Inventory of Publicly Owned Stockpiles and Natural Aggregate Resources at the Former LTV Mine and Vicinity

Minnesota Department of Natural Resources
Division of Lands and Minerals
William C. Brice, Director

Project 358
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Executive Summary

LTV Steel Mining Company mined magnetic taconite from the eastern end of the Mesabi Range in northeastern Minnesota for more than 40 years. During that time, LTV stockpiled on the order of a hundred million tons of waste rock and low-grade ore rock. Prior to that, previous companies mined natural iron ore and stockpiled various materials during those operations.

LTV filed for bankruptcy and closed the mine on January 5th, 2001. Cliffs Erie LLC, a subsidiary of Cleveland Cliffs, Inc, purchased the mining property and associated assets, including the railroad. Currently, mining does not occur on the property, and Cliffs Erie manages ongoing reclamation obligations and actively pursues economic and development opportunities of the property.

An opportunity now exists where the existing infrastructure and vast resources of broken rock could be used to supply demands for crushed rock aggregate, rip rap, railroad ballast, and decorative stone. The existing infrastructure at the former LTV Mine—electrical power, loading pockets, and rail lines--is conducive to establishing a high-volume operation.

The purpose of this project was to inventory the publicly owned rock and overburden stockpiles and explore for natural deposits of aggregate created by glacial activities in the evaluation area. A chief component of the inventory was to photograph each rock stockpile. The 103-square-mile evaluation area covers the former LTV mine and surrounding lands in St. Louis County, MN. Within Ranges 14 and 15 West, the area includes portions of Township 58N, all of 59N, and portions of 60N.

The results of this project include this report, one Plate that shows current infrastructure, and a second Plate that shows the locations of and kinds of stockpiles, occurrences of natural aggregate and abundant natural boulders, data collection sites, photo sites, and public land ownership. Also included are digital photos, a database, and rock samples reserved for review by interested parties.

All the stockpile materials were placed into five major categories: 1) lean taconite, 2) waste rock, 3) overburden, 4) lean ore, and 5) taconite. When LTV actively mined, the rock that was not processed was separated into these categories based on magnetic iron content. Rock that had between 10 and 19% magnetic iron was placed on lean taconite stockpiles, and rock with less than 10% magnetic iron was placed on waste rock stockpiles. The lean ore and taconite stockpiles are associated with natural ore mining.

Alternative uses of the stockpiled materials such as crushed rock aggregate, large and small rip rap, railroad ballast, and decorative stone are suggested. Some of the rock stockpiles contain materials that have potential for decorative stone with interesting patterns and colors. Four major classifications based on color were developed for the rock stockpiles. These were 1) gray with subtle color bands, 2) dark brownish gray, 3) gray with brown bands, and 4) mixed assortment of pale green, reddish purple, brown with thin light brown laminations, and gray rocks. Color classifications 1 and 3 are mostly associated with lean ore stockpiles,

and classifications 2 and 4 are mostly associated with waste rock stockpiles. The stockpiles were not built based on rock colors, but iron content, so the color usually varies within any given stockpile.

Some rock and overburden stockpiles around the Embarrass Natural Ore Pit (sections 5 and 6, T. 58N, R. 15W) have potential for decorative stone or gravel.

Natural gravel was found in most of the evaluation area except in the northeast. Except for scattered areas south of the mine pits where the gravel contains significant quantities of argillite, it appears to be of good quality. Concentrations of natural boulders occurred mostly along the Giants Range in the western part of the evaluation area. The potential for quarrying granite for crushed rock aggregate exists in certain areas.

Introduction

Near the eastern end of the Mesabi Range, in northeastern Minnesota, LTV Steel Mining Company mined and produced magnetic taconite units within the Biwabik Iron Formation for more than 40 years (Figure 1). In 1998, for example, the company mined and processed 23.7 million tons of ore. An additional 28.4 million tons of rock was blasted, stripped, and placed on stockpiles and 3.9 million cubic yards of overburden (surface material) was stripped (DNR Mineral Operations Report, 1999).

The Biwabik Iron Formation averages about 500 feet thick in this area. The formation consists of alternating layers of variable iron content. Layers with about 19% or more magnetic iron are considered ore and processed to make iron ore pellets. Layers containing 10 to 19% magnetic iron are considered "lean" and stockpiled separately for potential future processing as technology or economics improve. Rock containing less than 10% magnetic iron is considered "waste rock".

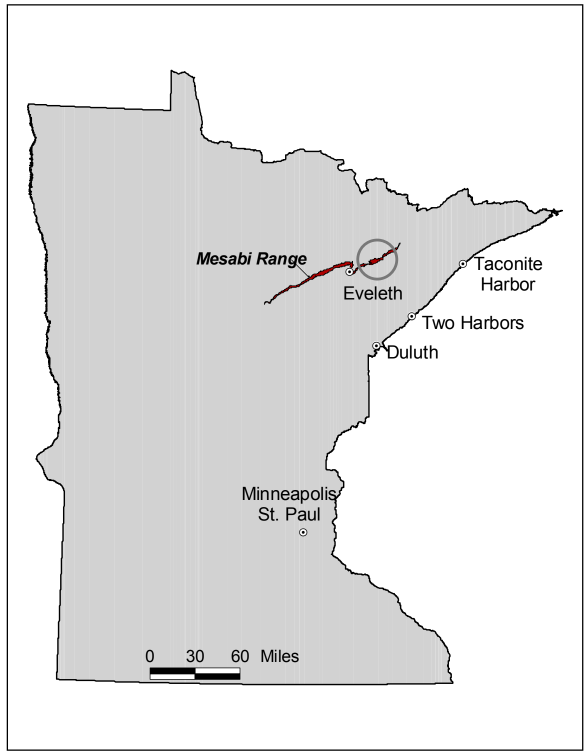

Figure 1. Index map showing location of the former LTV mine. The mine is inside the circle at the east end of the Mesabi Range.

LTV filed for bankruptcy and the mine closed on January 5th, 2001. Cliffs Erie LLC, a subsidiary of Cleveland Cliffs, Inc, purchased the mining property and associated assets, including the railroad. Currently, mining does not occur on the property, and Cliffs Erie manages ongoing reclamation obligations and actively pursues economic and development opportunities of the property.

Currently, an excellent infrastructure exists at the former LTV Mine. Railroad spurs extend to several areas of the mine and connect to rail routes that go west, south, and east, including three shipping ports on Lake Superior. Loading pockets and electrical power are also present.

Purpose

Now that the mine is closed, there may be opportunities to market the immense quantities of broken rock and other aggregate resources in the area. The purpose of this project was to inventory the publicly owned rock and overburden stockpiles and explore for natural deposits of aggregate in the evaluation area. A chief component of the inventory was to photograph each rock stockpile.

The evaluation area covers the former LTV mine and surrounding lands in St. Louis County, MN. Within Ranges 14 and 15 West, the area included portions of Township 58N, all of T. 59N, and portions of T. 60N (Figure 2).

With the mining infrastructure still intact, it is hoped this inventory will increase interest in the resources of the area. There may be opportunities to use some of the stockpiled materials for crushed rock aggregate, large and small rip rap, railroad ballast, fill material, landscape boulders and decorative stone.

Scope

This project began at the end of September 2002. Ownership of *rock* stockpiles were based upon mining production records held by the Minnesota Department of Natural Resources, at the Hibbing office. As a rule, the surface owner owns *overburden* stockpiles that sit upon their land. Although exceptions may occur, this assumption was used to determine ownership of overburden stockpiles. Mineral rights were not addressed.

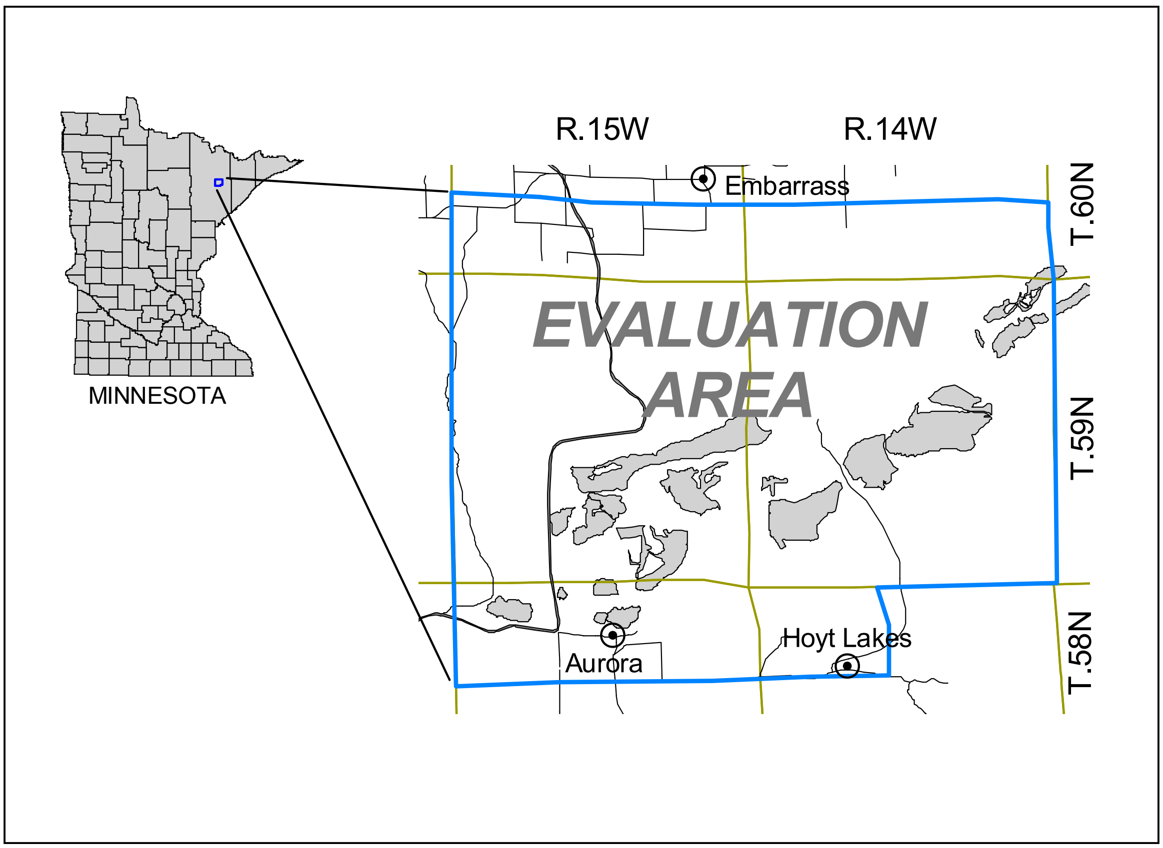

Figure 2. Detail of the evaluation area. The area encompasses the former LTV mining area and surrounding lands totaling about 103 square miles or just under three townships. Nearby towns and roads are indicated. Mine pits are indicated by gray shading. The mine pits were digitized previously by DNR personnel.

Land ownership was based upon records in the state database as of October 1, 2002 and from the 2002 St. Louis County plat book. No title work or other research of land ownership records was done.

The materials in each stockpile were qualitatively assessed for use as crushed aggregate, riprap, and decorative stone. Examples of representative rock types were collected for reference, but testing for compatibility as crushed aggregate was beyond the scope of this project. Several samples of natural aggregate were tested for particle size distribution (gradations) and qualitatively assessed for deleterious materials.

The map showing existing infrastructure reflects the condition in the fall of 2002. Some roads are no longer maintained and may become impassable with time as erosion occurs, and some may flood as water levels in the pits rise. The rail lines may degrade or be removed.

Methods

This project covered publicly owned parcels of land and stockpiles only, so it was important to determine ownership before fieldwork could occur.

Ownership

Stockpiles --A basic assumption for the *overburden* stockpiles was that the surface landowner owns the overburden stockpiles that sit upon their land.

Ownership of *rock* stockpiles has to do with mineral rights and nothing to do with ownership of the land surface. When a parcel of land, such as 40 acres, is mined, the owner or owners of the mineral rights receives royalties on the ore that is processed and they also retain ownership of the lean taconite or waste rock from that parcel. The lean taconite and waste rock are separated and usually stockpiled on other parcels of land. Normally it is not possible or practical to stockpile each owner's material on their land. As a result, rock stockpiles with some public ownership are often stockpiled on private land, which is usually mining company land, or vice versa.

Ownership of *rock* stockpiles was based upon mining production records held by the Minnesota Department of Natural Resources at the Hibbing office. Typically several entities have an ownership interest in any given stockpile. This is especially true for the relatively younger, larger stockpiles. Figure 3 shows the stockpiles that were evaluated.

Surface --The GAP Stewardship database, circa 1998, provided an initial indication of land ownership in the evaluation area. These data were confirmed or revised based upon land records in the state database as of October 1, 2002. This database, commonly referred to as the AS400, is regularly updated. While doing field work and comparing to the newly released St. Louis County Plat Book (CCI, 2002), it became apparent that some parcels designated as county tax forfeit lands were no longer such and other tax forfeit lands were not in the state database. St. Louis County was contacted and they provided data of their current tax-forfeit holdings in the form of an ArcView shapefile. The ownership map was

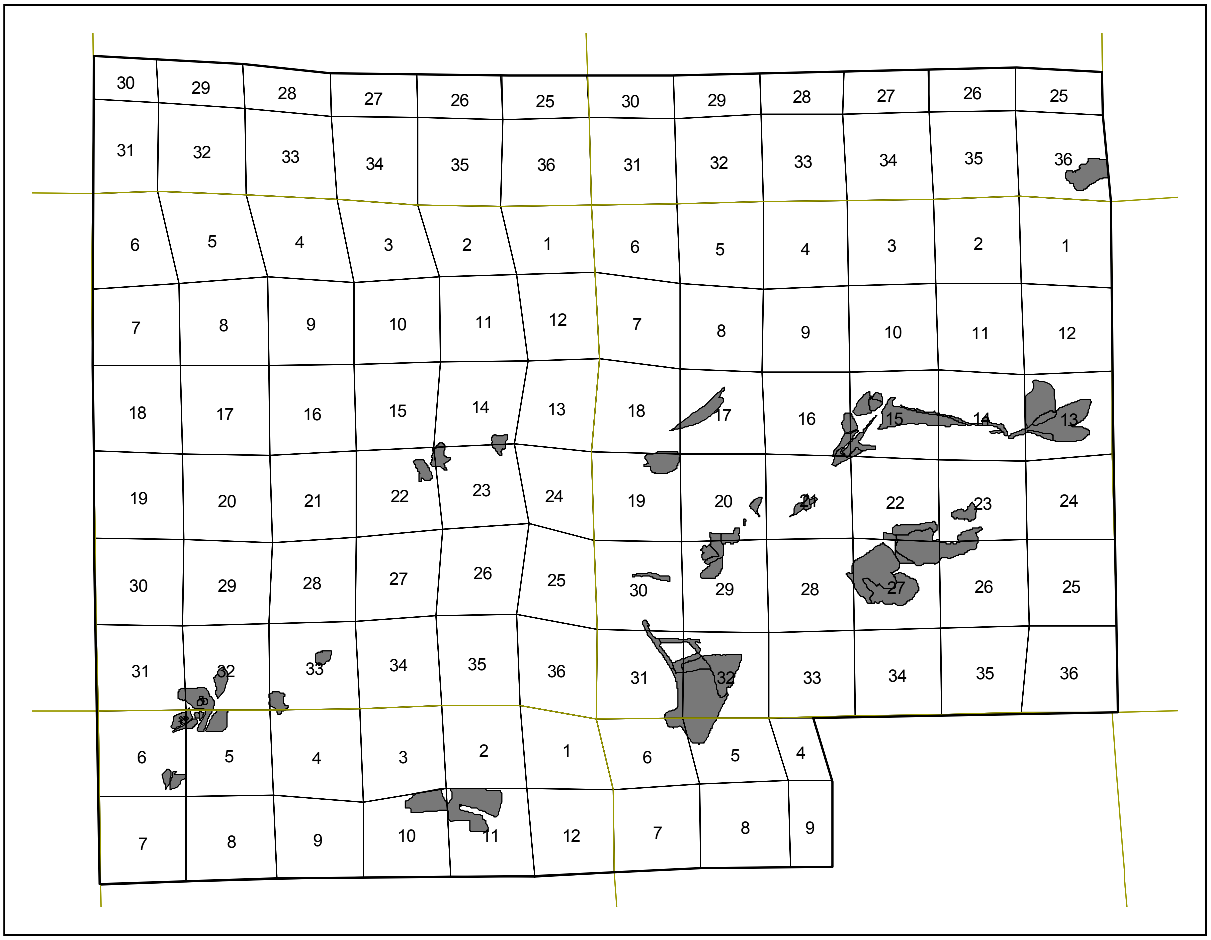

Figure 3. Map of mine stockpiles (gray tone) with some public ownership. Each numbered square represents a section of land--approximately one mile on a side.

updated with this information. Figure 4 shows the lands determined to be public within the evaluation area.

Field Work

Overburden and Rock Stockpiles --Every public overburden stockpile was inspected. Emphasis was on locating sand or gravel or significant numbers of boulders. The techniques frequently used were the examination of gullies and digging test pits to a depth of about 18 inches.

The rocks in each rock stockpile were qualitatively assessed for their potential use as crushed aggregate, riprap, and landscaping materials. Notes were made on the maximum, minimum and predominant particle size, sorting, and estimates of the quantities of boulders along a one hundred foot length. Access and whether portions were reclaimed were also noted. The field form used is included in Appendix A. Two or more digital photographs, which usually included one for perspective, and one or two close ups to show detail of the individual rock

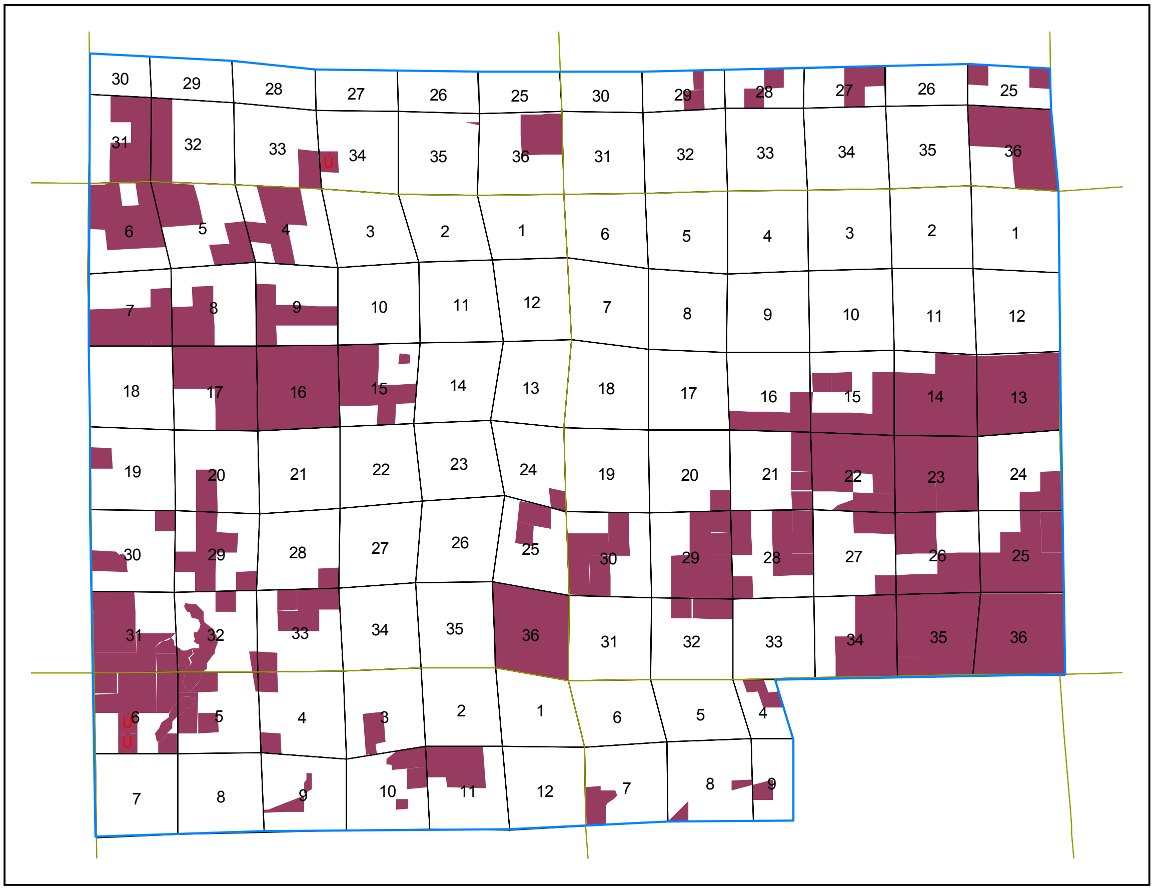

Figure 4. Map of public lands (gray tone) within the evaluation area. Each square represents a section of land—approximately one mile on a side.

pieces, were taken of each stockpile. These photographs are referenced to stockpile number and sample site and are on the enclosed compact disk.

Grab samples of rock from 11 sites were collected in 5-gallon buckets. These samples show the range of rock types and provide specimens for inspection. The samples were soaked in water and automotive detergent and hosed off to remove most of the dirt and grime. A staff geologist wrote geologic descriptions for these samples (Appendix B). Single hand specimens were collected from a few other sites. Each location that was described, photographed, or sampled was marked with a GPS unit. The field sites are indicated in Figure 5.

Rock stockpiles that contained rock materials that were hard, generally massive (usually broke in layers thicker than about 2 to 3 inches), and contained at most only minor amounts of slate were considered to have potential for crushed aggregate.

Natural Aggregate --Topographic maps and air photos were reviewed to determine which parcels or portions of parcels had a relatively high potential for sand and gravel or high concentrations of boulders. These areas and most of the other parcels were inspected for exposures that revealed the material type. Exposures included road and logging road

Figure 5. Map of field sites (small circles with dots) associated with mine stockpiles and other mining features. The light gray areas represent rock stockpiles and the dark gray areas represent overburden stockpiles.

cuts, gullies, gravel pits, and borrow sites. Where no exposures existed, test pits were dug. The test pits were about 18 inches deep.

Observations at each sample site were documented, locations were captured by hand-held Garmin 12XL or 76x GPS units, and the data were entered into a database. Ten samples of natural aggregate were collected and tested for gradations and qualitatively assessed for deleterious materials. These were 30-pound grab samples from test pits. Some exposures of aggregate were photographed. The field sites are indicated in Figure 6.

As indicated in Figure 6, some parcels were not inspected. These parcels occur in areas that now consist of open pit mines, contain commercial or residential development, or are covered by mining stockpiles. A few parcels in the northern part, for example, were not inspected due to their remoteness, poor accessibility, their low potential for containing sizeable aggregate deposits, and time constraints.

Laboratory testing:

Ten samples of natural sand and gravel and one sample of lean natural ore were washed and sieved according to MnDOT protocol for gradation analysis. Six of the samples and the

Figure 6. Map of field sites (small circles with dots) associated with natural aggregate exploration. The light gray areas represent public lands. The black outlines represent mine pits.

sample of lean natural ore were collected from stockpiles associated with and near the Embarrass Mine (sections 5 and 6, T. 58N, R. 15W).

Digitizing:
Stockpile footprints, and most of the infrastructure (roads, railroads, loading pockets) were digitized on the computer screen using ArcView software and an air-photo backdrop. The air photo (actually a mosaic of many photos) was taken in April 2001 and shows exceptional detail. This photo was taken after mining stopped and therefore accurately shows the current landscape except where subsequent reclamation has occurred. The wide haul roads were digitized at a scale of 1:5000. Narrower roads and the stockpile footprints were digitized at a scale of 1:2500, and the rail lines were digitized at 1:1500.

Database
Data were entered into an Access database. The database structure used was developed for a previous DNR project that inventoried mine stockpiles near Virginia and Calumet, Minnesota (DNR, 2001). The database from the current project, while containing the same structure, is separate from the earlier one.

Data were entered into six database tables. They were 1) stockpile, 2) mined/piled stockpile material, 3) observation, 4) stockpile photo location, 5) x, y coordinates, and 6) test results—sieve. Portions of the first five tables are reproduced in Appendices D through I.

Individual sample sites are identified as 3-digit waypoints. Stockpiles associated with the former LTV mine are assigned the 4-digit number used by the company and the DNR. Stockpiles outside the mine are given sequential 3-digit numbers starting with 100. Sample or observation sites not associated with a stockpile were assigned a stockpile ID value of 99 so that they could be included in the database.

Results

The results of this project include this report, one Plate that indicates current infrastructure, and one plate that shows the locations of and kinds of stockpiles, sample sites, photo sites, ownership, and infrastructure. Also included are digital photos, a database, and buckets of rock samples reserved for inspection.

Overburden and Rock stockpiles

Nearly 200 sample sites were documented in the mining areas. Table 1 lists the *major stockpile classifications* as well as *potential alternative uses*. The *major stockpile classifications* were determined by the mining company during mining, and are based on the iron content. These are the accepted terms used by former mining personnel and the DNR Engineering Unit. The *potential uses* listed apply to the majority of stockpiles of each type. They may not apply to every stockpile in a given category. Rocks within the waste rock stockpiles, for example, often vary from stockpile to stockpile and within the stockpile.

Table 1. Major classes of stockpile materials at the former LTV Mine and possible aggregate or landscaping products.

Major Stockpile Classification	Percent Magnetic Iron by Weight	Potential Uses
Lean Taconite	10-19%	Crushed aggregate, ballast, decorative stone, rip rap
Waste Rock	Less than 10%	Some crushed aggregate, ballast, decorative stone, flagstone
Lean Ore (from Natural Iron Ore Mines)	Unknown	Fill if it is subsequently covered
Taconite (from Natural Iron Ore Mines)	Unknown	Possible crushed aggregate, decorative stone
Overburden (both Natural Iron Ore Mines and former LTV Mine)	None	Sand and gravel, fill

The Biwabik Iron Formation in this area is hundreds of feet thick and consists of thick, alternating rock layers of variable iron content. The different layers that did not meet the cut off for ore grade were classified and stockpiled for iron mining purposes. During the life of the LTV mine, layers with about 19% or more by weight magnetic iron are considered ore and processed to make iron ore pellets. Layers containing 10 to 19% magnetic iron are considered "lean taconite" and stockpiled separately for future processing as technology or economics improve. Rock containing less than 10% magnetic iron is considered "waste rock". The stockpiles are segregated solely on their magnetic iron content. As a result, a waste rock stockpile may have a variety of rock types. The lean taconite stockpiles are quite a bit more uniform, but also may have subtle variations of rock types.

Some of the rock stockpiles have potential for decorative stone due to their interesting patterns and colors. There were four primary categories of rock based on their color and banding character. They are:

1. Gray with subtle color bands
2. Brownish gray
3. Gray and brown bands
4. Mixed assortment of pale green, reddish purple, brown with thin bedded light brown laminations, and gray rocks

Table 2 summarizes the aggregate and other potential uses of each stockpile inventoried.

Table 2. Summary of the aggregate and landscape potential of the mine stockpiles inventoried. Material type refers to Table 1. Color category refers to the four color categories listed above.

Stockpile #	Material Type	Aggregate Potential	Other Uses	Color Category	COMMENT
101	Overburden	Gravel	No	Nap	
102	Overburden	Gravel	No	Nap	
103	Overburden	Gravel	No	Nap	
104	Overburden	Gravel	No	Nap	
105	Overburden	Gravel	No	Nap	
105	Overburden	Gravel	No	Nap	
106	Overburden	Gravel	No	Nap	
106	Overburden	No	No	Nap	
107	Overburden	No	No	Nap	
108	Overburden	No	No	Nap	
109	Overburden	No	No	Nap	
110	Lean Ore	No	No	Nap	Lean Ore #3 (Natural Ore)
111	Taconite	Crushable?	Boulders, decorative	3	Taconite #4 (Natural Ore)
112	Lean Ore	No	No	Nap	Lean Ore #3A (Natural Ore)
113	Taconite	No	Boulders, decorative	3	Taconite #6 (Natural Ore)
114	Taconite	Crushable?	Boulders	2	Taconite #4A (Natural Ore)
1016	Waste Rock	No	Boulders	3	
1019	Waste Rock	No	No	2	Used for crushing, fissile slate
1020	Waste Rock	No	Boulders, decorative	2	
1041	Waste Rock	Crushable	Small rip rap	2	Fissile slate covers part

1044	Waste Rock	Crushable?	Boulders	2, 3	
2004	Overburden	No	Natural boulders	Nap	
2005	Overburden	No	No	Nap	
2005	Overburden	No	No	Nap	
2012	Waste Rock	Crushable?	Boulders	2	Some flagstone
2013	Waste Rock	Crushable?	Boulders, decorative	2, 4	Variable laterally
2014	Waste Rock	NM	NM	NM	under water
2021	Lean Tac	No	Decorative?	2	North end
2021	Lean Tac	Crushable?	Decorative?	2	South end
2022	Lean Tac	Crushable	Boulders	2	
2023	Lean Tac	NM	NM	NM	
2025	Lean Tac	No	No	2	
2029	Lean Tac	No	Boulders, decorative	2, 4	Nearly 100% green in places
2031	Lean Tac	Crushable	Boulders, rip rap	1	Hi Phos
2031	Lean Tac	Crushable	Boulders, rip rap	1	Hi Phos
2040	Lean Tac	Crushable	Boulders, decorative	1	Best choice for crushing?
2050	Lean Tac	Crushable	Boulders, rip rap	1	
2052	Waste Rock	NM	NM	NM	under water
2061	Lean Tac	NM	NM	NM	Partly beneath 2050
2062	Lean Tac	Crushable?	Boulders, decorative	3	
2064	Lean Tac	Crushable	Boulders, decorative	3	Hi Phos
2065	Lean Tac	Crushable	Boulders, rip rap	2	Numerous large boulders
5021	Waste Rock	No	Flagstone	2	Good flagstone site
7003	Lean Tac	Crushable	Boulders	2, 3, 4	
7006	Waste Rock	Crushable	Boulders, decorative	4	
7007	Lean Tac	Crushable	Boulders, rip rap	4	Used for crushing
7008	Waste Rock	Crushable	Boulders, decorative	4	
7010	Lean Tac	Crushable	Boulders, decorative	3	
7022	Lean Tac	Crushable	Boulders, rip rap	1	
7095	Waste Rock	NM	NM	NM	
7096	Waste Rock	NM	NM	NM	Small pad for structure
7097	Waste Rock	NM	NM	NM	Mostly used up for crushing
7099	Waste Rock	NM	NM	NM	Small new stockpile
7494	Waste Rock	Crushable	Boulders, decorative	4	
7694	Waste Rock	No	Boulders, decorative	4	
9006	Overburden	No	No	Nap	
9051	Lean Tac	Crushable	Boulders	1, 2	
9054	Waste Rock	NM	NM	NM	under water
9601	Waste Rock	Crushable	Decorative	4	

Nap = Not applicable to overburden stockpiles
NM = Not measured

Natural aggregate
More than 100 sample sites were documented. Natural aggregate was found at 77 locations as indicated in Figure 3 of Plate 2. The US Forest Service property (southeast part of evaluation area) contains mostly bedrock.

Laboratory results

Table 3 gives the gradation results for the aggregate samples. Three of the four samples from the natural aggregate deposits meet MnDOT's guide for class 5. The fourth is relatively clean (not many fines), consists mostly of coarse-grained granite, and therefore may be a good candidate for bituminous or concrete use. Note: the class 5 limits are provided as a point of reference to a familiar gravel product (Class 5). Specific projects may require aggregate meeting a different gradation or even more than one.

Examination of the washed fine fraction (minus #4 mesh, about 1/4 inch and smaller) revealed that most of the grains were angular or slightly rounded (subrounded). The dominant and secondary rock types are white to pink granite and fine-grained dark gray metagraywacke or metavolcanics, respectively. None or minor amounts of iron oxides and argillite, which are deleterious materials, were found in the samples from the natural deposits, especially those north of the mine pits.

Gradations for seven natural aggregate samples collected from overburden stockpiles indicate that five of the seven samples may be acceptable for class 5 (Table 3). The other two samples, numbers 81 and 82, were from stockpile # 106. Sample 82 was nearly 100% sand,

Table 3. Gradation results for each aggregate sample tested. Complete results are in Appendix C. The sieve sizes get smaller moving to the right in the table. The values below each sieve size are the percent, by weight, of the total sample that falls through (passes) that sieve. The cutoff we use for the gravel fraction is material larger than the #10 sieve (2 millimeters). For example, for sample # 70, 33% of the sample, by weight, was smaller (passed through) the #10 sieve. Stated another way, this sample has an average of 67% gravel (100-33=67). The two columns on the right show the percent of material retained (bigger) than the respective sieves.

Sample #	Stockpile ID # Type	Weight Percent of Material ***Passing*** Respective Sieve 1"	3/4"	3/8"	#4	#10	#40	#200	Weight Percent ***Retained*** on Respective Sieve crushable +3/4"	gravel +#10
70	110 Lean ore	78	70	54	40	33	21	10.0	30	67
276	Natural	73	69	60	46	34	6	0.8	31	66
278	Natural	65	62	55	46	36	20	5.5	38	64
81	106 Overburden	91	88	82	75	67	50	25.7	12	33
82	106 Overburden	99	98	98	97	97	84	27.0	2	3
83	106 Overburden	85	82	76	67	57	23	4.3	18	43
100	103 Overburden	77	71	58	48	40	23	6.9	29	60
104	102 Overburden	69	63	51	40	29	12	4.1	37	71
125	Natural	67	63	55	49	42	17	4.7	37	58
128	104 Overburden	77	75	66	60	53	32	10.1	25	47
135	Natural	97	92	79	68	60	19	3.1	8	40
Class 5 upper limits		100	100	90	80	65	35	10	0	35
Class 5 lower limits		100	90	50	35	20	10	3	10	80

Note: The class 5 limits are provided to provide a point of reference to a familiar gravel product (Class 5). Specific projects may require aggregate meeting a different gradation or even more than one.

with most of it being fine sand and silt. The other had substantial amounts of granular material, but it also had a very high percentage of fines. These fines were mostly silt rather than clay.

In the Embarrass pit area, the fine fraction of most of the samples appeared to have some argillite. Only two samples had noticeable iron oxides, which are deleterious for aggregate purposes. The sample from the lean ore pile contained significant iron oxides and broken rock fragments. Very high quantities of argillite, another deleterious material, occur in gravelly borrow sites in the vicinity of Hoyt Lakes' water tower and several other places south of the mine pits.

Glacial Boulders

The glacial material (till) covering the evaluation area is part of the Vermillion Moraine phase of the Rainy Lobe glacier (Hobbs and Goebel, 1982). This till contains boulders and is known to contain numerous boulders in some areas. Fourteen sample sites with 'concentrated' accumulations of boulders occurring at the surface are noted in Plate 2. Most

Figure 7. Abundant natural boulders visible after recent logging. Note person in top-center of figure for scale.

of the boulders consisted of a light-colored granite, with the remainder mostly dark gray in color (Figure 7).

Infrastructure

Plate 1 shows the current infrastructure associated with mining within the evaluation area. There is reasonable access to at least a portion of every stockpile. Figure 8 shows the typical access to stockpiles. Note that the roads inside lands controlled by Cliffs Erie are private.

Figure 8. Most stockpiles are accessible to the toe of at least one lift. Often access is available from the top of the lift.

Rail lines are intact with tracks leading eastward to Taconite Harbor, MN via Cliffs Erie's private railroad. Duluth Missabe and Iron Range (DM&IR) rail lines lead southeasterly and westerly from the former LTV Mine to Duluth, MN and Eveleth, MN area, respectively (see Figure 2 in Plate 1). Figures 9 and 10 show rail loading facilities and rail cars available at the former LTV Mine site.

Figure 9. Mechanized loading pocket used to load rock onto rail cars.

Figure 10. Side dump rail cars owned by Cliffs Erie.

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