INDUSTRIAL SILICA SAND MINING IN MINNESOTA

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STATE PROGRAM DIRECTOR OF INDUSTRIAL MINERALS

DEPARTMENT OF NATURAL RESOURCES
DIVISION OF LANDS AND MINERALS

Frequently Asked Questions and Answers
What is Industrial Silica Sand?

Industrial silica sand is well-rounded, well-sorted, sand consisting of almost pure quartz, or silicon dioxide (SiO$_2$).

Silica is one of the most common minerals found on the earth surface.

Silica is major component of many different kinds of rocks (like granites and gneiss) and come in many different varieties.
How is Silica Sand Used?

- **Crystalline silica** – defined crystal structure (10 forms)

- It is widely used in many applications:
  - Frac Sand/Cement (41%)*
  - Abrasives (2%)
  - Paint
  - Glass making (26%)*
  - Fillers (6%)
  - Water Filtration
  - Foundry Sand (11%)*
  - Golf/Equestrian (2%)
  - Electronics

* USGS 2012 Industrial Sand and Gravel Commodity Report
What is the history of Silica Sand mining in MN and WI

- Mining of silica sand has occurred for 100+ years
- Some of the sand caves in Minneapolis and St. Paul are mines
  - Initially mined for making beer bottles for breweries/foundry sand
  - Mines and caves also for storage
- Unimin in LeSueur County has been mining industrial silica sand for over 30 years
What’s the Difference between Construction and Industrial Sand?

Construction sand and gravel, mined in Minnesota’s glaciated terrain, consists of many different rock types.

*Construction Sand and Gravel*

*Industrial Silica Sand*

*Photographs taken at different scales*

*Photo by Minnesota Geological Survey*

Minnesota Department of Natural Resources, 2012
How was Silica Sand Deposited?

Source: http://www.scotese.com/
Where is Silica Sand Found Nationally?

Silica Sand Deposits in Red

Source: Modified from Bruce Brown, Wisconsin Geological and Natural History Survey

Minnesota Department of Natural Resources, 2012
Where is Silica Sand Found in MN?

What is the Current Status of Silica Sand Mining?
### Which Sandstones are of Interest?

<table>
<thead>
<tr>
<th>Time</th>
<th>Rock Units</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Devonian</td>
</tr>
<tr>
<td></td>
<td>Wapsipicung Group</td>
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<tr>
<td></td>
<td>Maquoketa Fm.</td>
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<tr>
<td></td>
<td>Dubuque Fm.</td>
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<tr>
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<td>Galena Group</td>
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<td>Decorah Shale</td>
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<td>Platteville Fm.</td>
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<td></td>
<td>Glenwood Fm.</td>
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<td>St. Peter Sandstone</td>
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<tr>
<td>Ordovician</td>
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<td></td>
<td>Jordan Sandstone</td>
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<tr>
<td>Cambrian</td>
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<td></td>
<td>Francia Formation</td>
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<tr>
<td></td>
<td>Ironton Ss.</td>
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<tr>
<td></td>
<td>Galesville Ss.</td>
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<tr>
<td></td>
<td>Eau Claire Formation</td>
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<tr>
<td></td>
<td>Mt. Simon Sandstone</td>
</tr>
<tr>
<td>Precambrian</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Huckleby Ss.</td>
</tr>
<tr>
<td></td>
<td>Igneous/Meta basement</td>
</tr>
</tbody>
</table>

**Source of Stratigraphic Column:** Minnesota Geological Survey

**Photo by Jon Ellington**

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*Minnesota Department of Natural Resources, 2012*
How is the Resource Accessed?

Active Mine in LeSueur County

Potential Mining in Southeastern MN

Dominated by Surface Mining

Surface Mining
Bench Mining
Underground Mining

Minnesota Department of Natural Resources, 2012

Modified from Tony Runkel, Minnesota Geologic Survey
What is Hydraulic Fracturing (Fracking)?


Minnesota Department of Natural Resources, 2012
Is Hydraulic Fracturing Occurring in MN?
Where is the Silica Sand Going?

Source: Energy Information Administration based on data from various published studies.
Updated: May 9, 2011

Minnesota Department of Natural Resources, 2012
What is Driving the Demand for Silica Sand?

annual shale gas production
trillion cubic feet

Source: EIA, Lippman Consulting (2010 estimated)

How Long will the Gas Boom Last?

U.S. dry gas production (trillion cubic feet per year)

History

- Net imports: 11%
- Shale gas: 14%
- Non-associated onshore: 20%
- Non-associated offshore: 9%
- Tight gas: 28%
- Coalbed methane: 2%
- Associated with oil: 8%
- Alaska: 2%

Projections

- Net imports: 45%
- Shale gas: 8%
- Non-associated onshore: 8%
- Non-associated offshore: 7%
- Tight gas: 22%
- Coalbed methane: 7%
- Associated with oil: 7%
- Alaska: 1%

Minnesota Department of Natural Resources, 2012
Limiting Factor – Rail Capacity

**US Inland Oil Boom Leading To Rail Car Shortage**
Published: Sep 16, 2011

By Ben Lefebvre
Of DOW JONES NEWSWIRES

**THE WALL STREET JOURNAL.**

Wednesday, April 13, 2011

**Rail Woes Hit Auto Deliveries**
Fairgrounds, Storage Lots Fill as Freight Car Shortages Stall Detroit Shipments

Minnesota Department of Natural Resources, 2012
What are the Specifications for Frac Sand?

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

Krumbein and Sloss, 1955

Silt and clay sized particles (<62.5 microns) must not exceed a 250 turbidity threshold of 250 FTU (Formazin Turbidity Units). However, processing significantly removes silts and clays.

Minnesota Department of Natural Resources, 2012
What do the Alternatives to Silica Sand Entail?
How does Silica Sand Mining Compare to Sand and Gravel Mining?

<table>
<thead>
<tr>
<th>CONSTRUCTION SAND &amp; GRAVEL</th>
<th>INDUSTRIAL SILICA SAND</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface mining: backhoes, bulldozers, excavators, screens, and conveyors</td>
<td>Surface mining: backhoes, bulldozers, excavators, screens, and conveyors</td>
</tr>
<tr>
<td>No underground mining</td>
<td>Underground mines and bench mining</td>
</tr>
<tr>
<td>Washing plants tend NOT use flocculants</td>
<td>Washing plants may use flocculants</td>
</tr>
<tr>
<td>Does NOT require blasting</td>
<td>May require blasting</td>
</tr>
</tbody>
</table>

Minnesota Department of Natural Resources, 2012
OBJECTIVE OF BLASTING/CRUNSHING FOR HARDROCK MINING
(e.g. Taconite, Granite, and Quartzite)

Blasting and crushing are used to fracture and break rocks into smaller, manageable pieces

Which produce angular, freshly broken rock faces

Iron ore before blasting

Iron ore after blasting
Blasting and Crushing for Silica Sand: How does it compare to other types of mining in Minnesota?

SILICA SAND MINING

Blasting and the use of crushers are used to loosen weakly cemented sandstone, while keeping the individual, round grains intact.

When the grains break, it lowers the performance for use as frac sand.

After processing, much of the silt and clay is removed and very few grains would have freshly exposed surfaces.
What are the Concerns Associated with Silica Sand Mining?

- **Environmental**
  - Water use and groundwater impacts – *Regulated by DNR*
  - Storm water runoff/Air – *Regulated by MPCA*
  - Noise – *Regulated by the County through Permitting*
  - Traffic – *Regulated by the County and State*
  - Air Quality – *Fugitive Silica Sand Particles*

- **Health** – Silicosis and exposure to crystalline silica

- **Quality of Life**
  - Property Values and Property Rights
  - Change in Landscape
What are Positive Outcomes of the Natural Gas Boom?

- Domestic and abundant source of energy
- Cheapest source of energy
- Natural gas is cleaner than coal and oil
  - Estimated to reduce carbon emissions by >40%*
  - 2x more efficient at generating electricity
- Increased income to the county tax base:
  - Scott Co ~$500,000/yr in royalties
  - LeSueur Co ~$620,000/yr in aggregate taxes


Minnesota Department of Natural Resources, 2012
Who Regulates Industrial Silica Sand Mining?

Similar to sand and gravel mining…

Counties, townships, or municipalities are the responsible governmental unit (RGU) for administering permits to mine and regulating the conditions of the permit for industrial silica sand.

Conditional land use permits, sometimes called special use permits, may be required from local planning and zoning offices.
Who are Other Regulating Authorities?

Depending on size and scope, the proposed mining operation may be subject to the following state and federal permits and regulations:

**Department of Natural Resources (DNR)**- Water Appropriation Permit; Public Waters Work Permit; Burning Permit; and Endangered or Threatened Species Taking Permit.

**US Army Corps of Engineers**- Section 404 Permit (discharge of dredged or fill material or excavation within waters and wetlands may require approval of the US Army Corps of Engineers).

**Environmental Quality Board (EQB)**- Requires environmental reviews in the form of an Environmental Assessment Worksheet (EAW) for operations excavating 40 or more acres of land at a mean depth of 10 feet and Environmental Impact Statement (EIS) for operations exceeding 160 acres.

**Board of Water and Soil Resources (BWSR)**- Wetland Conservation Act.

**Pollution Control Agency (MPCA)**- Section 401 Certification; Water Quality, and Air Quality Regulations. Additional resources related to industrial silica sand mining produced by MPCA can be viewed at:

Minnesota Department of Natural Resources, 2012
Industrial Silica Sand
Frequently Asked Questions and Answers

What is industrial silica sand (Frac Sand)? Answer
Where is industrial silica sand found? Answer
What is the current status of industrial silica sand mining in Minnesota? Answer
How is it mined? Answer
What types of industries use silica sand? Answer
What is "fracking"? Answer
Is fracking occurring in Minnesota? Answer
Why here? What makes our sand so unique? Answer
Who regulates industrial silica sand mining? Answer
Who are the other regulating authorities? Answer

What is Industrial Silica Sand (Frac Sand)?
Industrial silica sand refers to sand having the composition and grain-size distribution required for industrial applications. Specifically, industrial silica sand consists of well-rounded, sand composed of almost pure quartz grains. Quartz, or silicon dioxide (SiO₂), is one of the most common minerals found on the Earth's surface and is found in rocks like granite, gneiss, and sandstone. Industrial silica sand is a higher value product than sand and gravel used in the construction industry.

THANK YOU
Heather Arends
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Heather.Arends@state.mn.us
Environmental Regulations for Sand Mining

Environmental Quality Board Presentation

Wendy Turri
Manager
Municipal Wastewater

July 18, 2012
Frac Sand Basics
Relative Sizes

- **PM2.5**
- **PM10**
- **Human Hair**
- **US Sieve Size 140**
- **US Sieve Size 70**
- **US Sieve Size 20**, largest frac sand size
- **US Sieve Size 40**, desirable frac sand size
Presentation Overview

- Air Regulations and Permits
- Water Regulations and Permits
- Environmental Review
- Enforcement
Process Flow

Blast → Excavate → Crush

Sort ← Dry ← Wash

Store ← Transport to End Use
Federal Performance Standards (set of standards that regulate equipment at the site)

- **Nonmetallic Mineral Plants**
  - Applies to all steps of process except dryers.
  - Limits: Stack particulate concentrations, opacity
  - Control Strategy: Baghouse and Best Management Practices
  - Compliance Demonstration: Performance testing, Control Equipment Checks, Recordkeeping

- **Dryers in Mineral Industries**
  - Limits: Stack particulate concentration, opacity
  - Control Strategy: Baghouse, Wet Scrubber
  - Compliance Demonstration: Performance testing, Control Equipment Checks, Recordkeeping
Permit Types

- **Registration Permit** – Rules have been written and Frac sand facility applies for coverage.
  - No dryer and < 50 tons/year of particulate.

- **General Permit** – Permit has been adopted and Frac sand facility applies for coverage.
  - No dryers and < 90 tons/year of particulate matter.
  - Most of the Frac sand facilities will fall under this one.

- **Individual Permit** – Site specific, must have if using a dryer.
  - Requires 30 day public notice permit.
Permit Reporting Requirements

- **Annual**
  - Compliance Certification
  - Annual Emission Inventory

- **Semi-annual**
  - Deviation Reporting

- **Monthly**
  - Emission Calculations

- **~Daily**
  - Control Equipment Parameter Checks
  - Fuel Usage Logs
  - Throughput Data
Presentation Overview

- Air Regulations and Permits
- Water Regulations and Permits
- Environmental Review
- Enforcement
Process Flow

1. Blast
2. Excavate
3. Crush
4. Dry
5. Wash
6. Transport to End Use
7. Store

Flow Chart:
- Blast → Excavate → Crush → Wash → Dry → Transport to End Use → Store
Common Pollutants from Non-Metallic Mining Facilities

- Suspended solids
- Turbidity
- pH
- Chemical additives (as approved by MPCA)
- Heat
Water Quality Permits

- NPDES Permits – Regulating Pollutant Discharges to Surface Waters
  - Technology Based Effluent Limits (TBELs)
    - Level playing field
  - Water Quality Based Effluent Limits (WQBELs)
    - Protect designated uses
  - Limits for Frac Sand facilities
    - Solids, pH, flow, oil and grease, additives
Wastewater NPDES/SDS Permits: General vs. Individual

- **General: Majority**
  - Permit has already passed through public notice – no additional notice required
  - Covers multiple sites under common ownership and similar environmental impacts
  - Only allows stormwater and dewatering discharges to surface water

- **Individual**
  - Requires 30-day public notice
  - Requires comprehensive analysis of activities and potential environmental impacts
Presentation Overview

- Air Regulations and Permits
- Water Regulations and Permits
- Environmental Review
- Enforcement
Environmental Review

- **Environmental Assessment Worksheet (EAW)**
  - Greater than **40 acres**; average depth at least **10 ft**
  - Lower for forested or naturally vegetated land in shoreland areas

- **Environmental Impact Statement (EIS)**
  - Greater than **160 acres**; average depth at least **10 ft**
  - Also lower in shoreland areas

- The Local Unit of Government is the regulating authority
Presentation Overview

- Air Regulations and Permits
- Water Regulations and Permits
- Environmental Review
- Enforcement
Compliance Determination

- Complaints – follow up on all complaints
- Annual, quarterly, monthly reports
- Inspections
Enforcement Actions

- Enforcement response takes into account extent/severity of non-compliance, including:
  - Environmental harm
  - Economic benefit of non-compliance
  - First time vs. repeat offense
  - Speed with which the offense is corrected

- Approximately 20 different enforcement tools:
  - Monetary penalties
  - Stipulation Agreement
  - Supplemental Environmental Project
SILICA TOXICITY

Hillary M. Carpenter
Minnesota Department of Health
Silica Toxicity

• Crystalline silica is widely used in industry and has long been recognized as a major occupational hazard, causing disability and deaths in workers in several industries

• Silica exists in two forms – amorphous and crystalline

• When discussing the toxicity of silica the real concern is with respirable crystalline silica (PM$_4$)
Health Impacts of Silica

• Diseases associated with Crystalline silica include:
  • Silicosis – the hallmark disease – incurable, but preventable
  • Lung cancer
  • Chronic obstructive pulmonary disease (COPD)
  • Renal disease/kidney cancer
  • Several diseases of the immune system
Health Impacts of Silica

- Disease risk is related to both the levels and duration of silica exposure.
  - The onset of disease may occur long after the exposure has ceased
- Silica has a non-linear exposure response curve – risks of disease are greater at higher exposures
Workplace Exposure Limits for Silica

- The Occupational Safety and Health Administration (OSHA) permissible exposure limit for crystalline silica is 0.100 ppm (100 μg/m$^3$) for an 8-hour time-weighted average exposure.

- Adjusted to 24 μg/m$^3$ for a 24 hour, 7 day a week exposure.
Workplace Exposure Limits for Silica

• The National Institute for Occupational Safety and Health (NIOSH) recommended exposure limit is 0.05 ppm (50 μg/m³) for a 10-hour time-weighted exposure.
  • Adjusted to 12 μg/m³ for a 24 hour, 7 day a week exposure.
Health Impacts of Silica

• Occupational silicosis is underdiagnosed
  • There is significant risk to workers chronically exposed to silica concentrations lower than the OELs
  • Silicosis has been diagnosed at autopsy in workers exposed to occupational levels of 50-100 μg/m³
Ambient Silica Toxicity

• There appears to be a low level risk of contracting silica related disease from background levels of exposure

• However, ambient crystalline silica levels can be significantly elevated downwind of peak sources of silica such as mine or quarry operations
  • Silicosis has been reported in highly exposed, non-occupational cohorts
Silica Ambient Exposure Limit

• California’s EPA has developed a chronic exposure limit for silica in ambient air of 3 μg/m³
  • This value is 8 times less than the time-adjusted OSHA limit and 4 times less than the time-adjusted NIOSH recommendation.
  • The differences between acceptable risk levels for occupation settings and those for the general population are typically much greater than 4-8 fold.
Transportation of Silica Sand in Minnesota

EQB Briefing,
July 18, 2012
Minnesota Department of Transportation
Silica Sand as a Transportation Commodity

• Considered a common non-metallic mineral
• Normally handled as a dry bulk commodity, easily transferred by mechanical means including bucket loaders, clamshells, and conveyors
• Chemically inert, non-hazardous material (USDOT hazmat classification)
• Transported packaged and in bulk by all modes; truck, rail, barge, and intermodal container
Trucking

• Maximum weight for 5-axle semi-tractor-trailer is 80,000 pounds GVW – Approx. 25 ton payload
• No exceptions or allowances for overloads for silica sand, unlike agriculture or forest products
• All loads required to be covered on Interstates or over 30 mph on other roads; no dusting or leakage allowed, compliant with EPA regulations
• Due to wide use of scales and load devices, sand haulers have very low incidence of weight violations
Rail

• Silica sand normally hauled in unit trains of 100-125 100-ton cars; 10,000-12,500 tons payload per train

• Two types of equipment and handling used in rail transport per accepted practice: wet raw sand may be loaded in open hoppers or gondolas without appreciable drying and dusting during hauls; washed/graded/dried sand is transported in covered hoppers to prevent loss or contamination of cargo, and potential for dust

• All rail transport of any commodity must comply with EPA regulations for air quality (particulate contamination)
Barge

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

- City was founded and grew around water, and later rail, transportation, transport industry still important
- 15% of Port’s current business is silica sand, both rail and barge; majority of other business is Ag products
- Current Port sand capacity is 30,000 tons per week; equivalent of less than 200 truckloads per day (small fraction of total)
- Low transportation costs generated by Port a major key to agricultural viability in southeast MN & western WI
- Port activities, like commercial truck, rail, and barge transport, constitute interstate commerce and cannot be materially restricted by local & state jurisdictions
Winona Bridge

- Bridge designed for full load of trucks; loaded semis bumper-to-bumper across bridge, both lanes, is safely within design capacity
- 2011 closure was highly conservative maintenance measure to reinforce some gusset plates and maintain road surface
- Commercial trucks monitored for overloads by in-pavement scales (WIM devices) and cameras; no significant overloads reported
- Bridge is fracture-critical (some components not protected by redundancy in case of failure); is in MnDOT process for imminent replacement but still judged safe and regularly inspected
Silica Sand Accommodations

- MnDOT working on transport capacity improvements with rail and trucking firms at this and other alternate sites to minimize transport impacts
- City and Port pro-actively responding to dust-creating issues; unpaved road areas, turning and loading pads, intersections, bulk handling. Private tenants and other companies have been generally responsive to protect their business opportunities
- Counties considering extraction or ton/mile fees, and extraction limits, to offset local road deterioration and traffic impacts
- Noise, intersection geometrics, queue lanes, traffic and grade crossing safety, also being responded to as appropriate
Industry Guidelines (Canadian Sand & Proppants)

• “Air

Crystalline silica is a dangerous substance, and long-term exposure to it has been shown to cause silicosis, a potentially deadly condition. However, crystalline silica is formed by the crushing of sand grains, most commonly in sandblasting operations. At CSP, we need the sand to maintain its grain structure... any crushing of the sand makes our product unusable. Therefore, we go to great lengths to avoid any creation of the airborne crystalline silica particles in question.

We have multiple plans for controlling emissions at the plant. These include bag-house dust collectors on conveyors, bins, and elevators; paving selected areas of the plant; and using water to control dust on unpaved sections and stockpiles at the plant and mine sites. Records will be kept of all maintenance of the dust collection/suppression equipment.

Our emissions will be monitored using an ambient air quality monitor located on the plant site in conjunction with opacity monitoring on the stacks themselves. Reports from this monitor will be delivered to and analyzed by the DNR.

Employees will periodically wear monitoring devices that will measure their exposure to particulate matter. Reports from these devices are gathered and analyzed by the Mining Health and Safety Administration (MSHA).”

• “Water

CSP’s projected water usage is 125 million gallons annually. Most of this water is lost due to evaporation during our washing process. The rest is used in the dust suppression equipment. At the request of the city council we will be using water from the city water supply, as another local business recently upgraded their facility and reduced their annual water usage by 400 million gallons. There will be no hazardous chemical usage at any point in our process. During our scrubbing process, a flocculant is added to the sand and water mixture. This flocculant is an inert polymer which causes the dissolved and suspended fine material (silts, clays, and organics) to bind together. By doing this, we can separate the fines from the wash water and then recycle the water back into the wash process, saving millions of gallons annually.”
WHAT IS A GEIS?
Generic EIS (4410.3800)

- “… may be ordered by EQB to study types of projects that are not adequately reviewed on a case-by-case basis.”
- EQB may be RGU or designate another agency
- May be requested by a governmental unit or any other person
- Scoping process
- Specific projects are neither exempted from environmental review nor delayed because a GEIS is being prepared.
Previous Generic EISs

- GEIS on Timber Harvesting and Forest Management Practices
  - Initiated by citizen request in 1989
  - Completed in 1994
  - Sustainable Forest Resources Act (1995) created the Minnesota Forest Resources Council
  - MFRC charged with implementing GEIS recommendations


- GEIS on Urban Development in Minnesota (1999-2000)
  - Scoped but not funded
Unique attributes

- Cumulative impacts focus
  - also regional and statewide significance
- Discretionary nature
- Focus on recommendation development
  - also usefulness for project–specific environmental review ( tiering )
- Funding
  - no mechanism for assessing costs of preparing a GEIS
Thanks