Exploring Environmental Impacts Related to Frac Sand Mining and Processing - Minnesota Focus

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Introduction

Minnesota's economic minerals history took a turn in 1683 when Pierre Le Sueur excavated some blue-green clay from the banks of the Blue Earth River, believing he had found a valuable copper deposit. As it turned out there was no copper, but the aggregate industry in Minnesota was born. Sand and mineral processing on a commercial scale dates back to the 1800s and has provided the basic ingredients for infrastructure for over 100 years.

Over this period, conflicts with land use from this activity have been relatively rare and managed satisfactorily under local rule and ordinance. Environmental and health issues have been nearly non-existent. The methods and management of frac sand operations are essentially similar to those of historic aggregate mining. In many ways they are less impactful to the environment due to lower need for noisy and dusty crushing equipment, and a greater reliance on rail for larger mines. Obviously the level of public attention given to frac sand operations is far greater than for traditional sand and gravel mining. This is a function of the number and scale of projects being much greater than in the past. It is hard to ignore the public perceptions of mining, particularly as they have evolved in Wisconsin (which does not have a mandatory environmental review category for non-metallic mining). The result is that greater attention has been focused on the methods and potential impact of non-metallic mining, including frac sand. This presentation explores some of the factors related to frac sand mining and evaluates the potential environmental impacts due to frac sand mining and processing in Minnesota.

The Frac Sand Market in Minnesota

In Minnesota, the frac sand that is in highest demand is the 20-40 mesh sieve size (around 1 mm to 0.5 mm in diameter). The geologic formation in Minnesota with the largest percentage of this size fraction is generally considered to be the Jordan Sandstone. Although frac sand mining is occurring in the St. Peter and other formations, the presence of relatively coarser grains in the Jordan makes it much more marketable sand. It is also coarser and generally has a more reliably marketable percentage than the Wonewoc in Wisconsin. The downside is that this frac sand tends to occur in environmentally sensitive settings. In the Minnesota River Valley near the Twin Cities south to Mankato, it is found relatively close to the surface but often near or under the groundwater table. Along the Mississippi River Valley, the Jordan is present higher in the landscape but is more likely to be near sensitive features like scenic bluffs and trout streams, so aesthetic issues, surface and groundwater are likely to be scrutinized in detail.

The price of frac sand per ton gets a great deal of attention. It is important to note that the often quoted price of $100/ton is the price at delivery. This means that the rail and transload operator have marked up the product several times what the mine or plant is receiving for the sand.

The future demand of proppants appears to be stable, but the potential for oversupply might mean that the prices will eventually drift closer to the cost of production. This would point to fewer facilities being permitted and less tolerance for spending hundreds of thousands of dollars on environmental investigation.

Entitlement Process for Non-Metallic Mining

From a developer's or "land man's" perspective, the "entitlement" process includes all the steps required to get the rights to mine and operate a mine or facility. Once the facility is built, the process overlaps with operational compliance because the provisions included in the permit become as much a part of the operation as the act of mining itself. Other presenters will discuss these aspects in more detail, but a summary is provided below for convenience.

Before the Digging or Processing Can Begin

The process for developing a frac sand site goes through several major steps:

1. Property Identification – The site must be a viable mine site and must be available for purchase, lease, or other interest.
2. Resource exploration – If it is a mine site, this will require some level of geologic assessment but may also include other relevant information related to the viability of the property. For a plant site, the presence of available infrastructure and land area are important considerations.
3. Site Evaluation and Preliminary Engineering – Available information is compiled and synthesized to make a business decision on the property and work out the economic balance sheet. Zoning issues may also be addressed at this stage but if rezoning is needed, this will be addressed during environmental review and before permitting.

4. Environmental Review – Once the site is deemed economically viable and feasible for meeting the economic case, it may become subject to environmental review depending on the size and jurisdiction. If the mine is small and does not trigger any other legal threshold, it may go directly to permitting. Any project subject to governmental approval can be subject to a citizen petition for environmental review. No government action on the project can go forward prior to the completion of the environmental review.
5. Permitting – Typically, a local use permit is required consistent with zoning, as well as state air and water permits, and in some cases habitat, wetlands, and other local permits may be needed depending on the location and nature of the project. In some cases, operations may be grandfathered so that they do not need a new local permit. The state permits would be required where there is a change to the operations.
6. Operations – This may include specific provisions of permitting related to surrounding properties, compliance with monitoring plans, and on-going maintenance of control structures and discharges in accordance with permits.

The focus of this presentation is on items 4 through 6.

Environmental Review

Minnesota Rules 4410 provide a process for evaluating the potential for environmental impacts related to development. These rules were implemented to comply with federal NEPA statute. The rules specify types of projects requiring mandatory environmental review, identify the responsible government unit, and identify a process for the government unit to evaluate the review. Most often the government unit responsible for non-metallic mining is the city or county that has zoning authority over the property involved. The government unit prepares the Environmental Assessment Worksheet (EAW) or Environmental Impact Statement (EIS) — typically based on a draft document prepared by the proposer — that includes information and studies relevant to the project.

This process is NOT a permit or a test. It does not require that every detail be spelled out or exhaustive studies be conducted. The intent of the review is to identify impacts early in the planning process so that they can be accommodated in the proposal and provide information to regulators that will aid in drafting permit conditions that address the potential impacts and offer contingencies to protect the environment.

The two types of environmental review in Minnesota are the EAW and the EIS. The EAW is a shorter, less detailed summary of available information. It is intended to be used as a means to determine if the more detailed EIS is required. Most often the EAW provides adequate information for future permitting on its own without need for an EIS. However, in cases where an EIS is mandatory under Minnesota rules, the EAW serves to identify the potential environmental effects that must be studied in the EIS.

A successful frac sand mining operation will include assessment of the potential environmental impact of the operation on the proposed site. A common practice is to provide a voluntary EAW to the government unit even if it is not required because it is a recognized format and sets a bar for environmental due diligence when it comes to siting a new facility or mine.

A key element of an EAW or EIS is a detailed project description. This provides a clear understanding of the impacts of mining and processing, and also provides a means for articulating a clear mining plan with specifics of all the proposed activities. Vague or general concepts for an operation are not acceptable from a local and state permitting perspective.

Permitting

Most non-metallic mines are governed under local (city or county) ordinance. This is the primary source of operational mining requirements and is the place where critical expectations for the project, including reclamation and monitoring, are established.

Other state or local permits may be required. The investigative requirements of those permits are often the same as those required for environmental review (e.g. air, water, natural resources) and may occur concurrently. The requirements for permits are noted in the description below related to various media impacts.

Effects, Impacts and Significance

What are Impacts?

Most people would agree that an environmental impact is significant if something is harmed or otherwise upset so that it's no longer working properly.

The first concern is usually regarding human health. People don't want to live next to a facility that is going to harm the health of their family. Addressing this risk means gaining an understanding of the source (its location and magnitude or concentration), identifying an exposure pathway (e.g. a means to get it in contact with someone), and determination of likely a receptor (someone receiving the stuff that is migrating). These factors form the risk assessment exposure model used to assess health impacts. If there is a pathway, the next step is to identify the harmful concentration thresholds of the chemical in question.

If you are below the limit, it is unlikely to pose a threat. “Unlikely” is a statistical probability, though so to be safer, the values used to trigger action are established often far below the human health risk limit. This type of assessment applies mainly to chemical risks, so air and water quality are the most likely media to be involved.

The determination of impacts to the environment is vague because often these are systems that defy the assignment of a single parameter or value that means there is low risk. Minnesota Rules do have definitions related to the adequacy of environmental review. These include evidence of small magnitude or degree, mitigation through on-going regulatory authority, or other studies or actions that will supersede the presumed impact. In addition, the state has certain rules and policies related to habitat that can help calculate a possible worst-case scenario. If the worst-case scenario is manageable with little long-term effect, then the more likely operational scenarios are likely to be safe. The health risk model can be applied to environmental risk in that if there is no completed pathway for a process or source to reach any environmental receptor, then the impact to that receptor cannot be considered significant. To do this, it is important that the processes and sources for the operation be well defined and carefully thought out prior to environmental review.

Projects that fail to define the mine or plant processes and locations early in environmental review are doomed to fail on cost and budget. The resulting delays and mistrust generated by not having a plan or changing the plan during public review can also kill a project. Always provide sufficient detail of the project so that environmental impacts can be defined and evaluated thoroughly.

Air

Sand is made of the mineral quartz, chemically known as silicon — dioxide one of the most common and inert substances that make up our planet. Since we are designed to breathe only air, excessive levels of other things in our lungs can do damage. Silica sand dust is no exception. Silicosis from occupational exposure to sand dust is a well-known health hazard. However, the concentrations of dust at a typical mine site are far lower than what is considered an occupational health hazard.

This is because the sand is often handled in watered piles, and because workers exposed to the dust are not in confined buildings near the source of the dust where the concentrations are highest. Residences near mines typically receive more dust from gravel roads than from processes at a sand mine. Higher levels of dust are possible at sand processing facilities, but these facilities are required to meet state and federal particulate standards that are protective of human health.

The potential air pollutants of most concern from frac sand mining are airborne particles, including particles less than 10 microns in size (PM_{10}), particles less than 2.5 microns in size (typically called "fine particles" or $PM_{2.5}$), and crystalline silica, which ranges across both size categories. These fine particles are typically handled while wet at frac sand mine sites and are used as backfill for reclamation, thus removing the source and eliminating exposure. However, when dry, the particles can become airborne — especially under windy conditions. The crystalline silica particle size of most concern is smaller than 4 microns; current sampling methods for these fine particles produce reasonable results but it should be noted that according to the Minnesota Pollution Control Agency, there is no generally accepted ambient monitoring method for these size of particles, and there is no method that differentiates between silica and other types of particles. There are known health risks associated with airborne crystalline silica. However, the available information on health effects comes almost exclusively from occupational settings, where exposures are more concentrated. There are no federal or state standards for silica in ambient air. Available air monitoring data from several sites in Wisconsin indicates background levels of dust at the sites monitored are well below the National Ambient Air Quality Standard for PM10.

Sand processing facilities have other emissions besides dust. The fuels used to run generators and exhaust from dryers and other equipment have emissions that are subject to permit limits. Typically, levels of these types of fumes, vapors, and gases are very low. Air dispersion models and stack testing are methods used to demonstrate that these sources are complying with permit limits and are not a risk to nearby receptors.

As part of the environmental review and air permitting process in Minnesota, air dispersion modeling is often required for each source. The air permitting process will require a detailed description of all mining and processing equipment. . You need to declare your operation early, and if you make changes during the permitting process you may need to remodel your site. Also, Minnesota does not have a construction waiver process; you cannot commence construction at your facility until the air emission permit has been issued.

Groundwater

Groundwater issues typically get more attention in Minnesota than in Wisconsin because much of the Jordan Sandstone is near or below the water table. Further to the east along the Mississippi River, the Jordan is above the water table, but there are more trout streams and sensitive resources that rely on groundwater. Also, because many rural areas rely on shallow wells, the state laws are designed to protect the rights of those water users above those of an industrial use. Groundwater also supplies wetlands and surface water with vital base flow that can be reduced if mining reduces or reverses flow from these features.

Water use for sand processing, as well as mine dewatering, is often cited as a concern related to ground water use. Concerns revolve around the change in water level due to mining, and the quality of the groundwater leaving the mine site. If the mine or facility is using municipal water supply or utilizes accumulated stormwater, then groundwater impacts are likely to be minimal, particularly if the process water is circulated.

The main concern locally is the potential for nearby wells to dry up as water levels go down. A well survey is required by state law in order to obtain an appropriations permit. The survey will require a significant effort to survey, map, and collect information on nearby wells. The wells most likely to be affected will need to have a detailed survey including construction information, which will need to be verified at the owner's well. This level of cooperation with the owner means that there will need to be negotiations up front. Many proposers often avoid the need for expensive data collection by agreeing in writing to replace or deepen the well at the owner's request. Water appropriations permits are issued by the Minnesota Department of Natural Resources (MDNR), which will often accept such an agreement if it removes the possibility of further dispute. Note that modeling is important to determine which wells are likely to be affected and the pre-mining survey needs to be done to limit frivolous claims by landowners seeking a new well.

An important factor to consider in water level impacts is whether the operation is full time 24/7, or if it is limited to standard work week and seasonal operations. Any pause in the pumping allows the water levels to recover, so one obvious strategy for limiting impacts is to reduce hours of operation. If mining is conducted entirely above the water table and groundwater is used for washing and dust control only, impacts are likely to be minimal because the well can be designed to minimize potential impact (e.g. by placing it in a deeper aquifer). If the mine uses groundwater to move and circulate the sand as well as for washing and other uses, then the impacts to water levels increase.

Groundwater resources must be evaluated for any mine site in order to design the facility. Depth to water is the most important factor, but availability of water is also a consideration. The information needed to assess these mining concerns is also adaptable to assessing impacts. Typically, a geologic investigation is needed, including at a minimum installation of monitoring wells and water level monitoring. Pumping tests, geophysical surveys, and groundwater modeling are typically needed for sites that plan to dewater or mine below the water table. This information is also valuable in assessing geotechnical stability of the mine and can be collected in conjunction with addition data on the sand resource. Groundwater models of the site can then be used to test alternative mine configurations, depths and pumping demand to optimize the site for the maximum profit with the minimum benefit.

Surface Water

There have been several well-publicized surface water discharges and some other minor ones that escaped media focus. They are nearly always related to discharge of very small sand and clay particles, or "fines," that flow beyond the control structures or ponds designed to retain them. The ponds are used to clarify the water until the fines settle out and the water is clear enough to be reused for washing, infiltrates into the ground, or is discharged according to surface water permitting requirements.

The fines are usually managed in ponds or large tanks called clarifiers. Flocculants are sometimes added to decrease the time it takes to settle out the fines. The flocculants are considered inert and have been used in many municipal water treatment plants safely and effectively for many years. The levels used in these operations do not represent health risks or migrate in groundwater. This is supported by monitoring data. Many operations choose not to use flocculants (due partly to the perception that they are adding a chemical to the water) and instead rely on physical settling in larger ponds. The larger ponds carry a higher risk of failure if not constructed properly, and if failure does occur, the magnitude can be greater than a smaller pond using flocculants.

The fine sand is not toxic but spills of sediment into waterways degrade water clarity and can upset fragile ecosystems, especially wetlands. Spills on land can smother native vegetation and allow noxious weeds to take over. It is worth noting that there are other potential contaminants associated with mines and plants, including above ground storage tanks. Sites with drainage problems and a poor record of stormwater control can expect increased scrutiny of their inspection and containment procedures. However, in most environments a spill of sand fines is eventually incorporated into the natural soil and/or sediment with little long term impact.

Wetlands

As indicated above, most wetlands are protected by state or federal law. The main impacts related to mining are the physical removal of the wetland during stripping of overburden, but also they can be adversely affected by changes in the volume of groundwater or surface water flow, as well as the chemistry of the water. A wetland is defined by its vegetation, hydrology, and soils, so changes to any of those factors are possible under a variety of mining scenarios.

Wetlands are assessed using a process called wetland delineation, where the wetland boundary is mapped and the wetland type and quality is defined. The survey includes an inventory of the plant species present within the wetland and the soil types that support the wetland. In addition, historical and public data are accessed to see if the area contains mapped wetlands and protected waters. Often these resources are of limited accuracy and can tend to wildly over- or underestimate the acres of wetlands at a particular site.

The most common impact to wetlands is that they are removed with overburden prior to mining. The wetlands may be mitigated by offsetting creation of wetlands elsewhere, but in some cases the wetlands cannot be removed and have to be preserved and the mining managed in such a way as to avoid impact. Another common mining impact is from dewatering or water consumption from the mining operation. This can be avoided by decreased pumping or mitigated infiltration of dewatered groundwater. Often detailed groundwater models are used to predict the impact from the operation and the likely effectiveness of mitigation efforts.

A common oversight in performing wetland surveys is that it is typically limited to the property that is proposed, and often regulators (MDNR) will expect that off-site wetlands and resources be evaluated since impacts from groundwater go beyond the property boundaries. Landowners may not be open to having their property surveyed for fear that this the presence of wetlands will limit the use of their property. If this is the case, the MDNR will recognize the effort and typically not expect proposers to trespass to gain the information requested.

Calcareous Fens

These are a special class of wetland that has statutory protection in Minnesota. The statute requires no degradation of the fens and is aggressively enforced by the DNR and local units of government. The fen relies on a unique water chemistry that is rich in bicarbonates and higher pH. Because mining frac sand in Minnesota means mining out carbonate rocks that feed fens, the presence of a fen must be carefully investigated by looking for seeps and indicator plants during the wetland survey/delineation. The vegetation adapted to the fens is unique and sensitive to changes in water volume and chemistry. This means that increased efforts are needed to investigate the unique hydrogeology of the area around the fen, and the likely impacts need to be modeled in several different ways. Also, a fen management plan will be required to ensure that monitoring efforts and contingency plans are in place to meet statutory protection requirements.

Threatened and endangered species

A biological survey is typically conducted to assess the types of habitats and species present at and near the proposed site. Federal and state protected species need to be inventoried from public data bases as well as a field visit. A taking permit is required to remove or modify habitats if such an action is likely to result in negative impacts to protected species. The permits are discretionary and protection of listed species must be justified as having economic or social benefit and describe alternatives. This issue is typically less relevant in historically mined areas because of past land disturbance, but for greenfield sites this is an often overlooked and a very important aspect of environmental review. Unexpected delays related to protected species can be costly and terminal. These should be evaluated in pre-review feasibility assessment of the site.

Cultural and Historical Resources

Whenever a project disturbs the surface, consideration must be given to the possibility that cultural resources exist in a given area. These can include burial mounds, artifacts, or entire settlements of paleo-Americans. This category can also include historically relevant structures or other infrastructure. Generally a review of state databases is sufficient to provide information on known resources in an area. However, any site that is located either higher in the landscape or along a river (especially the confluence of two or more tributaries) should be investigated with a field survey. Most projects of the scale requiring an EIS will also involve a field investigation. Additional triggers for cultural resources studies and review include the presence of state-owned lands or the requirements inherent in federal permitting under the National Historic Preservation Act.

Summary

The impacts associated with frac sand mining are similar to other types of mining and center on air, water, and land included in the proposed mine property — and in some cases — the adjacent land. Air and water require the most extensive permitting, regardless of the location of the site. However, the local jurisdiction typically has the most control over the project and will most often form the point of the spear when it comes to turning the right to mine into profits.

The two required ingredients for assessing environmental impacts include details on the mining/operations that will be performed and data on the site that can predict how those operations will result in changes that might constitute a significant impact. The results of this process does more than merely inform, it can be used to develop permit conditions that provide for safe and profitable development of the frac sand site.