AGGREGATE RESOURCE POTENTIAL IN PARTS OF NORTHERN ST. LOUIS AND LAKE COUNTIES, MN

Sand and Gravel Potential and Silt and Clay Potential Resources

Produced by the Aggregate Resource Mapping Program
Division of Lands and Minerals
Minnesota Department of Natural Resources

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The project boundary was developed to evaluate and map sand and gravel potential and silt and clay potential around known copper + nickel + platinum group element deposits in northern St. Louis County and Lake County, Minnesota.

Classifying Sand and Gravel Potential: Sand and gravel resources were divided into four categories based on the type of geologic feature, probability (certainty), sand and gravel thickness, overburden thickness, deposit size (areal extent), textural characteristics (grain size distribution), quality (soundness and durability), and the sediment description as observed in the field (Table 1; see definitions of terms in Footnotes below Table 1). For example, a classified landform, such as an ice contact feature, typically contains sand and gravel. The resource has a high probability of containing aggregate when the landform has gravel pits located within its boundaries, sand and gravel is observed at or near the surface, and sand and gravel is encountered in surrounding water wells. Historical laboratory test results of aggregate quality are compiled, interpreted, and extrapolated from Mn/DOT pit sheets. In addition to Mn/DOT quality data, observations of quality characteristics can be assessed during field work. Thickness of overburden and sand and gravel were determined from observations and water well information. For example, if a deposit has areal extent greater than 15 acres, has thickness greater than 10 feet, has overburden thickness of 5 feet or less, has high quality, good texture, and an existing gravel pit, then the resource is classified as having high potential (Table 1).

The areas classified as nonsignificant sand and gravel resource potential (low and limited potential) meet the criteria listed in Table 1. Deposits that are too small in areal extent; are too thin; have too thick of overburden; contain significantly more sand than gravel; lack identified resources; or do not meet quality specifications are in these categories.

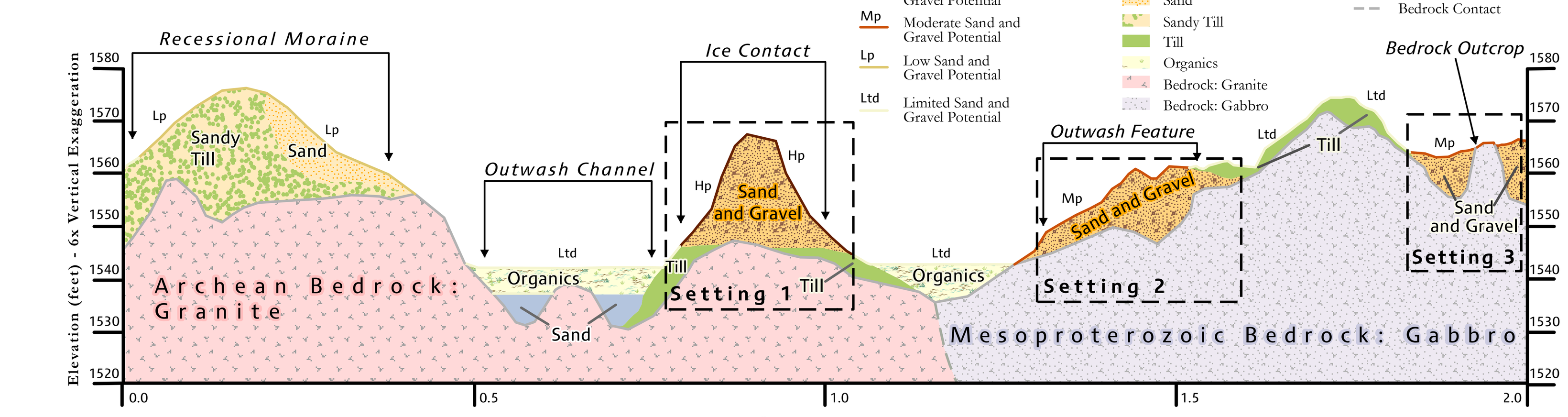
Table 1: Classification Matrix of Sand and Gravel Potential[1]

Characteristics	SIGNIFICANT RESOURCES		NONSIGNIFICANT[2] RESOURCES	
	High Potential	Moderate Potential	Low Potential	Limited Potential
Surficial Geology Features	Glaciofluvial feature; outwash channel; outwash feature; ice contact feature	Ice contact feature; linear ridge; recessional/ ground moraine; outwash terrace, channel, feature	Outwash features; alluvial valley; lake plain; recess-ional/ground moraine; ice contact; linear ridge; beaches	Alluvial valley; bedrock; lake plain; outwash channel feature; recessional/ground moraine; glaciofluvial feature
Predominant Sediment Description	Sand and gravel	Till, sand and gravel	Till, sand, sand with gravel	Till, silt, sand, bedrock
Probability[3]	Moderately high to very high	Moderate to high	Low to moderately low	Very low to low
Sand and Gravel Thickness[4] (in feet)	10-50+	0-45+	0-40+	0-15+
Overburden Thickness (in feet)	0-5	0-15	0-45+	0-35+
Sand and Gravel Deposit Size (areal extext[5])	Moderately large to very large (10-30+ acres)	Moderate to moderately large (5-15+ acres)	Moderately small to small (3-10+ acres)	Very small to small (<1-5+ acres)
Sand and Gravel Textural Characteristics[6]	Good to very good	Moderate to good	Poor to moderately poor	Very poor to moderately poor
Sand and Gravel Quality[7]	Moderately high to very high	Moderate to high	Moderately low to low	Very low to moderately low

Footnotes Associated with Potential Sand and Gravel Resources Seen on Table 1

[1]**Table** excludes classification of silt and clay potential.
[2]**Nonsignificant:** Term representing aggregate resources that do not meet the criteria for high or moderate aggregate potential according to the characteristics listed in Table 1. This is a relative classification that changes from one mapping region to another.
[3]**Probability:** The degree of certainty that aggregate exists within a mapping unit largely defined by the amount of available information.
[4]**Thickness Variability:** The thickness of a deposit may range from 0 to stated value due to the presence of bedrock outcrops or lateral discontinuation of the deposit.
[5]**Areal Extent:** The size, horizontal extent, or distribution of a unit (e.g., area in acres). This attribute does not necessarily reflect the size of an individual polygon but the size of a deposit found within that polygon.
[6]**Textural Characteristics:** Particle size distribution, defined as the percentage of gravel or sand vs. silt or clay (e.g., sieve analysis).
[7]**Quality:** The physical characteristics of the material, such as soundness (e.g., magnesium sulfate test), durability (Los Angeles Rattler test), and percent of deleterious rock types such as iron oxide, disintegrating rock, or unsound chert. Field observations supplement historic data.

Figure 1: Conceptual Cross-Section Displaying Sand and Gravel Potential And Relative Bedrock Influence



Conceptual Cross-Section: The cross-section above conceptually illustrates three geologic settings observed within the project area. The purpose of the cross-section is to demonstrate how bedrock affects sand and gravel potential. Local bedrock may influence the sand and gravel deposit in two ways: 1) local bedrock topography may have directed the meltwater flow and the sand and gravel deposition and 2) local bedrock may also be the predominate rock type within the gravel clasts, and influence gravel quality.

Setting 1 shows a steep hill of sand and gravel deposited by meltwater that flowed through or on glacial ice. The resulting landform is called an ice-contact feature. In this setting, the sand and gravel overlies granitic bedrock, a high-quality source of aggregate. A deposit with high quality gravel lithology combined with other factors like a thickness greater than 10 feet with little to no overburden, results in a classification of high potential for sand and gravel. **Setting 2** shows a sand and gravel deposit over gabbroic bedrock which produces less desirable aggregate. Therefore, the deposit reflects the lower quality and is classified as moderate potential for sand and gravel. The bedrock topography is highly variable in **Setting 3** and controls how sand and gravel is distributed. Where bedrock is exposed at the surface, sand and gravel thickness may range between 0 to 20+ feet thick within a single mapping unit. All but high potential classifications have possible bedrock outcrops.

Printed Map Scale 1 : 63,360

Based on a 1:50,000 scale MN DNR resource assessment

Miles: 0 1 2 3 4
Kilometers: 0 1 2 3 4 5 6

Sand and Gravel Potential and Silt and Clay Potential

Potential is defined as an assessment of the relative probability that a deposit exists within a given mapping unit. Evaluation of specific deposits was not done in this reconnaissance-level study.

Significant Sand and Gravel Resource Potential
- **High Potential:** Units inferred to contain highest sand and gravel resource potential.
- **Moderate Potential:** Units inferred to contain moderate sand and gravel resource potential.

Nonsignificant Sand and Gravel Resource Potential
- **Low Potential:** Units inferred to contain low sand and gravel resource potential.
- **Limited Potential:** Units inferred to contain limited sand and gravel resource potential or units with insufficient data to indicate the existence of sand and gravel.

Silt and Clay Resource Potential
- **Silt and Clay Potential:** Units inferred to contain silt and clay resource potential.

Identified Resources: Gravel Pits, Sand Pits, Borrow Pits, and Quarries

Excluding Taconite Mine Lands

Number of sites in project area, e.g., 10 large gravel pits

Small <5 Acres	Medium 5-15 Acres	Large >15 Acres	
□ 129	□ 31	□ 10	**Gravel Pits:** Sites that have been or are currently being mined in deposits of sand and gravel.
⊠ 24	⊠ 10	⊠ 3	**Gravel Pits – Mn/DOT ASIS:** Sites were identified by Mn/DOT as part of the Aggregate Source Information System (ASIS).
△ 8	None	△ 1	**Sand Pits:** Sites that have been or are currently being mined in deposits of sand with little or no gravel.
None	None	1	**Sand Pits – Mn/DOT ASIS:** Sites were identified by Mn/DOT as part of ASIS.
6	None	None	**Borrow Pits:** Sites comprising very small excavations or sites in nongranular deposits.
⚒ 3	⚒ 1	None	**Quarry:** Sites include one medium active dimension stone quarry and three small inactive quarries referenced from topographic maps.

Field Observations, Test Holes, and Quality Testing

Field Observations: A total of 805 field observations were logged during the fall of 2009 and spring of 2010. The map displays field observations by their primary material symbol.

- ■ Sand and Gravel
- ▲ Sand
- × Clay/Silt
- • Till/Boulders
- ◊ Bedrock Outcrop

Mn/DOT Tested Quality Samples: 12 samples taken from field observations and test holes were tested for quality by Mn/DOT. The quality tested samples are labeled on the map like this: Quality Tested Quality Tested

Test Holes: A total of 36 test holes were completed during the spring of 2010. The map labels identify each test hole by primary material type (e.g., sand, sand and gravel, till).

e.g., Sand **Test hole location with an example label of primary material type**

Taconite Mine Lands and Copper + Nickel + PGE Deposit Footprints

Mine lands: Excluded from aggregate assessment. Includes all iron mining features: mines, stockpiles, tailings basins, haul roads, etc., where access is controlled.

Copper + Nickel + Platinum Group Elements Deposit Footprints: These are unverified, generalized footprints based on a variety of sources and are provided here only for point of reference.

***Transportation Features**
- MN Highway
- County Highways and Roads
- Township and Other Roads
- Municipal Roads
- Forest Roads
- Railroad Tracks
- Airport Runway

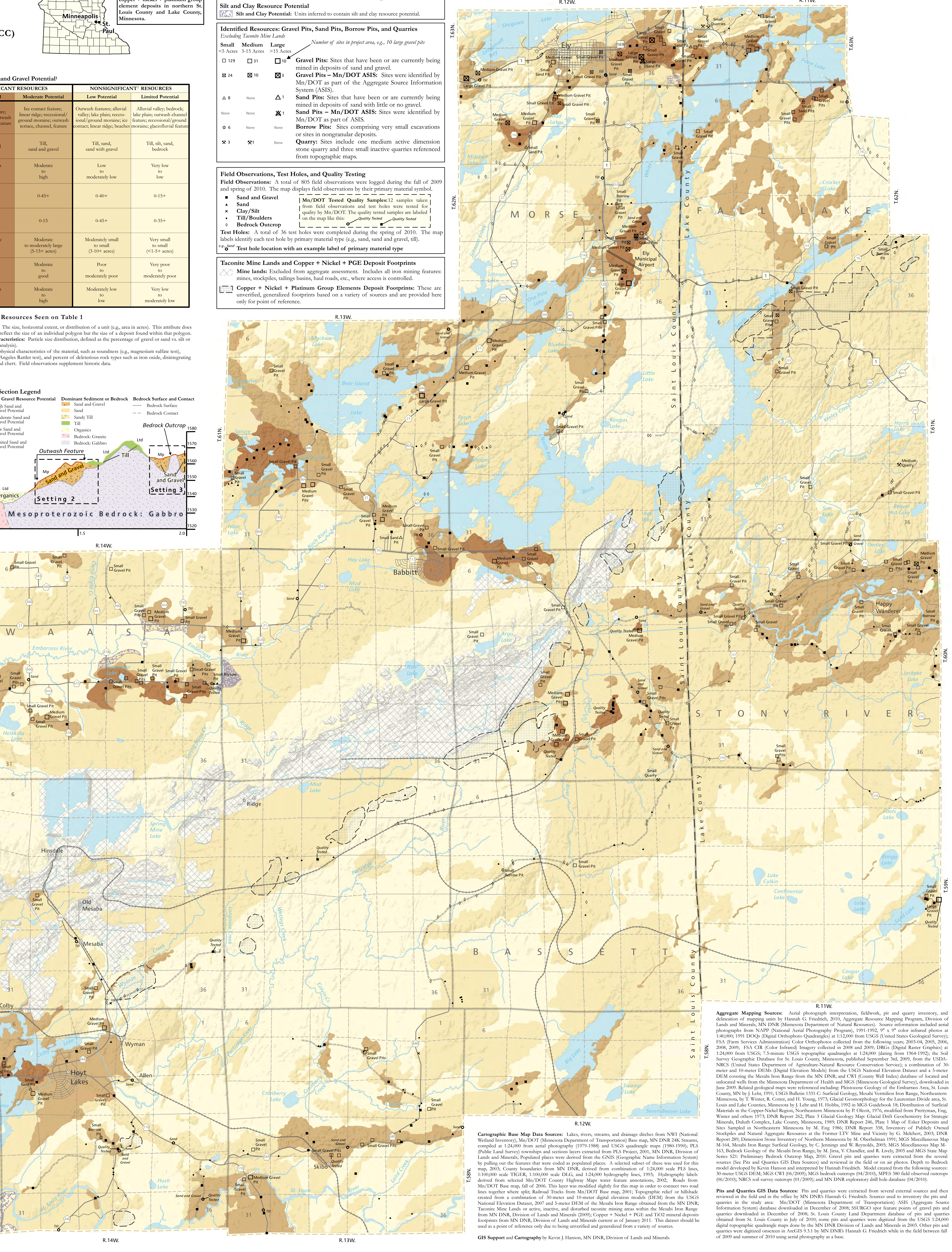
Bounding Features
- Project Boundary
- County Boundaries
- PLS Township Boundaries
- Section Boundaries *Sections 1,6,31, & 36 labeled*

Cities and Populated Places
Ely Skibo *(Size of font type indicates relative populations)*

Physical Features
- *Water Features (Lakes, rivers, tailings basins)*
- *Rivers & Streams*
- Shaded Topographic Relief (Azimuth = 315, Altitude = 45)

***Transportation Features** *are from Mn/DOT and were current at the time of field work. Other GIS road layers were used for field work that were not mapped by Mn/DOT. These sources are unpublished and were not used for this map.*

Map Disclaimer: This map was prepared from publicly available information, field data, and geologic interpretations. Every reasonable effort has been made to ensure the accuracy of the factual data on which this map interpretation is based. However, the Department of Natural Resources does not warrant the accuracy, completeness, or any implied uses of these data. Users may wish to verify critical information; sources include both the references here and information on file in the offices of the Minnesota Department of Natural Resources and the Minnesota Geological Survey. Every effort has been made to ensure the interpretations conform to sound geologic and cartographic principles. This map should not be used to establish legal title, boundaries, or locations of improvements.



Aggregate Mapping Sources: Aerial photograph interpretation, fieldwork, pit and quarry inventory, and delineation of mapping units by Hannah G. Friedrich, 2010, Aggregate Resource Mapping Program, Division of Lands and Minerals, MN DNR (Minnesota Department of Natural Resources). Source information included aerial photographs from NAPP (National Aerial Photography Program), 1991-1992, 9" x 9" color infrared photos at 1:40,000; 1991 DOQs (Digital Orthophoto Quadrangles) at 1:12,000 from USGS (United States Geological Survey); FSA (Farm Services Administration) Color Orthophotos collected from the following years; 2003-04, 2005, 2006, 2008, 2009; FSA CIR (Color Infrared) Imagery collected in 2008 and 2009; DRGs (Digital Raster Graphics) at 1:24,000 from USGS; 7.5-minute USGS topographic quadrangles at 1:24,000 (dating from 1964-1992); the Soil Survey Geographic Database for St. Louis County, Minnesota, published September 3rd, 2009, from the USDA-NRCS (United States Department of Agriculture-Natural Resource Conservation Service); a combination of 30-meter and 10-meter DEMs (Digital Elevation Models) from the USGS National Elevation Dataset and a 5-meter DEM covering the Mesabi Iron Range from the MN DNR; and CWI (County Well Index) database of located and unlocated wells from the Minnesota Department of Health and MGS (Minnesota Geological Survey), downloaded in June 2009. Related geological maps were referenced including: Pleistocene Geology of the Embarrass Area, St. Louis County, MN by J. Lehr, 1991; USGS Bulletin 1331-C: Surficial Geology, Mesabi Vermilion Iron Range, Northeastern Minnesota, by T. Winter, R. Cotter, and H. Young, 1973; Glacial Geomorphology for the Laurentian Divide area, St. Louis and Lake Counties, Minnesota by J. Lehr and H. Hobbs, 1992 in MGS Guidebook 18; Distribution of Surficial Materials in the Copper-Nickel Region, Northeastern Minnesota by P. Olcott, 1976, modified from Prettyman, Eng, Winter and others 1973; DNR Report 262, Plate 3 Glacial Geology Map: Glacial Drift Geochemistry for Strategic Minerals, Duluth Complex, Lake County, Minnesota, 1989; DNR Report 246, Plate 1 Map of Esker Deposits and Sites Sampled in Northeastern Minnesota by M. Eng 1986; DNR Report 358, Inventory of Publicly Owned Stockpiles and Natural Aggregate Resources at the Former LTV Mine and Vicinity by G. Melchert, 2003; DNR Report 289, Dimension Stone Inventory of Northern Minnesota by M. Oberhelman 1991; MGS Miscellaneous Map M-164, Mesabi Iron Range Surficial Geology, by C. Jennings and W. Reynolds, 2005; MGS Miscellaneous Map M-163, Bedrock Geology of the Mesabi Iron Range, by M. Jirsa, V. Chandler, and R. Lively, 2005 and MGS State Map Series S21: Preliminary Bedrock Outcrop Map, 2010. Gravel pits and quarries were extracted from the several sources (See Pits and Quarries GIS Data Sources) and reviewed in the field or on air photos. Depth to Bedrock model developed by Kevin Hanson and interpreted by Hannah Friedrich. Model created from the following sources: 30-meter USGS DEM; MGS CWI (06/2009); MGS bedrock outcrops (04/2010), MPES 380 field observed outcrops (06/2010); NRCS soil survey outcrops (01/2009); and MN DNR exploratory drill hole database (04/2010).

Pits and Quarries GIS Data Sources: Pits and quarries were extracted from several external sources and then reviewed in the field and in the office by MN DNR's Hannah G. Friedrich. Sources used to inventory the pits and quarries in the study area: Mn/DOT (Minnesota Department of Transportation) ASIS (Aggregate Source Information System) database downloaded in December of 2008; SSURGO spot feature points of gravel pits and quarries downloaded in December of 2008; St. Louis County Land Department database of pits and quarries obtained from St. Louis County in July of 2010; some pits and quarries were digitized from the USGS 1:24,000 digital topographic quadrangle maps done by the MN DNR Division of Lands and Minerals in 2003. Other pits and quarries were digitized onscreen in ArcGIS 9.3.1 by MN DNR's Hannah G. Friedrich while in the field between fall of 2009 and summer of 2010 using aerial photography as a base.

Cartographic Base Map Data Sources: Lakes, rivers, streams, and drainage ditches from NWI (National Wetland Inventory), Mn/DOT (Minnesota Department of Transportation) Base map, MN DNR 24K Streams, compiled at 1:24,000 from aerial photography (1979-1988) and USGS quadrangle maps (1980-1990); PLS (Public Land Survey) townships and sections layers extracted from PLS Project, 2001, MN DNR, Division of Lands and Minerals; Populated places were derived from the GNIS (Geographic Name Information System) by pulling out the features that were coded as populated places. A selected subset of these was used for this map, 2003; County boundaries from MN DNR, derived from combination of 1:24,000 scale PLS lines, 1:100,000 scale TIGER, 1:100,000 scale DLG, and 1:24,000 hydrography lines, 1993; Hydrography labels derived from selected Mn/DOT County Highway Maps water feature annotations, 2002; Roads from Mn/DOT Base map, fall of 2006. This layer was modified slightly for this map in order to connect two road lines together where split; Railroad Tracks from Mn/DOT Base map, 2001; Topographic relief or hillshade created from a combination of 30-meter and 10-meter digital elevation models (DEM) from the USGS National Elevation Dataset, 2007 and 5-meter DEM of the Mesabi Iron Range obtained from the MN DNR; Taconite Mine Lands or active, inactive, and disturbed taconite mining areas within the Mesabi Iron Range from MN DNR, Division of Lands and Minerals (2009); Copper + Nickel + PGE and TiO2 mineral deposits footprints from MN DNR, Division of Lands and Minerals current as of January 2011. This dataset should be used as a point of reference only due to being unverified and generalized from a variety of sources.

GIS Support and **Cartography** by Kevin J. Hanson, MN DNR, Division of Lands and Minerals.

Products of this project include a CD/ROM with the final report, map, GIS data, and metadata.