 Operational Impacts
5.1.2.1 Blasting

Depending upon the geological formations, blasting may be used to make the sand more amenable to removal. Blasting activities are likely to be performed on an intermittent basis at mining sites. Air pollution emissions related to this activity are commonly considered fugitive in nature and insignificant, and may be controlled through various methods.

Mining operators would be required to maintain a fugitive dust prevention plan, whereby methods to minimize fugitive dust emissions resulting from blasting operations would be described and followed. The WDNR can review, make suggestions, and approve these methods and typically facilities will work with their surrounding community on awareness of such events. Materials used in blasting are also regulated by the department or the department of industry, labor and human relations.

Allowable fugitive dust emissions from blasting are covered by the facility’s air management permit issued by the WDNR and are limited to 10% opacity. Opacity is defined as the degree to which emissions reduce the transmission of light and obscure the view of an object in the background. Limited observation at existing mine sites by WDNR inspectors has shown fugitive dust emissions from blasting are not significant.

5.1.2.2 Overburden Removal, Excavation, and Crushers

The removal and protection of topsoil and subsoils that lie above the target sandstone is typically required through NR 135 reclamation permits when a new mine or phase of a mine is opened during mine expansion. This work may be accomplished by using hydraulic excavators, trucks, dozers, and scrapers. Extraction is performed by front-end loaders in less consolidated deposits while blasting is required in others. When blasting is necessary, the process begins by drilling holes into the sandstone in order to allow breaking it into smaller more workable pieces by blasting with explosives (see Blasting section above). Materials will then be excavated by front-end loaders and, depending on the conglomeration of such material, a crusher unit may be utilized to further reduce particle size. Resulting materials would then be conveyed, likely by slurry transport, to further processing (see Pumps and Washing sections below). The soils are typically stored and protected in stockpiles or vegetated berms.

Air pollution resulting from this activity would include minor combustion emissions from equipment and fugitive dust (particulate). Combustion emissions are typically considered insignificant per s. NR 407.05(4)(c)9.f. Wis. Adm. Code. Those emissions may be minimized through routine maintenance of equipment to operate most effectively and efficiently. Water trucks or recycled water from the pumps and slurry system (washing operations) may be used to eliminate fugitive dust concerns during removal and excavation. Water bars or other wetting techniques may be used to minimize dust from crusher units. Soil stockpiles are seeded and mulched for revegetation as soon as the season’s work is complete, which helps minimize and eliminate fugitive dust.

These activities are typically located further within the mine area rather than near property boundaries. Therefore, it is uncommon for fugitive dust to escape off-site except during periods of strong winds and dry conditions. BMPs and fugitive dust control plans are utilized to minimize fugitive dust. These practices or plans are requirements under NR 415 Wis. Adm. Code, with specific requirements for industrial
sand mines under s. NR 415.075(6), Wis. Adm. Code, for mines that produce 2,000 tons per month or more. Facilities that implement such practices and/or plans reduce potential impacts to public health, and are subject to review and approval by the WDNR and may be made available to the public upon request.

Finally, any facility that operates a crusher unit is subject to the New Source Performance Standards (NSPS) under s. NR 440.688, Wis. Adm. Code. These units would be subject to a limitation of no greater than 15% opacity. Since most crushers do not utilize any capture system associated with their operation/emissions, the unit is considered a fugitive source of emissions. Beyond the requirements of the NSPS, the unit would also be covered by the fugitive dust prevention plan (previously discussed above).

5.1.2.3 Pumps and Washing

Some facilities utilize a slurry pump and washing system to further prepare the sand for storage, drying or loading (transport). Once the mined sand is collected and has gone through a crusher (if required), the sand is converted to a slurry by the addition of water typically provided by a closed-loop (onsite water reuse). A slurry system may require approximately 3,000 gmp of water (this can differ greatly depending on the type of slurry system utilized at each site). To the extent possible, water will be conserved and recycled by means of a settling pond. Please refer to the Storm water/Wastewater section for more information regarding wastewater discharge.

Processing is conducted with equipment which may include screening, hydrocyclones and other wet processing methods. Flocculents (chemical additives) may be used to treat colloidal clays. The materials (mainly sand) processed are within a closed-loop system, and are wet. Therefore, there will be very minimal, if any, associated air pollution emissions from this process; and this is typically considered an insignificant activity. Finished sand from the wet process will be a coarse graded material that will be stored in a stockpile.

5.1.2.4 Stockpiles

Stockpiles seen at mining or processing sites typically contain the coarse sand raw material that will eventually be fed to a dryer. The stockpiled sand is typically wet at first, but then may dry out as it sits in the open environment. Moving sand from the stockpiles and to a dryer is usually done with front end loaders and material conveyors. Please refer to the conveyor section below for more information on that activity.

Air pollution resulting from this activity would include fugitive dust (particulate). Operators would be required to maintain and follow a fugitive dust prevention plan. Depending on the processing steps taken prior to stockpiling, the grain size of the sand in the stockpiles are typically larger than PM (PM, or particulate matter, is defined as any airborne finely divided solid or liquid material with an aerodynamic diameter smaller than 100 micrometers); especially if hydrosizers are utilized during the washing phase.

5.1.2.5 Loading/Unloading – Mining Operations

Loading operations at a mine may include the transfer of raw materials into trucks or railcars for transport. Unloading operations at a mine may include the dumping of fines/reject sand brought from processing plants or other operations. Loading operations
may or may not be within an enclosed structure. Material is loaded in an enclosed structure to reduce fugitive emissions and/or assist in the capture and return of raw materials back into the process (less loss of material that could be used further down the process line). Unloading typically is done in the open environment as a fugitive source.

Activities resulting in fugitive emissions would need to follow a fugitive dust prevention plan, whereby methods to minimize fugitive dust emissions resulting from the activity would be described and followed. Such activities are considered significant and may be further regulated by specific emission limitations; whereby the limitations and compliance demonstration methods would be described by any air pollution control permit issued to the facility. Those operations that are captured and/or controlled would also be considered a significant activity, and would follow the same protocol for regulation as above.

5.1.2.6 Mobile Equipment Traffic (Fugitive Particulate & Diesel Particulate)

Mines and processing plants will include mobile equipment traffic on-site (e.g., front-end loaders, trucks, etc.). The WDNR does not account for mobile equipment emissions off-site, but has regulations for the minimization of fugitive dust that may apply to any transportation. Air pollution resulting from this activity would include minor combustion emissions from equipment and fugitive dust (particulate). Combustion emissions are typically considered insignificant per s. NR 407.05(4)(c)9.f., Wis. Adm. Code. Those emissions may be minimized through routine maintenance of equipment.

Roadway fugitive dust emissions, associated with truck traffic, may be controlled through BMPs included within a fugitive dust prevention plan. Control measures may include: (1) paving roadways, (2) spraying of water on dusty roads or sweeping of dust laden roadways, (3) utilization of a wheel wash or tire bath at the entrance/exit of the facility, (4) posting and maintenance of a low speed limit on paved or unpaved roads or other areas used by haul trucks inside the facility’s property line, and (5) covering, treatment or securing of materials likely to become airborne from haul trucks during transport, prior to any transportation off site from the quarry or mine (precautions to prevent particulate matter from becoming airborne, according to s. NR 415.075(2)(a), Wis. Adm. Code).

Diesel exhaust emissions off-site are not regulated by stationary source air pollution control permits. Emissions from diesel exhaust specific to a facility/project are not directly included in an air quality dispersion modeling analysis. They are included indirectly through inclusion of background. Diesel exhaust (mobile source) emissions are included in the air quality dispersion model only as part of the background concentrations and are added to the total impact from the stationary source emission impacts and do show attainment of the ambient air quality standards. Federal EPA regulations apply to diesel engine manufacturers for the minimization of diesel particulate or other types of emissions, and consequently those emissions are not regulated by WDNR.

5.1.2.7 Generators (Electrical Generating Units)

Most mining operations include the utilization of an electrical generator to supply electricity to equipment such as pumps, conveyors, and crushers/screen plants. The generators typically combust diesel fuel. The engines usually have very short exhaust stacks and could have relatively high potential emissions if operated 24 hours per day, 7 days a week. However, most units do not operate year round and when operated at a
location within the mine within a timeframe established by the operator and WDNR, will attain and maintain ambient air standards.

Depending on the use and portable status of the units, several regulations (Federal and State) may apply, which would further minimize pollution and ambient air impacts. One common best management practice (BMP) to meet these standards is the firing of ultra-low sulfur diesel fuel, although this is not required by Federal law. Emissions from such units are included in the WDNR’s air dispersion analysis (see section 5.1.3), which is used to establish permit requirements to assure attainment of ambient air standards.

5.1.2.8 Conveyors

Conveyors are used throughout the mine and processing plant. They are used to transport sand short distances to different operations on the sites or to stockpile material. Sand conveyed from the active mining area to storage piles is typically wet and would not require any further BMPs. However, sand conveyed from the storage piles to further processing (transfer to dryers) is typically dry and would require fugitive dust minimization practices.

Air pollution resulting from this activity would include fugitive dust (particulate). Operators would be required to maintain and follow a fugitive dust prevention plan, whereby methods to minimize fugitive dust emissions resulting from the conveyors would be described and followed. Some conveyors at larger operations would also be subject to a visible emission limitation (visible dust plume), thereby potentially making the fugitive dust prevention practices more stringent or requiring utilization of better controls (e.g., covering of conveyors).

5.1.2.9 Dryers

Prior to sand being sized and stored as a final product, it typically goes through a drying process to reduce the moisture content. Sand is brought from stockpiles to the dryer via conveyors. The dryers operate on natural gas (or propane fuel as backup) and heat the sand to evaporate water. Emissions from the drying process are typically controlled by some mechanical collector (cyclone or baghouse), reducing particulate matter exhausted through a stack. The dried sand is then fed by conveyors to storage bins or directly to a screen house via conveyors.

Air pollution resulting from this activity would include combustion emissions and particulate. Combustion emissions are minimized by firing clean burning fuels such as natural gas or propane. Resulting particulate (mainly sand and very small quantities of combustion particulate) from the drying process is typically controlled by the use of a cyclone or baghouse. These devices are able to achieve a control efficiency of at least 95% or better (some baghouses can achieve 99.5% or better control). Collected materials in the baghouse will be disposed of at the mine site as fines or reject material.

Emissions from the dryer are subject to the new source performance standards (NSPS) in s. NR 440.73, Wis. Adm. Code. Particulate matter and PM$_{10}$ (particles smaller than 10 microns) emissions from the drying process are limited to 0.057 grams per dry standard cubic meter (g/dscm), according to s. NR 440.73(3)(a), Wis. Adm. Code. Furthermore, emissions are also subject to a visible emissions limit of 10 percent opacity, per s. NR 440.73(3)(b), Wis. Adm. Code. Typically by complying with the particulate matter limit
and utilization of a control technology, the visible emission limitation will be met. However, some facilities will also be required to either utilize a continuous opacity monitoring system to measure and record the opacity of emissions discharged, or have a certified visible emissions observer measure and record 3-6 minute averages of the opacity of visible emissions to the atmosphere each day of operation.

5.1.2.10 Screening

Sand is transferred from dry storage bins or directly from the dryer and then passed through vibrating screens. The sand is screened into one of several grades (sizes) and then conveyed to storage or to trucks for shipping. The screen house may contain the following pick-up points (dust collection points): bucket elevators, screens, and conveyors. The pick-up points within the screening area are typically routed to a mechanical control device.

Air pollution resulting from this activity would include particulate, stacked and/or fugitive. Resulting particulate from the screening process is typically controlled by the use of a cyclone or baghouse. Some facilities enclose the screening operation within a building, further minimizing fugitive emissions from the pick-up points.

The screening process may be subject to the NSPS in s. NR 440.688, Wis. Adm. Code if the processing plant has a capacity greater than 25 tons per hour. The NSPS applies to each crusher, grinding mill, screening operation, bucket elevator, belt conveyor, bagging operation, storage bin, enclosed truck or railcar loading station, per s. NR 440.688(1), Wis. Adm. Code. The NSPS provides limitations on visible emissions (opacity) of no greater than 7 percent.

Operators would be required to maintain and follow a fugitive dust prevention plan, whereby methods to minimize fugitive dust emissions resulting from the screening would be described and followed.

5.1.2.11 Storage Bins/Silos

Storage bins or silos are located throughout the processing plant and are utilized to store raw materials or final product. Materials or product are transferred to these devices via conveyors.

Air pollution resulting from this activity would include particulate, stacked and/or fugitive. Resulting particulate from the storage (loading of bins/silos) process could be controlled by the use of a cyclone or baghouse, and the bins/silos may be equipped with an air displacement vent filter. Operators may be required to maintain and follow a fugitive dust prevention plan for any fugitive emissions, whereby methods to minimize fugitive dust emissions resulting from the storage activities would be described and followed.

The storage bins/silos may be subject to the NSPS in s. NR 440.688, Wis. Adm. Code, if the processing plant has a capacity greater than 25 tons per hour.
5.1.2.12 Loading/Unloading – Processing Plant Operations

A processing plant located at a mine will not have unloading operations, whereas a processing plant that is located in a different location than the mine(s) will have truck or rail unloading of raw materials. The processing plant will have loading operations regardless of its location relative to a mine. Unloading operations typically consist of a dump station that may be enclosed to capture most fugitive emissions. Unloaded sand is dumped into an auger or conveying system which transports the sand to storage piles or bins/silos. Loading operations typically consist of a conveyor system (from storage bins/silos) to a spout over trucks or railcars. The conveyor system and spout may be enclosed to capture particulate or minimize fugitive particulate dust.

Air pollution resulting from this activity would include particulate matter from either stacks or fugitive sources. Resulting particulate from the loading and unloading processes could be controlled by the use of a cyclone or baghouse, or unloading processes through underground or covered conveyor systems. Operators may be required to maintain and follow a fugitive dust prevention plan for any fugitive emissions, whereby methods to minimize fugitive dust emissions resulting from the loading/unloading activities would be described and followed.

5.1.3 Potential Emissions, Ambient Air Dispersion Modeling and Risk Analysis

The WDNR uses dispersion modeling to evaluate the ambient air impact of air pollution sources. The following is a brief description of how the modeling process works. A model is a mathematical simulation, designed to predict what can or will happen in real-world scenarios. Atmospheric dispersion modeling is useful in predicting the impact a particular facility will have with respect to a given pollutant. The major benefit of dispersion modeling is that it is an inexpensive way to assess the impact of a source. This information is vital in assessing a facility’s compliance with respect to the National and State Ambient Air Quality Standards (NAAQS) and increments as well as the various Hazardous Air Pollutant (HAP) standards, both federal and state. Dispersion modeling incorporates information about a facility, such as source/stack parameters, facility layout information and emission rates, along with 5 years of meteorological data in order to predict concentrations of pollutants in the vicinity of the facility. The point of highest impact is determined through the use of a receptor grid that is set up by the modeler, and could be the result of (besides other factors) inversions. The pollutant concentration at the point of highest impact is added to a previously determined background concentration and then is compared to the corresponding ambient air quality standard. The emissions from the facility (and nearby sources that contribute to impacts) must attain and maintain the NAAQS, which are set to protect public health and welfare, in order for any permit to be considered approvable by the WDNR. Those standards (NAAQS) are set at levels such that the most susceptible populations (children, elderly, and people with respiratory conditions) are protected.

All modeling completed in the State of Wisconsin for use by WDNR is conducted in accordance with these WDNR procedures as well as guidance contained in the Guideline on Air Quality Models, EPA document 40 CFR part 51, Appendix W. The present EPA approved dispersion model is AERMOD. This model is used for all dispersion modeling conducted for or by the WDNR.
The air quality analysis (air dispersion modeling) uses the worse-case maximum potential emissions from the facility. Those emissions are based on several factors, including: fuel type and characteristics, emission factors, operational design and control equipment, and any enforceable operational and/or emission limitations. The conditions that demonstrate compliance with the NAAQS will be set in the air pollution control permit as enforceable emission limits, control device operations, operational parameters (fuel type and amounts used), among other requirements. Any future expansion or increase in production or combustion sought by the facility, above what may already be approved in a permit, may result in a new air pollution control permitting action, which would again analyze all aspects of compliance with all air pollution rules and regulations.

5.1.3.1 Ambient Air Dispersion Modeling for Mining and Processing Operations

Depending on project specific conditions and proposals, an air analysis may include analysis of point (stack) and fugitive sources, soil and vegetation impacts, or visibility impairment.

Fugitive based particulate emissions, including PM$_{10}$ and PM$_{2.5}$, from truck traffic onsite may be included in the model as a volume source.

Any facility emitting SO$_2$, PM/PM$_{10}$, and/or NO$_X$ may have a potential adverse impact on visibility through atmospheric discoloration or reduction of visual range due to increased haze. The Clean Air Act Amendments require evaluation of visibility impairment in the vicinity of PSD Class I area due to emissions from new or modified air pollution sources. (Note: A Class I area is an area that is afforded additional protect under the Clean Air Act from the impacts of air pollution. National Parks, National Wilderness Areas and National Monuments are all designated as Class I areas.) If a PSD Class I area is located within 100 kilometers of the site, visibility impacts on distant Class I areas will be assessed.

Near the proposed project site, under certain meteorological conditions, the stacks will emit a visible steam plume that, after traveling a relatively short distance, will dissipate by dispersion and evaporation. A visible steam plume can be expected to occur when ambient air temperatures are relatively low with respect to plume temperature, thus promoting plume cooling and condensation, and when ambient humidity levels are relatively high, preventing evaporation of the water in the plume. The persistence of the plume is dependent upon wind speed and the time required for evaporation.

An ‘Air Dispersion Analysis’ Correspondence/Memorandum is generated for each project in order to demonstrate the impact of the proposed project on State or Federal ambient air quality standards. The WDNR may not issue an air pollution control permit to a facility that can’t demonstrate attainment and maintaining ambient air quality standards. Assuming the results of the modeling analysis demonstrate that the primary standard for the listed pollutants will be met, the health of "sensitive" populations such as asthmatics, children, and the elderly will be protected. Additionally, the welfare of the public is also protected, including protection against decreased visibility, damage to animals, crops, vegetation, and buildings.
5.1.3.2 Inhalation Risk and Non-Carcinogenic Effects Screening for Hazardous Air Pollutant Emissions

Depending on project specific conditions and proposals, an inhalation risk and screening analysis may be conducted. Hazardous air pollutant (HAP) emissions are known to occur from sand mining and processing operations. Reviews of existing and proposed projects have identified that all HAPs are from combustion sources, and are expected to be minimal. HAPs are regulated by ch. NR 445, Wis. Adm. Code, and/or regulated by any established federal National Emission Standards for Hazardous Air Pollutants (NESHAPs), whichever is more stringent.

Crystalline silica is not currently a regulated HAP under Federal or State regulations. However, crystalline silica emissions from these operations would be considered a particulate matter type and form of pollutant, for which regulations exist and apply. Furthermore, particulate matter emission control measures (emission control equipment such as baghouses, and fugitive dust control measures) reduce emissions of crystalline silica as well. WDNR has completed a study on the pollutant in 2011, and the results of that study are available on the WDNR’s website. State regulated HAPs are included within NR 445, Wis. Adm. Code (which also includes all Federal HAPs).

5.1.4 Potentially Applicable Air Pollution Regulations


5.1.5 Cumulative Air Impacts

The WDNR considers cumulative air impacts and includes impacts generated by the project in addition to those from the nearby local industries. DNR's independent review of cumulative air impacts from stationary sources includes analyzing ambient air impacts of emissions from other nearby sources in addition to the proposed facility (please refer to the Ambient Air Dispersion Modeling and Risk Analysis section 5.1.3 for more information.) The review is conducted to assure that the cumulative impacts from all sources considered will result in attainment of all ambient air quality standards when the sources operate in compliance with their existing or proposed air pollution control permits.

5.1.6 Conclusion for Air Impacts

Air quality impacts must be expected to be within acceptable and permittable standards. The WDNR will require enforceable operational controls as permit conditions, in addition to air emission monitoring equipment, protocol to monitor, and following a department approved fugitive dust prevention plan to assure this. Based on WDNR’s analysis and considering enforceable permit requirements the proposed action is expected to achieve compliance with applicable air quality standards and regulations and maintain air quality.
5.2 IMPACTS TO WATER RESOURCES

A sand mine can have multiple interactions with water. The site may be located near a river, stream, or wetland; or groundwater may be encountered as the site is excavated.

Water may also be used during the mining or processing stages. Material will be washed to remove fines. Washing may require the installation of a high capacity well. Wash water may be reused or discharged after washing to the ground surface, surface or surface waters depending on the volume and design of the operation. Sand excavated from below the water table may be saturated with water. As this material is stockpiled the water will run off the pile and leach into the ground or may be directed to on-site settling ponds. In addition, if the mine has buildings on-site a well may be present to supply water for cleaning, cooking, drinking, or sanitation.

The sites also receive water in the form of rain or snow that may be collected or allowed to run off depending on the volume and design of the operation. Steps must be taken to ensure that this storm water is handled properly so that sediment-laden water does not leave the site and possibly contaminate water resources or wetlands.

The following sections detail how water is used in a sand mining setting, the potential for impacts as well as how that use is regulated to help prevent impacts.

5.2.1 Groundwater

5.2.1.1 Process water

Silica sand mining and processing plants are likely to utilize groundwater to some extent. Potential uses of process water at mines and processing facilities include transporting, cleaning, and sorting sand, as well as dust control. For five planned sand mines in northwest Wisconsin proposed pumping capacities range from 700 to 1380 gallons per minute (gpm). Expected average water use ranges from 420,500 gallons per day to 2 million gallons per day (292-1380 gpm). These volumes are typical of closed-loop processing systems, where evaporation and incorporation into product are the main sources of water loss. By contrast, open-loop systems that do not recycle process water could use 2000-3700 gpm. All of these wells would be classified as high capacity wells, subject to state permit requirements. Any smaller-volume wells must meet state well construction standards.

The effects of groundwater pumping are highly site-specific and vary based on local geology, hydrogeology, and proximity to surface waters. A cone of depression forms around any well when it is pumped, lowering the groundwater level to an extent based generally on the well construction and pumping regime. Depending on well construction, pumping regime, and local geology, groundwater quality may be subject to change. Wells may become a conduit for contamination of groundwater if not properly constructed and maintained.

All wells must meet construction requirements mainly designed to prevent pollutants at the land surface from entering the underlying aquifer and to protect the quality of the water being discharged from the wells (Ch 281.17 Wis. Stats., and is specifically described in NR 812 Wis. Adm. Code). The WDNR may specify more stringent well
location, well construction, and pump installation requirements when deemed necessary for the protection of public safety, safe drinking water, and the groundwater resource. The WDNR may deny, grant a limited approval, or modify an approval under which the location, depth, pumping capacity or rate of flow and ultimate use is restricted so that the supply of water for any public utility will not be impaired. Process water may not be discharged to any well including any bored, drilled or driven shaft, dug hole whose depth is greater than its largest surface dimension, improved sinkhole or subsurface fluid distribution system (NR 815, Wis. Adm. Code.)

All high capacity wells are routinely screened for potential impacts to waters of the state. Any WDNR approval for a high capacity well operation identified as having the potential to cause significant impacts to trout streams, outstanding resource waters, exceptional resource waters, or other waters of the state will contain additional conditions designed to prevent significant adverse impacts. High capacity wells proposed near springs will be reviewed to determine whether construction and operation will result in substantially reduced flow from the spring. For springs that typically flow at rates greater than 1 cubic foot per second (cfs), the WDNR may not approve a proposed well that will reduce annual spring flow by more than 20%.

A detailed water balance may be required to determine the approximate water loss related to applications for high capacity wells that may result in a water loss exceeding 95%. However, this provision is not expected to apply to nonmetallic mining operations, since the average estimated water loss from nonmetallic mining in the Great Lakes Basin is 10% (Shaffer and Runkle, 2007).

Concerns have been raised about high capacity withdrawals affecting water levels in nearby private wells. During the high capacity well screening process, the WDNR will attempt to identify nearby private wells where significant groundwater drawdowns could occur. In cases where the WDNR discovers or receives concrete scientific evidence linking the proposed well(s) to a potentially significant adverse impact to private water supplies, any high capacity well approval would be conditioned, through permit conditions, to avoid such impacts. The WDNR also recommends that private well owners establish baseline information on static water levels and water quality parameters such as arsenic, nitrate, and iron. This information should be shared with mining officials prior to any new high capacity well operations. Information on sampling and certified labs is available on the WDNR website (dnr.wi.gov).

5.2.1.3 Dewatering water

If sand mining operations are performed below the water table, they may require significant additional groundwater pumping in order to dewater the active mining area. This can lead to an increased potential for impacts to groundwater and surface water resources. The majority of sand mining in Wisconsin is done above the level of the water table where no dewatering is required.

Mines that clean or process sand commonly use polyacrylamides as a flocculent to remove unwanted minerals and fines from the sand. Acrylamide may be present in frac sand wash water if they are using it as a flocculent in their wash operations. Acrylamides appear to be biodegradable in aerated soils. As a result, unless polyacrylamide levels are very high in the wash wastewater there may not be a great potential for acrylamide to contaminate groundwater at sand wash water storage/discharge sites. The types of
ponds and the minerals removed may also affect the potential for groundwater impacts. Sealed ponds will have very little potential for groundwater impacts. Unsealed ponds will likely seal themselves with the fines that are removed from the frac sand. Dewatering water may not be discharged to any well including any bored, drilled or driven shaft, dug hole whose depth is greater than its largest surface dimension, improved sinkhole or subsurface fluid distribution system (NR 815, Wis. Adm. Code.) More research is needed to determine concentrations of acrylamides in frac sand wash water when mines are using polyacrylamide polymer flocculation products.

The US Environmental Protection Agency (EPA) has set a Maximum Contaminant Level Goal (MCLG) of zero for acrylamides in public drinking water. Wisconsin does not have groundwater standards for acrylamide under NR 140, Wis. Adm. Code. Because of the difficulty of testing for such compounds at very low levels, EPA limits the amount of acrylamide in the polymeric coagulant aids used by public drinking water systems to 0.05% by weight and the dosage of polymeric coagulant aid which can be added to raw water to remove particulates, to 1ppm. Some people who drink water containing high levels of acrylamide over a long period of time could have problems with their nervous system or blood, and may have an increased risk of getting cancer.

5.2.1.3 Drinking water

Any new well will, at a minimum, be subject to construction standards found in NR 812, Wis. Adm. Code (Well Construction and Pump Installation). If any of these new wells are determined to be a public system, then construction standards of NR 812, Wis. Adm. Code, and operation standards and maintenance of public water systems of NR 810, Wis. Adm. Code, will also apply. A public water system is defined as a system that has at least 15 service connections or that regularly serves an average of at least 25 individuals daily at least 60 days out of the year. All public water systems are regulated by the Department to assure safe reliable drinking water.

If a mining or processing operation provides drinking water to more than 25 people and has drinking water available more 6 months a year it would be regulated as a Non-community non-transient water system and be subject to conditions and testing in NR 809 and NR 810 Wis. Adm. Code. These water systems would need a certified operator and would need to sample at least annually for bacteria and nitrates. Sampling for other parameters such as lead, copper, inorganics, and volatile organic compounds (VOC’s) would be set by NR 809 Wis. Adm. Code.

In addition to operator and sampling requirements, NR 810 Wis. Adm. Code would also regulate distribution systems and system capacity. A WDNR public water system specialist would be assigned to the facility. The facility would be inspected every five years.

5.2.2 Surface Water Resources

Wisconsin is home to about 84,000 miles of streams and 1.2 million acres of lakes. Although more than 47% of Wisconsin’s original wetlands have been lost, more than 5.3 million acres of wetland are still present across the state. Due to the state’s numerous wetlands and streams, combined with the rapid expansion of sand mining, it is likely that some mines will be located near Wisconsin surface water resources.
The construction and operation of a nonmetallic mining site in proximity to surface water has the potential to affect surface water through a variety of mechanisms. The most direct impact is the removal of nonmetallic material directly from the stream channel, lakebed, or the immediate stream bank or lake bank. This activity changes the process of deposition and transport of sand, gravel, and other bottom material which can lead to increases in siltation, erosion, and the loss of fish and aquatic life habitat. Active construction within the stream channel and on stream banks results in the direct mortality of aquatic life, increases turbidity, and may suspend contaminated sediments. Construction or expansion of mining operations into waterways may also alter the chemical properties of the water body. In some cases these alterations may be significant enough to effect the composition of aquatic life in the waterway.

Indirect impacts to surface waters from nonmetallic mining sites include the discharge of contaminated storm water runoff from the mine, dewatering processes taking place in the mine, or inadvertent releases from wastewater storage ponds. Other indirect impacts include the interception and contamination of groundwater that flows to streams and lakes, loss of wildlife habitat near stream corridors, and degradation of natural scenic beauty associated with our public waterways.

Storm water discharges from nonmetallic mining sites are regulated by the state through WPDES Permits. However, because of the scale of frac sand surface mines it should be recognized that the NR 135 nonmetallic mining reclamation plan, enforceable by the NR135 Reclamation Permit, includes provision for the control of surface water and erosion that takes place both during site development and site reclamation. The statewide standards require that measures protective of surface waters are included in the reclamation plan and invoked during site development to protect surface water and to have no adverse effect on adjacent properties. Such measures include diverting unaffected surface flows around the disturbed area, prior to the removal, and protection of topsoil or surficial soil materials (as defined in s. NR 135.02). Such protective measures must be in place before any site disturbance and are addressed in the approved reclamation plan, enforceable under the NR 135 Reclamation Permit. Because of the magnitude of frac sand surface mines, the approved reclamation plans will involve a phased development and contemporaneous reclamation sequence to minimize the footprint of the operation and the potential for erosion due to surface water and wind.

Most nonmetallic mines are designed to be internally drained to capture and contain all storm water discharges within the active mining project site. However, the majority of mines are only designed to contain up to a 10- or 25-year rain event. During larger rain events, silt, sand, and even gravel can be washed from the mine site into surface waters. Dewatering discharges are regulated by the WDNR and have a limit of 40 mg/l for total suspended solids (TSS). Although this TSS limit exists, dewatering discharges may contain high amounts of small particles that are not included in the TSS analysis, but can still cause significant turbidity issues at the point of discharge. Dewatering discharges must also meet a pH range of 6.0 to 9.0 and oil and grease limits of 15 mg/l or less.

Few studies have explored the impacts of nonmetallic mining sites where groundwater is intercepted and either pumped (via mine dewatering) directly to surface water or a settling pond, which then, through seepage, recharges groundwater and ultimately feeds a nearby stream. In either case, groundwater may be warmed, and thermal affects may be
seen in cool or cold water streams. Other considerations include chemical changes such as increases in biological demand (decreased oxygen concentrations) and ammonia when groundwater is diverted to a surface water pond.

5.2.2.1 Permit jurisdiction in or near surface waters

A number of environmental regulations are in place to restrict mining activities and protect waters of the state including:

- Wisconsin Pollutant Discharge Elimination System (WPDES) Storm Water Permits
- Ch. 30 and 31 Wis. Stats. waterway permits

For all nonmetallic mines, Wisconsin nonmetallic mine law (NR 340 Wis. Adm. Code) applies to any sand mines where an activity regulated by Ch. 30 or Ch. 31 Wis. Stats. is proposed. For typical sand mines, this includes activities such as:

- Ponds within 500 feet or connected to navigable water
- Grading on or near the bank of a navigable water (distance varies based on the waterway)
- Realignment of a navigable stream
- Dredging from streams and lakes
- The construction of culverts or bridges on navigable waterways

Wisconsin’s nonmetallic mining code recognizes that “…without adequate controls serious degradation of water quality, fish and wildlife habitat, and public interests in recreation and scenic beauty could occur during and after the excavation, dredging or grading in or near navigable waterways.” The code goes further and substantially restricts the mining of sand and aggregates from within stream channels and from the immediate banks of Wisconsin’s navigable streams. Section NR 340.15, Wis. Adm. Code, directs the WDNR to assume that excavation from stream channels and immediate banks shall be avoided where reasonable alternatives exist.

5.2.2.2 Cranberry exemption

Some of the counties in central Wisconsin that are seeing an increase in frac sand mining are also home to much of the state’s cranberry farming. Mining sand is a routine practice in the process of raising cranberries. Growers use sand in the cranberry beds to provide adequate drainage for the roots of the cranberry plants. The sand prevents root rot and fosters plant growth.

Chapter 94.26, Wis. Stats., was established in 1867 and exempts cranberry growers from much of the laws applying to waters of the state under Chapter 30, Wis. Stats. With this exemption in place cranberry growers can, in theory, mine sand wherever and however they desire for use in cranberry production. Growers are taking advantage of the high demand for sand and are selling their sand on the frac sand market. However, the Department has recently determined that the exemption in Ch. 94.26, Wis. Stats., from portions of Chapters 30 and 31, Wis. Stats., for cranberry culture is not applicable to non-metallic mining sites where a NR 216, Wis. Adm. Code, stormwater permit is required. For those non-metallic mining operations where the material is sold and hauled off site, Chapters 30 and 31, Wis. Stats., jurisdiction will be applied.
5.2.3 Wetlands

Wetlands are a valuable natural resource and are important to the ecology and economy of Wisconsin. They are protected by state law and recognized as providing a variety of values and functions including:

- Storm and flood water storage
- Groundwater recharge and discharge
- Filtering capability
- Shoreline protection
- Habitat for aquatic organisms and wildlife
- Recreational, cultural, educational, scientific, and natural scenic beauty

State statutes define a wetland as "an area where water is at, near or above the land surface long enough to be capable of supporting aquatic or hydrophytic vegetation and which has soils indicative of wet conditions.” This definition, along with delineation procedures described in *The 1987 U.S. Army Corps of Engineers Wetland Delineation Manual* and appropriate regional supplements are used to identify and delineate wetlands.

A high percentage of the State’s wetlands are associated with a stream, river, or lake. One of the targeted areas for silica sand mining is the alluvial deposits near or within these wetlands which are found in central Wisconsin. The counties included in this area have a significant percentage of the total land surface area mapped as wetland. For example, 17% of Jackson County and 10% of Monroe County are mapped as wetland. Because of the extensive network of waterways and wetlands in this region, it is challenging for a silica sand operation to completely avoid wetland impacts within the direct footprint of the mining site and the necessary transportation infrastructure.

5.2.3.1 Locating wetlands

To determine if wetlands are likely present on a potential sand mining property, the WDNR recommends that applicants use the Wisconsin Wetland Inventory maps, the hydric soil layer, and other maps located on the WDNR’s [Surface Water Data Viewer](#). These maps should only be used as guides and an onsite investigation by a professional wetland delineator is required to verify the presence or absence of wetlands.

5.2.3.2 Impacts to wetlands

Adverse impacts to wetlands related to a sand mine site can be classified as either direct or indirect. Direct impacts are caused by the physical alteration of a wetland by the discharge of fill material or excavation within the wetland to mine the sand deposit. Discharges may also be related to infrastructure development such as roads, railroads, utilities and to a lesser extent the sand handling and processing site. Both types of alterations result in loss of the wetland and the associated values and functions.

Indirect impacts typically involve changes to the landscape that affect the local hydrology by altering surface drainage patterns as well as changing groundwater levels. This can have the effect of starving a wetland of the necessary water; reducing its ability to support hydrophytic vegetation. Impacts to adjacent wetlands can be minimized if there is no dewatering of the excavation site or if the dewatering or wash water process is
developed with a closed system so all the pumped water stays on site and is not discharged to adjacent surface waters.

5.2.3.3 Wetland permitting

The excavating or placement of any material in wetlands requires a WDNR approval known as a Water Quality Certification. The WDNR reviews a project to determine if it complies with the requirements of Chapters NR 299 and NR 103, Wis. Adm. Code. State regulations require that wetland impacts be avoided if possible. As such, permit applicants will need to demonstrate that they cannot avoid or reduce wetland impacts, and that the project will not have significant adverse impacts on wetland functions and values including secondary impacts.

In addition to state regulations, the US Army Corps of Engineers may assert jurisdiction over a wetland that is connected to a federally navigable waterway. If jurisdiction is asserted, the facility would be required to attain a permit from the Corps under section 404 of the Clean Water Act.

5.2.4 Storm Water/Wastewater Management

Water generated by or contaminated with sediment as a result of frac sand operations is handled primarily with two general WPDES permits: the Nonmetallic Mining Operations Permit (NMM) (Permit No. WI-0046515-05) and the Construction Site Storm water Discharge Permit (Permit No. WI-S067831-3).

Mining activity for the purposes of the NMM begins the first time ground is broken at a mine site. This negates the need for an operator to obtain a duplicative construction site storm water discharge permit for the same area.

The NMM permit is considered an operations permit and regulates discharges of storm water and wastewater from the mine sites from the initial commencement of site development and lasts until the site has been reclaimed.

In addition to using the NMM permit to regulate the actual removal of material from the ground, the WDNR has also used it to cover adjacent/proximal processing facilities where wet and dry sorting may occur.

5.2.4.1 Storm water

Should the site discharge storm water offsite and/or to surface waters of the state, the operator is required to prepare and implement a Storm Water Pollution Prevention Plan (SWPPP) that will specify the use of standard Best Management Practices (BMPs) to be installed to control sediment in storm water runoff (defined as externally drained). If the site does not discharge offsite or to surface waters of the state, meaning all storm water runoff is directed into seepage areas where there is enough storage for the 10-year/24-hour rain event, no SWPPP is required and storm water requirements are minimal (defined as internally drained).
When new mines are opened, it is common for them to start out as externally drained. Initial operations when opening a mine include stripping topsoil, overburden, and building perimeter berms. In this beginning phase it is difficult to manage the site so that storm water drains internally. However, as the site matures the goal is usually to develop an internally drained operation.

5.2.4.2 Wastewater

The WDNR regulates a number of wastewater discharges at mine sites. The most common discharges include pit dewatering (regardless of whether the water results from precipitation or groundwater) and wash water generated from mine processes. The primary pollutant being regulated is sediment in suspension, so the requirements for the discharges vary depending on the resource being discharged to. Discharges to surface waters are more stringently regulated than are wastewater discharges to groundwater via seepage.

5.2.4.3 Construction site storm water and erosion control

The WDNR has typically required this permit only for operations where a stand-alone processing plant is being constructed or for the construction of rail spurs to service mines or processing plants. Requirements for a construction site permit include preparing an erosion control plan that details the BMPs that will be used to control erosion during construction as well as a storm water management plan that details how sediment will be controlled once construction is complete.

5.2.5 Contaminated sites

The DNR Remediation and Redevelopment program regulates sites that have been contaminated due to spills or leaks of hazardous substances from fuel storage tanks, landfills, industrial sites, etc. Ch. 292.11, Wis. Stats., assigns responsibility for cleanup of hazardous substances. A mine operator could incur liability for cleanup, if mine operations cause the release of a hazardous substance, or mobilize or alter the movement of an existing plume of hazardous substance in groundwater.

5.3 FISHERIES IMPACTS

Nonmetallic mining has not had significant negative impacts to fisheries resources in the past. This can mainly be attributed to the relatively low number of sand mines in the state. However, with the recent boom in frac sand mining the number of nonmetallic mines throughout the state has increased. In many instances they are located close to coldwater resources or in the floodplains of river systems. The following fisheries impacts may need to be considered:

- Runoff from the mine site and settling ponds into a coldwater resource causing high levels of turbidity especially in headwater streams where there is natural reproduction of trout.
- Runoff from the mine site and settling ponds causing sedimentation in streams
- If sedimentation/turbidity occurs during fall spawning period, sedimentation would cover/suffocate eggs, leading to no reproduction for that year.
- Amount of warm water runoff from settling ponds could potentially increase the water temperature of coldwater resources.
- Warmer water temperatures could cause coldwater tolerant species of fish and invertebrates to disappear.
- High capacity well withdrawals could decrease stream flows.
- Reduced spring volume could also have thermal impacts on streams.
- Entrapment of fish in ponds located within a floodplain.
- Conversion of riverine or stream habitat to a lake habitat in cases where bed excavation/enlargements and realignments of channels occur.

### 5.4 SOLID WASTE MANAGEMENT/ SPILLS HANDLING

Mining and processing activities generate solid wastes similar to any business or industry including: paper and packaging from office or shop activities and break room wastes such as paper and plastic bags, paper toweling, fast food containers, plastic and aluminum beverage containers, and food wastes. These wastes should be recycled or disposed of at a licensed sanitary landfill.

Vehicles, heavy equipment, and processing equipment will also generate wastes as a result of repair or maintenance activities. These wastes will likely include engine oils, transmission and cooling fluids, hydraulic fluids, filters, parts cleaning solvents, and paints. These wastes can generally be recycled with the exception of the parts cleaning solvent which, if generated, will need to be characterized and potentially handled and disposed of as a hazardous waste. It is likely that if maintenance activities are conducted at a facility it would be classified as a Very Small Quantity Generator (VSQG) of hazardous waste and would need to comply with VSQG regulations. There are a number of companies who service VSQGs to pick up and properly dispose of or recycle small quantities of hazardous waste.

Facilities which utilize a wet process to wash the sand will generate nonmetallic mineral fines as a waste product. Section NR 500.08(2)(b), Wis. Adm. Code, exempts disposal of spoils from sand, gravel or crushed stone quarry operations and nonmetallic earth materials from most solid waste regulations. Use of these fines for mine reclamation, provided their use is consistent with the mines reclamation plan approved by the respective county under NR 135, Wis. Adm. Code, is acceptable to the WDNR.

As with any industry that uses vehicles and heavy machinery the potential for spills of gasoline, diesel fuel and hydraulic fluids exists. Chapter NR 706, Wis. Adm. Code, specifies when a spill must be reported to the WDNR. But whether a spill is reportable or not, all spills need to be cleaned up to the extent possible and contaminated materials need to be properly disposed of.
5.5 RECREATION AND MANAGED LANDS

Proximity of mining operations to state-owned and managed lands may be of concern due to potential impacts to Nature Based Outdoor Activities (NBOA’s) such as hunting, trapping, fishing, hiking and cross-country skiing, as well as other “quiet” outdoor recreational pursuits (e.g., nature study, biking, etc.). There are also concerns with regard to mine operation impacts on resident wildlife. The magnitude of the impact depends on proximity of the sand mine to the given property, the type of mining operation and the hours of operation.

Specific impacts that may need to be considered include:

5.5.1 Noise

Noise from equipment operation, vehicle use (both on site and on the area road system) and blasting can impact the quality of the recreational user experience on a given property potentially diminishing the quality of that site for a particular endeavor.

Noise may also affect wildlife usage of the property. Chronic or episodic noise-related disturbance may result in wildlife movement away from the source of disturbance, potentially impacting reproductive success as well as the quality of wildlife-based recreation – hunting, trapping, and nature study.

5.5.2 Dust

Generation of airborne dust may result in aesthetic impacts to a property (vegetation, facilities covered with dust) and impacts to visitors (dust inhalation, settling on vehicles).

5.5.3 Lighting

Sand mines operating at night may require lighting that could negatively impact the quality of a park or recreation area user’s experience. Lighting at night may also constitute a disturbance sufficient to affect wildlife usage patterns on a given property.

5.5.4 Traffic

Increased traffic to and from the mine will result in increased levels of noise. Depending on traffic routes and volumes, user access to a property could be impacted. Increased levels of mine related traffic may also result in higher levels of incidental wildlife mortality due to road kill.

5.5.5 Air quality

Exhaust and dust from mine operations (equipment and traffic), if detectable, may negatively impact recreational users of a property.

5.5.6 Forests

Forest cover must be removed to accommodate active mining as well as overburden storage. Forest products can be recovered and marketed during the mine development
phase, but the practice of forestry and mining are mutually exclusive because of the loss of forests.

Forest loss and the loss of associated habitats may be temporary and could be restored through mine reclamation after mining ceases. While a forested condition may be restored, it is likely that it would be different from the original forest because of changes in soil depth, soil profile, topography, depth to groundwater, etc.

5.6 ENDANGERED AND THREATENED SPECIES AND HABITATS

Wisconsin’s Endangered Species Law (http://dnr.wi.gov/org/land/er/laws/, s. 29.604, Wis. Stats.) requires the protection of our state’s endangered and threatened species and directs the WDNR to determine whether any activity the WDNR conducts, funds, or approves may affect endangered or threatened species. As part of the permit approval process, an Endangered Resources Review (ER Review) is required from the WDNR to make this determination. In addition, regardless of whether a WDNR permit or approval is required or funding is involved, Wisconsin’s Endangered Species Law still applies to all projects.

5.6.1 ER Reviews

An ER review may be completed in two ways: permitting staff may conduct an ER Review as part of their permit process or a project proponent may request a review for their project directly from the Bureau of Endangered Resources (BER). The ER review considers several tools or sources of information to ensure compliance with state and federal laws. One of the primary tools is a search of the Wisconsin Natural Heritage Inventory (NHI) database to determine what federal and state endangered and threatened species have been confirmed in the proposed project area. The project area evaluated consists of both the specific project site and a buffer area surrounding the site. The size of the buffer varies depending on the ecological and land use characteristics of the site and surrounding area. Records from the buffer area are considered because most lands and waters in the state, especially private lands, have not been surveyed. Considering records from the surrounding landscape provides the best representation of species and communities that may be present on a specific site.

Other sources of information should be considered in the review, including information about the project site, wildlife and plant databases, and species experts. Habitat assessments or surveys may be necessary to determine whether state or federally listed species occur within a project area or to confirm whether suitable habitat is present for an identified species or community.

The NHI database includes the following information:

- Animals and plants federally listed as Endangered or Threatened, those Proposed or Candidates for federal listing, and their Proposed or Designated critical habitats. Federally listed animals are protected on all lands. Federally listed plants are protected only on federal lands or on projects that include federal funding (http://www.fws.gov/endangered/laws-policies/index.html). If federally protected species or habitats are likely to be impacted by a project, consultation with the United States Fish and Wildlife Service (USFWS) should occur. An exception to this pertains to the Karner Blue Butterfly (KBB), a federally listed butterfly,
which falls under special provisions of a Habitat Conservation Plan (HCP) that is administered by the WDNR. (http://dnr.wi.gov/forestry/karner/).

- Animals (vertebrate and invertebrate) listed as Endangered or Threatened in Wisconsin are protected by Wisconsin’s Endangered Species Law on all lands and waters of the state. If state protected animals are likely to be impacted by a project, consultation with the WDNR should occur.

- Plants listed as Endangered or Threatened in Wisconsin are protected by Wisconsin’s Endangered Species Law on public lands and on lands that the person does not own or lease, except in the course of forestry, agriculture or utility actions. If state protected plants are likely to be impacted by a project and are not covered by one of the exemptions above, consultation with the WDNR should occur.

- Special Concern Species, examples of high-quality natural communities (sometimes called High Conservation Value areas), and natural features (e.g., caves and animal aggregation sites) are also included in the NHI database. These resources are not legally protected by state or federal endangered species laws. However, other laws, granting, or permitting processes may require or strongly encourage protection of these resources. The main purpose of the Special Concern classification is to focus attention on species about which some problem of abundance or distribution is suspected before they become endangered or threatened.

5.6.2 Incidental Take

The Wisconsin Endangered Species Law allows the WDNR to authorize the taking of state endangered or threatened species if the taking is not for the purpose of, but will be only incidental to, the carrying out of an otherwise lawful activity, and will not jeopardize the continued existence of the species in the state (http://dnr.wi.gov/org/land/er/take/). Authorization generally occurs through an Incidental Take Permit, which requires an application, a Conservation Plan with required elements (including minimization and mitigation measures) and a 30-day public notice period prior to authorization.

5.7 ARCHEOLOGICAL AND HISTORIC IMPACTS

Under provisions of Wisconsin statutes, state agencies (including WDNR) are directed to cooperate with the Wisconsin Historical Society (WHS) in order to identify and protect any WHS-recorded archaeological sites, historic structures, and other cultural resources which may be adversely impacted by agency actions such as permitting. Protection of these resources may be accomplished through avoidance or required field investigations (as directed by WDNR, after internal review).

If such a project is federally funded, licensed, or permitted, additional investigations to identify and protect recorded and unrecorded cultural resources may also be required under provisions of federal law.
5.8 SOCIO-ECONOMIC IMPACTS

Construction and operation of mines and processing facilities and transportation of sand by truck or rail will have the potential to cause significant socio-economic impacts on nearby neighbors particularly in rural locations where the existing land use is predominantly agricultural. Impacts may include: noise from mining and transport operations, increase in traffic and road deterioration, visual impacts, light disturbance from night mining, and property value impacts. For those properties with deposits of frac sand present, prices exceeding $10,000 per acre have been reported.

In the long term, mines are eventually closed and reclaimed. The reclamation plans for many mines involve replacement of the stockpiled topsoil and either a conversion to or a return to agricultural use. Where this is not feasible some mines have been reclaimed into prairie or oak savannah and provide wildlife habitat. At a very minimum mine sites need to be reclaimed by stabilizing and revegetating the area.

Construction and operation of the mines and processing facilities and transportation of the sand has the potential to have significant direct and secondary beneficial impacts on Wisconsin’s economy. It is difficult to put exact numbers on the economic impact since the mines and processing operations vary in size and design but the Wisconsin Economic Development Corporation estimates that the average processing facility will create 50-80 new jobs. It is also estimated that the average mine will create around 10 new jobs. This does not include the secondary jobs that will be created by the need to transport the sand. It is estimated that the average starting wage for general laborers will be approximately $13.50 per hour plus $1.00 per hour in standard benefits. More skilled laborers such as welders and mechanics are estimated to make about $20.00 per hour. Managers, engineers, and geologists will make the competitive prevailing wage for their profession.

The Wisconsin Economic Development Corporation estimates that the average processing plant will require an investment of between $20-$40 million dollars for equipment, buildings, and infrastructure and up to $100 million for a processing facility that includes resin coating.

Short term secondary impacts will occur in the building and trades sectors as these facilities are being constructed. There is also potential for an increase in sales of mining and other heavy equipment such as dump trucks. There will also be the typical secondary economic impacts that would be expected as a result of any new business coming to Wisconsin and bringing new jobs.

5.9 TRANSPORTATION IMPACTS

Vehicular traffic on local roads will have an impact on the service life and condition of the roads. The degree of road deterioration will depend on the amount of traffic resulting from sand mining operations, the type of vehicles transporting the sand and the design specification the road was constructed to.

Additionally there may be terrestrial and water resource impacts as a result of creating new transportation infrastructure such as roads and rail spurs to support the mine or
processing facilities. The WDNR will work with developers to assure the impact of this infrastructure will take into consideration and comply with regulations set to protect threatened and endangered species. The developer will also need to comply with wetland regulations described in this document administered by the WDNR and local shoreland zoning regulations administered by the appropriate county as applicable.

As mentioned earlier, the preferred and most economical method of transporting frac sand is by rail. Most of the processing facilities are being located near or adjacent to existing rail lines. Planners with both the Wisconsin Department of Transportation and within the railroad industry did not anticipate the significant increase in demand for rail transport that resulted from Wisconsin’s expanding frac sand mining industry. At this point no new major rail line routes are being proposed. However, a number of existing rail routes will need to be upgraded to handle the increase in rail traffic. Furthermore, some major spurs or rail sidings to stage rail cars at the processing facilities have been constructed or are under consideration.

At the present time there is no discussion of converting recreational trails back to railroads but that is a possibility.
6.0 Legal Framework

The following information is a listing of regulations that may apply to sand mining in the State of Wisconsin.

6.1 LOCAL AND COUNTY ZONING ORDINANCES

Sand mines may be regulated by local ordinances, depending on the County or Township where the facility is sited.

6.1.1 Shoreland zoning

The shoreland zoning ordinance adopted by each county in Wisconsin provides development standards for shorelands in unincorporated areas to limit impacts on water quality, fish and wildlife habitat, recreation, navigation and natural scenic beauty. NR 115 Wis. Adm. Code sets minimum standards for the local ordinances, but many counties have adopted standards that are more restrictive than the state minimum standards. Shoreland zoning pertains to lands within 1,000 feet of the ordinary high-water mark (OHWM) of a navigable lake, pond or flowage and lands within 300 feet or within the floodplain of a navigable river or stream, whichever distance is greater.

Each county’s development standards may vary, but generally a permit or variance would be required for:

- A permit would be required for any “structure” within the shoreland zone
- A variance would be required for “structures” that are within 75 feet of the OHWM of a navigable waterway.
- A permit or vegetation management plan may be required for removal of shoreline vegetation that exceeds certain limits.
- Filling, grading, lagooning, dredging, ditching or excavating in a shoreland zone
- Filling or grading of more than 2000 square feet is typically regulated with a conditional use or special exception permit.
- A permit is needed to fill any area that is a wetland. If there is a practicable alternative to filling the wetland, the permit may not be granted.

6.1.2 Conditional Use permit

Each zoning district, as defined in a municipality’s zoning code, has two types of uses. The first type of use is the permitted uses. These do not require additional review other than the zoning review for issuance of a building permit. The second type of use is a conditional use. These are uses not permitted outright but may be allowed if certain standards and conditions are met and the municipality grants approval.

Conditional uses assure property owners that uses of adjacent properties will be as compatible as possible with property uses established in their neighborhood.

A frac sand mine would likely be classified as an industrial facility. If a property is not zoned for this use the mine developer would have to apply for and receive a conditional...
use permit from the county. These permits are usually considered at a county board meeting, which may provide an opportunity for public input on the permit decision.

6.2 WDNR REGULATIONS

6.2.1 Nonmetallic Mining
- NR 135: Requires reclamation of nonmetallic mining sites. Reclamation is controlled through a reclamation permit issued by the county. Reclamation may occur contemporaneously with the development of new mining phases, especially in large surface mining projects, or upon the cessation of mining operations. In either case, reclamation proceeds according to an approved reclamation plan developed to achieve a specific post mining land use. Implementation of the reclamation plan is enforceable by the reclamation permit and guaranteed through the posting of a financial assurance instrument payable exclusively to the county.

- NR 340: Establishes consistency in the application of state statute chapter 30 to nonmetallic mining to avoid unnecessary adverse effects caused by nonmetallic mining in or near navigable waterways.

6.2.2 Air
- NR 407: Regarding operation permits and permit applications for direct stationary sources.

- NR 415: Categorizes particulate matter air contaminant sources and to establish emission limitations for these sources in order to protect air quality.

- NR 440: Enables the WDNR to implement and enforce standards for new stationary sources promulgated by the US EPA.

- NR 445: Establishes emission limitations for hazardous contaminants from stationary sources.

6.2.3 Groundwater and Drinking Water
- NR 135: Reclamation standards in NR 135.08, provide that there be no adverse impact on groundwater quantity or quality, referencing NR 140, from site reclamation. This provision often applies upon cessation of mining, in the typical limestone quarry (static in terms of its footprint throughout its operation), but may apply to various phases of on-going reclamation in large surface mines where areas are being opened up for mining while a previous mined-out phase is being contemporaneously reclaimed.


- NR 299: Establishes procedures and criteria for the application, processing and review of state water quality certifications required by the provisions of the federal water pollution control act.
- **NR 809**: Establishes minimum standards and procedures for the protection of public drinking water.

- **NR 810**: Governs the operation and maintenance of all public water systems to provide safe drinking water to consumers.

- **NR 812**: Establishes uniform minimum standards and methods to extract groundwater for any purpose while protecting groundwater and aquifers from contamination.

- **NR 815**: Prohibits the injection or discharge of fluids to any well including any bored, drilled or driven shaft, dug hole whose depth is greater than its largest surface dimension, improved sinkhole or subsurface fluid distribution system.

- **NR 820**: Requirements to avoid, minimize, and manage impacts from groundwater withdrawals.

- **NR 850**: Establishes annual fees for water withdrawals from the state.

- **NR 856**: Establishes requirements for registering water withdrawals and collecting and reporting of accurate water withdrawal data to support management of the state’s water resources.

- **State Statute Chapter 280**: Pure Drinking Water

**6.2.4 Navigable Waters**

- **NR 340**: Establishes consistency in the application of state statue chapter 30 to nonmetallic mining. The WDNR permit regulates both the operation and reclamation of nonmetallic mines. It is intended to avoid unnecessary adverse effects caused by nonmetallic mining near navigable waterways and to restrict excavation, dredging and grading where the adverse effects cannot be minimized or avoided.

- **State Statute Chapter 30**: Navigable Waters Harbors and Navigation

- **State Statute Chapter 31**: Regulation of Dams and Bridges Affecting Navigable Waterways

- **State Statute Chapter 281**: Water and Sewage.

**6.2.5 Wetlands**

- **NR 103**: Establishes water quality standards for wetlands

- **NR 299**: Establishes procedures and criteria for the application, processing and review of state water quality certifications required by the provisions of the federal water pollution control act.
- **NR 350**: Establishes standards for development, monitoring, and long term maintenance of wetland mitigation projects that are approved by the WDNR.

- **NR 351**: Identifies and incorporates by rule any federal regulation for determining whether certain activities in nonfederal wetlands are eligible for exemption state statute.

- **NR 352**: Designates the wetland delineation manual procedures to be used to delineate nonfederal wetlands.

- **NR 353**: Facilitates the regulation of projects whose purpose is wetland conservation.

- **State Statute Chapter 281**: Water and Sewage.

6.2.6 Stormwater
- **NR 216**: Regulates stormwater on site by controlling erosion and sedimentation through a Non Metallic Mining Operations General Permit -WPDES GP WI-0046515-4.

6.2.7 Wastewater
- **NR 216**: Also regulates discharge of other wastewaters from a non metallic mining operation through the General Non Metallic Mining WPDES permit. These wastewaters include waters generated from washing the sand, equipment washing and any non contact cooling waters.

6.2.8 Endangered Resources
- **Chapter 29**: Wild Animals and Plants

6.2.9 Solid Waste
- **NR 500**: Provides definitions, submittal requirements, exemptions and other general information relating to solid waste facilities.
- **State Statute Chapter 287**: Solid waste reduction, recovery and recycling.
- **State Statute Chapter 289**: Solid waste facilities.

6.2.10 Hazardous Waste
- **NR 600**: Provides definitions, exemptions and requirements for the identification, management and disposal of solid wastes which are determined to be hazardous wastes.
- **State Statute Chapter 291**: Hazardous waste management.

6.2.11 Hazardous substances spills
- **NR 700-749**: Establishes requirements for emergency and interim actions, public information, site investigations, design and operation of remedial action systems, and case closure.
- **State Statute Chapter 292.11**: Hazardous substances spill law.
6.2.12 Forestry
- NR 48 and s. 28.11(11) Wis. Stats. establish requirements and procedures for withdrawal of lands from the county forest law program prior to such lands being used for purposes contrary to the law. Commercial sand mining is a contrary purpose. Lands can only be withdrawn from the program if they can exhibit a higher and better public benefit out of the program.
- NR 46 and s. 77 Wis. Stats. subchapters I and VI establish requirements and procedures for withdrawal of lands designated under the Forest Cropland (FCL; subchapter I) and the Managed Forest Lands (MFL; subchapter VI) programs prior to such lands being used for purposes contrary to the law. Commercial sand mining is a contrary purpose. Withdrawal taxes and fees are assessed to the owner of record at the time of withdrawal.

6.2.13 WDNR Enforcement
With the multitude of regulations the WDNR may have over a nonmetallic mine, it is important to note that there are times when permits are either not acquired prior to an activity taking place, or permit conditions are not being followed. The most common violations with regard to nonmetallic mining are a lack of attention to erosion control or storm water management, and not obtaining the proper permits for the operation. Permitting is sometimes neglected either because of a lack of information, or because of changing conditions in the mine.

A common issue regarding mine permits arises when a mine owner obtains a permit under NR 135, Wis. Adm. Code, but as the mine continues to expand over time it reaches a wetland or navigable waterway where a Chapter 30 permit, Wis. Stats., is required in addition to the NR 135 permit. Since the mine is already permitted under NR 135 permit, the owner may not be aware of the need to attain a Chapter 30 permit.

Enforcement options for violations can include use of the Department’s stepped enforcement process, the issuance of civil citations, or a combination of the two.

6.3 OTHER STATE PERMITS

6.3.1 Department of Safety and Professional Services
- Has jurisdiction on building construction and any fuel storage tanks on mine or processing plant property and Blasting.

6.3.2 Department of Transportation
- DOT has authority on licensing truck drivers transporting the sand as well as truck safety, load limits, and size restrictions.

6.4 FEDERAL REGULATIONS

6.4.1 Clean Air Act, Clean Water Act, and Safe Drinking Water Act
- Wisconsin has the responsibility to implement the Federal Clean Air Act, the Federal Safe Drinking Water Act and the Federal Clean Water Act (with the
exception of wetlands regulation which are jointly regulated by the WDNR and the US Army Corps of Engineers). If enforcement actions are necessary, the federal government may take its own action, or may work in conjunction with the state.

6.4.2 Section 7 of the Endangered and Threatened Species Act
- The previously mentioned Endangered and Threatened Species Act of 1973 is jointly administered by the Wisconsin DNR and the US Fish and Wildlife Service through a formalized cooperative agreement.

6.4.3 Mine Safety and Health Administration
- Has responsibility for worker health and safety when the mine is in production.
7.0 Conclusions

The widespread use of the hydraulic fracturing technique by the oil and gas industry has resulted in the rapid expansion of frac sand mining in Wisconsin. The current non-metallic mining regulations implemented at the county level, as well as the various environmental regulations implemented by the department are adequate to ensure that permits for individual sand mining operations and processing facilities are protective of public health and the environment. As the number of sand mines and processing facilities increase, especially if clusters of these facilities begin to occur, the department may consider examining cumulative environmental impacts.

However, most sand mine siting is controlled through local zoning decisions. Unless the mine is intended to be sited in or adjacent to a navigable water, DNR authorities will not impact most siting decisions. Public comments in response to the operations sited to date have frequently focused on several impacts that the state has no authority to regulate. These impacts include: noise, lights, hours of operation, damage and excessive wear to roads from trucking traffic, public safety concerns from the volume of truck traffic, possible damage and annoyance resulting from blasting, as well as concerns regarding aesthetics and land use changes.
8.0 Links for readers to go to for more information:

- Silica sand in Wisconsin [http://wisconsingeologicalsurvey.org/silica-sand.htm](http://wisconsingeologicalsurvey.org/silica-sand.htm)

- **Frac sand mining would add jobs in Wood County, study finds**
  [http://www.wisconsinrapidstribune.com/article/20111014/WRT0101/110140662/Frac-sand-mining-would-add-jobs-Wood-County-study-finds?odyssey=tab%7Ctopnews%7Cimg%7CFRONTPAGE](http://www.wisconsinrapidstribune.com/article/20111014/WRT0101/110140662/Frac-sand-mining-would-add-jobs-Wood-County-study-finds?odyssey=tab%7Ctopnews%7Cimg%7CFRONTPAGE)

- **Centers for Disease Control paper on silicosis**

- **Frac sand sites (map)**

- **More information on fracking**

- **Study on the economic impacts of frac sand mining**
  [http://centralwisconsinhub.wausaudailyherald.com/assets/pdf/U01805151013.PDF](http://centralwisconsinhub.wausaudailyherald.com/assets/pdf/U01805151013.PDF)

- **Wikipedia page on Hydraulic Fracturing**

- **Article on Hydraulic Fracturing**


APPENDIX II
Team Members - Experience and Expertise

Summit Envirosolutions, Inc.

Summit was founded in 1990 and has enjoyed over 20 years of providing high quality environmental engineering and consulting services while developing and pioneering new technologies. Summit has been actively engaged in the mining industry for 18 years and in the silica sand mining industry for three years. Summit has been actively involved in the non-metallic mining industry in Minnesota and Wisconsin. The firm has assessed numerous properties for potential silica sand mines in Goodhue, Houston, Wabasha, Winona, and Olmsted Counties in Minnesota and Wood, Clark, Eau Claire, Barron, Washburn, Pepin, Buffalo, and Trempealeau Counties in Wisconsin. Summit has been involved in the prospecting, testing, siting, transportation planning, permitting, wet- and dry-plant process design, mine operation planning, storm water and erosion control planning, and reclamation planning at mines in these counties.

de maximis Data Management Solutions, Inc

ddms was founded in 2006 by Summit and de maximis, Inc to leverage our respective expertise in providing advanced Geographic Information System (GIS), database development, internet programming, and data visualization technologies to the environmental industry. Summit and ddms share office space in the Energy Park area of St. Paul, Minnesota. ddms is staffed with GIS and data professionals and has developed internet tools for GIS, document management, scheduling, and database mining and reporting.

BWK Consulting

BWK provides expert geological consulting services in the field of mining geology for the aggregates industry including sand and gravel, the silica sand industry, and the metals industry. Mr. Bruce Kramer is the Principal of the firm. Bruce retired from 3M Companies in June, 2010, where he worked for over 40 years as a Geologist and Geological Engineer. Bruce did extensive industrial minerals exploration, mine planning and reclamation, and industrial minerals process engineering for the Industrial Mineral Products division. Bruce managed the 3M permitting application submittal for a 2000 acre aggregate operation in northern California with a successful submittal to the lead agency in late 2010. Bruce has performed numerous evaluations of non-metallic mineral deposits and processes around the world. Most recently Bruce worked as a mining and quality control consultant to various 3M suppliers of Industrial Minerals in China.
TKDA Engineering

TKDA, headquartered in St. Paul, Minnesota, was founded in 1910 and has a staff of over 180 employees providing engineering, architecture, and planning services. TKDA supported the Summit Team for the Goodhue County study of non-metallic mining by providing technical expertise in regulatory requirements associated with mining, planning, landscape architecture, and transportation.

Kestrel Design Group

Mr. Peter MacDonagh is Director of Design and Science for the Kestrel Design Group. He was trained in horticulture at the National Botanic Garden in Ireland, and Landscape Architecture at the University of Minnesota. Peter is a registered landscape architect, horticulturist, certified wetland delineator, and adjunct professor at the University of Minnesota since 1999. He has been a certified arborist since 1992. Peter authored the site and water portions of the State of Minnesota’s Sustainable Building Guidelines (B3), completed the award-winning Minnesota Soil Bioengineering Handbook and the Native Seed Mix Design for Roadside Manual for Minnesota Department of Transportation; which is now the official Native Seed Guide for Minnesota agencies. He is a recognized authority on sustainable landscape architecture, ecological restoration and is widely sought for his expertise in urban storm water management, green roofs, urban trees and healing damaged landscapes.

EcoSmith Consulting, Inc.

Ms. Sarah Stai has 18 years of experience as a field biologist, research scientist, and environmental consultant. She uses her diverse background, including graduate coursework in environmental planning and law, to prepare impact assessments in the context of environmental policy, land use planning, and water resources. Her project experience has involved the impacts of proposed wind farms on bird communities, habitat assessments for a large-scale ecosystem restoration, and analysis of alternatives for flood damage reduction in a major watershed. She has also prepared a range of environmental review documents for residential, commercial, industrial, and mixed use developments, with wetlands/wildlife corridors, open space preservation, traffic, and nutrient budget management as key issues.