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UNITED STATES
DEPARTMENT OF AGRICULTURE
FOREST SERVICE

MINERAL POTENTIAL REPORT

For the

RAINY RIVER WITHDRAWAL

Superior National Forest
St. Louis, Lake, and Cook Counties, Minnesota

LANDS INVOLVED:
Approximately 225,504 acres in portions of
Townships 57–63 North, Ranges 5–13, 15–17 West; 5th Principal Meridian, Minnesota
(*see Attachment 1 for detailed lands description*)

Prepared By:

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Summary

The United States Forest Service submitted an application requesting that the Secretary of the Interior withdraw approximately 225,504 acres of National Forest System lands within the Superior National Forest, Minnesota (see map 1) from disposition under the mineral and geothermal leasing laws for 20 years, subject to valid existing rights. The October 21, 2021, Notice of Application for Withdrawal (86 Fed. Reg. 58,299) published in the Federal Register, which initiated a 2-year segregation of the subject lands from disposition under the mineral and geothermal leasing laws, subject to valid existing rights. The 2-year period is intended to allow for consideration of the withdrawal application by the Secretary of the Interior in accordance with section 204 of the Federal Land Policy and Management Act and the BLM's withdrawal regulations at 43 C.F.R. Part 2300.

This mineral potential report was prepared to assess the mineral occurrence and development potential of the subject lands included in the Rainy River withdrawal application area.

Conclusions

The purpose of the withdrawal application is to advance a comprehensive approach to protect and preserve the fragile and vital social and natural resources, ecological integrity, and wilderness values in the Rainy River watershed and the Boundary Waters Canoe Area Wilderness in northeastern Minnesota. In Minnesota, the United States Forest Service has the authority, under a unique set of leasing laws, to decide whether exploration and development of hard-rock mineral resources is appropriate land use. However, the withdrawal application identifies a need to advance a comprehensive approach in protecting the Rainy River watershed and wilderness values of the Boundary Waters Canoe Area Wilderness from potential effects from mining, rather than on a case-by-case basis.

Within the withdrawal application area, there are approximately 67,663 acres (30 percent) with high potential for the occurrence of leasable copper, nickel, cobalt, and platinum-group metals.[1] Considered a world-class deposit, and one of the largest undeveloped copper-nickel and platinum-group metal deposits in the world, geologic formations of the Midcontinent Rift Duluth Complex, such as the South Kawishiwi Intrusion, have seen 70 years of study generating mine development proposals as recently as 2019. These formations may potentially contain vast economic quantities of copper, nickel, cobalt, and platinum-group metals. Refer to the Minerals Economics section (Table 7, Figures 7 and 8) for more information on potential economic significance.

Numerous gold prospects have also been identified within the greenstone belt of the Wawa subprovince within the withdrawal application area. Based on available data, occurrence potential within this approximately 1,218-acre (0.5 percent) area is considered high for gold, copper, zinc, and iron-ore. Though no economic discoveries have been made in Minnesota, the area may be geologically analogous to the Hemlo mining district in Ontario, Canada, which has multiple gold mines that have been operational for decades.

The remaining 157,881 acres (70 percent) within the withdrawal application area have mineral occurrence potential that varies from low to high depending on commodity, but all non-South Kawishiwi Intrusion

[1] U.S. Geological Survey publications refer to platinum, palladium, rhodium, ruthenium, iridium, and osmium as platinum-group elements. These are chemical elements with similar properties and tend to occur together in nature. All six elements are transition metals on the periodic table and are often referred to as platinum-group metals.

related mineralization occurring on subject lands is considered low potential for mineral development. Refer to the “Potential for the Occurrence of Mineral Resources” section for more detailed discussion, which includes rationale for determining the potential for mineral deposits occurring in the withdrawal application area and a series of mineral occurrence potential maps (map 7 through map 11).

If the requested withdrawal were to be approved by the Secretary of the Interior, federal mineral interests within the area would become unavailable to new exploration and development through Bureau of Land Management leasing actions (that is, prospecting permits and preference right mineral leases) for up to 20 years. Any new applications submitted to the Bureau of Land Management for prospecting permits or preference right mineral leases would be denied.

Salable mineral resource (sand, gravel, and dimension stone) availability would not be impacted by the withdrawal as the relevant salable mineral authorities were not included in the Forest Service’s withdrawal application to the Secretary of the Interior.

Introduction

Purpose and Scope

This mineral potential report has been prepared in support of the Forest Service's application to withdraw lands from disposition under the United States mineral and geothermal leasing laws,[2] subject to valid existing rights, for a 20-year period. This report examines the mineral occurrence and development potential of the withdrawal application area located within the Rainy River watershed (or subwatersheds), which drains into the Boundary Waters Canoe Area Wilderness. The potential for mineral resources is a prediction of the likelihood of the occurrence of these resources. The occurrences of a mineral resource do not necessarily imply that the mineral can be economically exploited or is likely to be developed; mineral occurrence potential includes both exploitable and potentially exploitable occurrences. The potential for the occurrence of a mineral resource also does not imply that the quality and quantity of the resource is known. The lands included in the withdrawal application, which contain a total of 225,504 acres of federal fee title ownership, are situated in St. Louis, Lake, and Cook Counties across the La Croix, Kawishiwi, Laurentian, and Tofte Districts of the Superior National Forest, northeastern Minnesota (see map 1).

The 2004 Record of Decision for the Superior National Forest Land Resource Management Plan (Forest Plan) established management direction for the Boundary Waters Canoe Area Wilderness. The Forest Service manages this wilderness and its various uses and activities to be compatible with wilderness character. In concert with the Wilderness Act of 1964 and the Boundary Waters Canoe Area Wilderness Act of 1978, the Forest Plan management direction for the Boundary Waters Canoe Area Wilderness provides (SNF 2004):

- Protection of watershed upon which many cities and rural communities depend for pure water
- Critical habitat for wildlife threatened by extinction
- Maintain gene pools to provide a diversity of plant and animal life
- Serve as a unique irreplaceable "living laboratory" for medical and scientific research
- Protection for geologic resources
- Serve as a haven of solitude and freedom from the pressures of our fast-paced, industrialized society
- A unique repository for cultural resources

To protect the Rainy River watershed and Boundary Waters Canoe Area Wilderness (see map 1) from potential adverse environmental impacts arising from mining within adjacent non-wilderness lands, and to meet wilderness management direction, the Superior National Forest recommended the subject lands be withdrawn from disposition under the mineral and geothermal leasing laws for 20 years, subject to valid existing rights. The Forest Service Eastern Region submitted the application for withdrawal to the Bureau of Land Management on September 28, 2021. The BLM accepted the application and published a Notice of Application for Withdrawal and Segregation of Federal Lands[3] in the Federal Register on October 21, 2021. Publication of that notice temporarily segregated the lands from disposition under the geothermal and leasing laws for a period of 2 years while the Superior National Forest prepares the reports and analysis that the BLM will use to prepare the case file that will inform the Secretary of the Interior's decision. Copies of the application for withdrawal and the Federal Register Notice can be found within

[2] The relevant mineral leasing laws in the withdrawal area are the Act of June 30, 1950 (codified at 16 U.S.C. 508b), the Mineral Resources on Weeks Lands Act of March 4, 1917 (codified at 16 U.S.C. 520), and Section 402 of the President's Reorganization Plan No. 3 of 1946, 5 U.S.C. appendix, 60 Stat. 1097, 1099-1100.
[3] "Notice of Application for Withdrawal and Segregation of Federal Lands; Cook, Lake, and Saint Louis Counties, Minnesota, 86 Fed. Reg. 58, 299." (Oct. 21, 2021).

the withdrawal case file. Under the withdrawal application, new exploration and development of federally owned leasable minerals within fee title lands would be prohibited. The withdrawal application does not affect Superior National Forest authority for the disposition of salable minerals.

This report is based on publicly accessible geologic literature and maps published by federal and state governments, universities, and private individuals and summarized. The opinions and conclusions in this report are based on this review, Bureau of Land Management and Forest Service records, and the author's 21 years of experience managing minerals and geologic resources within the Superior National Forest. No field work was involved in the research. This report should not be used for any purpose other than that for which it is intended.

Lands Involved

The subject lands are located in portions of Townships 57–63 North, Ranges 5–13 West; 5th Principle Meridian; St. Louis, Lake, and Cook Counties, Minnesota and contain approximately 225,504 acres in aggregate. For a complete list of lands included in the withdrawal application, see "Attachment 1 – Land List for the Rainy River Withdrawal."

The withdrawal application lands were selected based on surface water flow direction. The U.S. Geological Survey has divided and subdivided the United States into successively smaller hydrologic units nested within each other, from the largest geographic area to the smallest geographic area. The hydrologic unit code level 8 watershed delineations for the Rainy Headwaters catchment were used to establish the withdrawal application area boundary of lands tributary to the Boundary Waters Canoe Area Wilderness. The withdrawal application boundary, as shown on map 1, was developed to the nearest Public Land Survey System section (640 acre) parcel resolution. Lands selected for application included all federal surface and subsurface rights (wholly owned or fee title) including parcels with a mineral reservation that will expire during the 20-year withdrawal period. Any parcels that straddled the watershed divide boundary (hydrologic unit code 4) were included as whole 40-acre parcels; the withdrawal application boundary follows the exterior of the parcel. As a result, portions of some parcels have been included in the withdrawal application area that do not have a surface water connection to the Boundary Waters Canoe Area Wilderness. Streams either flow to the Lake Superior watershed or bypass the wilderness area and flow directly into Crane Lake and Voyageurs National Park. In areas where the watershed divide is located outside the exterior boundary of the Superior National Forest, the withdrawal application boundary is clipped to the national forest boundary.

Land Status Record Data

Forest Service Land Status records indicate that all surface and subsurface estates for the withdrawal application lands are owned in fee simple title by the federal government and parcels with mineral reservations that will expire within the 20-year withdrawal period. The area encompassing the withdrawal application boundary, including all ownerships, is approximately 570,008 acres.[4] Subject lands total 225,504 acres[5] consisting of approximately 198,479 acres (88 percent) public domain lands and 27,065 acres (12 percent) acquired lands (see map 1). Acquired parcels have been acquired under a variety of authorities including the Week's Act of March 1, 1911 (36 Stat. 961), Clarke-McNary Act of June 7, 1924 (43 Stat. 653), and The Department of Agriculture Organic Act of August 3, 1956 (P.L. 84-979); all acquisitions are subject to Week's Act Status under the authority of the Act of September 2, 1958 (P.L. 85-862). Public Domain lands were designated as National Forest System lands in Presidential Proclamations 848 (1909), 1215 (1912), 2213 (1936), and 1800 (1927). On October 21, 2021, the Federal Register

[4] Total acreage within project boundary is calculated from National Forest System Geographic Information System (GIS) geospatial databases and may differ from actual surveyed acres.
[5] Acreage derived from Superior National Forest Land Status Atlas and Tabular Record.

notice segregated these subject lands for a period of 2 years from disposition under the geothermal and mineral leasing laws, subject to valid existing rights. For all withdrawal application lands, surface management is administered by the Forest Service with mineral estate management administered by the Bureau of Land Management.

Existing Withdrawals

Directly north and adjacent to the withdrawal application area, the Boundary Waters Canoe Area Wilderness and mining protection area were withdrawn from mineral leasing, permitting, or other authorization in 1978 through the Boundary Waters Canoe Area Wilderness Act (P.L. 95-495) (map 1). The purpose of the legislation is to protect the wilderness character of the unique landscape. The total area withdrawn is approximately 1.3 million acres, with the Boundary Waters Canoe Area Wilderness comprising 1.1 million acres and the mining protection area totaling 227,000 acres.

A Secretarial order dated July 29, 1910, established Power Site Reserve No. 148, withdrawing 3,578 acres for water-power sites along the "Birch River and Tributaries" within the national forest.

Lands Status on National Forest System Lands in Minnesota

Minnesota has a unique combination of authorities making federally owned hard-rock mineral resources within National Forest System lands subject to disposition under a leasing system managed by the Bureau of Land Management. Land status is paramount in identifying the specific roles and responsibilities of the Forest Service in the administration of these resources. A brief description of applicable authorities is provided below.

Public Domain Lands on National Forests in Minnesota

In Minnesota, on National Forest System lands reserved from the public domain, deposits of federal hard-rock minerals are subject to disposal under the Act of June 30, 1950 (16 U.S.C. 508b). The Bureau of Land Management has authority under this Act, delegated from the Secretary of the Interior, to permit the prospecting, development, and utilization of federal hard-rock minerals on National Forest System lands in Minnesota. However, this Act also provides that the consent of the Secretary of Agriculture, delegated to the Forest Service, must be given to the Bureau of Land Management before such development and utilization is permitted.

Acquired Lands

The Weeks Act of March 1, 1911 (36 Stat. 961) authorized the federal government to purchase lands for stream-flow protection, and to maintain the acquired lands as national forests. The Mineral Resources on Weeks Lands Act of March 4, 1917 (16 U.S.C. 520) gave the Secretary of Agriculture the authority to permit the prospecting, development, and utilization of the mineral resources of the lands acquired under the Weeks Act of March 11, 1911, upon such terms and for specified periods or otherwise, as he may deem to be for the best interests of the United States. The authority was then transferred to the Secretary of the Interior pursuant to the Reorganization Plan No. 3, of July 16, 1946 (60 Stat. 1097), which set forth that the Secretary of the Interior may allow mineral development of these lands "only when he is advised by the Secretary of Agriculture that such development will not interfere with the primary purposes for which the land was acquired and only in accordance with such conditions as may be specified by the Secretary of Agriculture in order to protect such purposes." Thus, for prospecting permits and leases containing Weeks Act Lands, the Secretary of Agriculture has consent authority as well as authority to prescribe binding conditions to protect the purposes for which lands were acquired.

Weeks Act Status for Certain Lands

The Act of September 2, 1958 (P.L. 85-862) made all acquired National Forest System lands (past and future) within the exterior boundaries of National Forests subject to the Weeks Act of 1911, and to all other applicable laws, rules, and regulations. Thus, all lands acquired under National Forest System authority (Clark-McNark, General Exchange Act, etc.) are subject to the same legal and regulatory authorities as lands acquired under the Weeks Act itself, including that the agency has consent authority as well as authority to specify conditions to protect the purposes for which the lands were acquired.

Implementing Regulations at 43 C.F.R. 3500

The Bureau of Land Management's regulations "Leasing of Solid Minerals Other Than Coal and Oil Shale," at 43 C.F.R. Part 3500, implement the leasing of solid minerals from Section 402 of the Reorganization Plan No. 3 of 1946, the Mineral Resources on Weeks Act Lands of 1917, and the Act of June 30, 1950. These regulations detail the process and regulatory framework for issuing prospecting permits and leases. The regulations also specify that the Bureau of Land Management must obtain consent from the surface managing agency prior to issuance of permits or leases. Inherent with the consent decision is the ability for the surface managing agency to prescribe conditions for protecting resources on those lands.

Bureau of Land Management regulations Minerals (Other Than Coal) Exploration and Mining Operations – General, found at 43 C.F.R. Part 3590, are designed to promote orderly and efficient mineral exploration, development, processing and production operations without waste or avoidable loss of mineral resources; to promote operating practices which will avoid, minimize, or correct damage to the environment; and to avoid, minimize or correct hazards to public health and safety. The regulations also outline roles and responsibilities of surface managing agencies (for example, the Superior National Forest) in the management and administration of leasable mineral operations.

Federal Mineral Leasing and Permits

The Superior National Forest completed a Federal Hardrock Mineral Prospecting Permits Environmental Impact Statement in May, 2012 which analyzed the effects of granting consent to the Bureau of Land Management for the approval of 29 prospecting permit applications and the resultant exploration activities anticipated if the permits were to be approved. The Superior National Forest signed the Record of Decision on May 5, 2012 granting consent to the Bureau of Land Management for the issuance of 28 of these permits. Superior National Forest consent included permit stipulations for the protection and mitigations of impacts to resources affected by exploration activities authorized under the permits. At the time of segregation on October 21, 2021, all but 13 of these permits had been relinquished or had expired. The remaining 13 permits (MNES054387, MNES054050, MNES054194, MNES054195, MNES054196, MNES053731, MNES055301, MNES055302, MNES055305, MNES053868, MNES054037, MNES055203, and MNES055206) were remanded following settlement in Ctr. for Biological Diversity et al. v. Leverette et al., No. 1:20-cv-02132-DLF (D.D.C), and await environmental analysis and a new Bureau of Land Management decision on the permittees' 2014 application for extension.

Two hardrock mineral leases were also held within the withdrawal application area (leases MNES 1352 and MNES 1353) along and near the western boundary of the Duluth Complex. Originally issued to INCO Alloys International, Inc. in 1966, the leases were eventually transferred to Franconia Minerals Corp. (a wholly owned subsidiary of Twin Metals Minnesota, LLC). However, on January 26, 2022, the Department of the Interior canceled leases MNES 1352 and MNES 1353 as improperly renewed. Mineral resources identified on all former and current mineral authorizations indicate that copper, nickel, and "associated minerals" (for example, platinum-group metals or cobalt) were the commodities of interest.

The Bureau of Land Management has recently received a prospecting permit application, MNES057276, outside the withdrawal application area . No other Bureau of Land Management leasable mineral or geothermal authorizations occur in the withdrawal application area other than those hard-rock mineral authorizations described above.

Physiography

Minnesota is centrally located within the North American continent and positioned at the boundary of the Laurentian Upland and the Interior Lowland physiographic provinces. These provinces are low-lying and relatively featureless in comparison to other, more geologically active areas of the continent. Major tectonic activity has not occurred in the last 1,000 million years across the state (Ojakangas and Matsch 1982).

West of Lake Superior, the topography rises to an elevation of about 1,600 to 1,900 feet above sea level. There are numerous ridges exceeding 2,000 feet along the north shore of Lake Superior, the result of differential erosion within formations of the North Shore Volcanic Group. The highest point in Minnesota is found in this area at Eagle Mountain, with an elevation of 2,301 feet above sea level inside the Boundary Waters Canoe Area Wilderness. (Heinselman 1996).

The Superior National Forest is separated by a major continental divide. West of the divide, Quetico Provincial Park, Voyageurs National Park, and much of the Superior National Forest, drain to Hudson Bay watershed via the Rainy and Nelson Rivers. East of the watershed divide drains to Lake Superior by way of the St. Louis River and shore-land streams to Lake Superior.

During the last couple million years, several advances and retreats of glaciers have created a landscape of shallow soils, well-exposed bedrock, and scattered glacial land-form features across the withdrawal application area.

Geologic Setting

For the purposes of this report, the geologic features are considered in four major groups, or geologic terranes. The first three, from oldest to youngest are the volcanic, intrusive, and sedimentary rocks of the Wawa Subprovince; the highly metamorphosed sedimentary and granitic rocks of the Quetico Subprovince; and the volcanic and intrusive rocks of the Midcontinent Rift (table 1). The Superior National Forest, including the withdrawal application area, straddles portions of these major geologic terranes. The fourth terrane, the Animikie Group, composed of metamorphosed sedimentary rocks, occurs as a relatively small "wedge" within the withdrawal application area (map 2 and map 3). Since this terrane constitutes a very small percentage of the area and does not contain subject lands, detailed discussion of this group is limited within this report. Surficial, glacially derived features of the Quaternery Period are also discussed as separate geologic features.

Table 1. Geologic terranes[1] within the withdrawal application area, by acreage and percentage

Area[2]	Wawa Subprovince	Quetico Subprovince	Midcontinent Rift
Total area of terrane within application area	115,714 acres (20%)	14,669 acres (2.6%)	438,240 acres (77%)
Area of subject lands within terrane of the application area	21,201 acres (9.4%)	2,030 acres (0.9%)	202,989 acres (90%)

1. See the "Geologic Setting" section and map 3 through map 5 for description of geologic terranes and National Forest System lands found within each. Percentages are from subject lands.

2. Withdrawal application lands acreage calculated from geographic information systems (GIS) data (see map 1) and may have minor deviations from the acres listed in Superior National Forest's Land Status Atlas. The Land Status Atlas and Tabular record are the sources for application land list legal descriptions and official acreages listed in the application.

Minnesota contains some of the oldest rocks on Earth, dating to 3.6 billion years ago. Though geologically inactive today, Minnesota's geologic history includes the accretion of island arcs and microcontinents, periods of mountain building, crustal rifting, transgression of shallow seas, deposition, erosion, and glaciation. The Geologic Map of Minnesota Precambrian Bedrock Geology (Jirsa et al. 2012) divides the state into several areas, or geologic subprovinces, based on lithology, structure, geophysical and other characteristics. Subprovinces that make up a portion of the larger Archean Superior Province of the Canadian Shield include the Wawa-Abitibi, Wabigoon, Quetico, and the Minnesota River Valley (map 2). These terranes are all similar due to accretion processes during their formation yet differ in the supracrustal and plutonic rocks they contain (Klenner et al. 2012).

The Wabigoon and Wawa-Abitibi subprovinces include alternating sequences of greenstone belts and metamorphosed sedimentary rock that range from 100 to 900 kilometers wide east to west through Minnesota, Ontario, and Manitoba. (Henry et al. 1998; Morey and Sims 1976). These structures were intruded by granitic plutons which metamorphosed the country rock to varying degrees. These subprovinces are approximately 2.7 billion years in age and are composed of approximately two-thirds plutonic and one-third supracrustal rocks, including the greenstone belts which are unconformably overlain by alluvial and fluvial sediments (Card 1990; Klenner et al. 2012).

Card (1990) described the Quetico subprovince as a metasedimentary belt with granitoid intrusions, constrained on the north by the Wabigoon and the Wawa-Abitibi to the south, forming an accretionary prism accreted onto the Wabigoon and later compressed by the Wawa. Although considered separate terranes, the Quetico, Wawa, and Wabigoon subprovinces are structurally similar due to the tectonic events which created them approximately 2.7 billion years ago (Card 1990; Klenner et al. 2012). Roughly three-fourths of the Quetico is composed of plutonic and gneissic rocks with one-fourth consisting of low-to-medium grade supracrustal rocks (Card 1990; Klenner et al. 2012). The metasedimentary rocks grade from greenschist facies at the margins to amphibolite facies near the center (Perry et al, 2006).

Beginning approximately 1.1 billion years ago, the Midcontinent Rift developed when mafic magma rose to the surface causing a crustal-scale rifting event in the heart of the North American continent. Rocks of the Midcontinent Rift can be traced from surface exposure and gravity anomalies beginning in the south from Kansas, into Minnesota, and through Lake Superior, and extending to the lower peninsula of Michigan (figure 1). Several sequences of layered intrusive mafic rocks created the Duluth Complex. This arcuate series of layered intrusions can be traced almost 200 miles from the northeastern-most border of Minnesota, west and south through the heart of the area known as the Arrowhead, to Duluth. Co-genetic extrusive bimodal (mafic and felsic) rocks also formed basalts in the sea floor and covered the land with lava flows creating the North Shore Volcanic group adjacent to Lake Superior (Holm et al. 2007).

Little remains of Phanerozoic-aged rocks in Minnesota due to erosion. Paleozoic sedimentary rocks such as sandstones, limestones, and shales, were deposited during a series of six sea transgressions, and can only be found in the southeast and northwestern portions of the state (Mossler 2008). During the Jurassic and Cretaceous periods, progression of seas deposited sediments in northwestern and western Minnesota. Following erosion during the Tertiary, an extensive period of glaciation between 1.8 million years and 10 thousand years ago was the major land-forming event. Four major glacial advances occurred which deposited till and created abundant geomorphological features, the source of Minnesota's nickname, "Land of 10,000 Lakes" (Klenner et al. 2012).

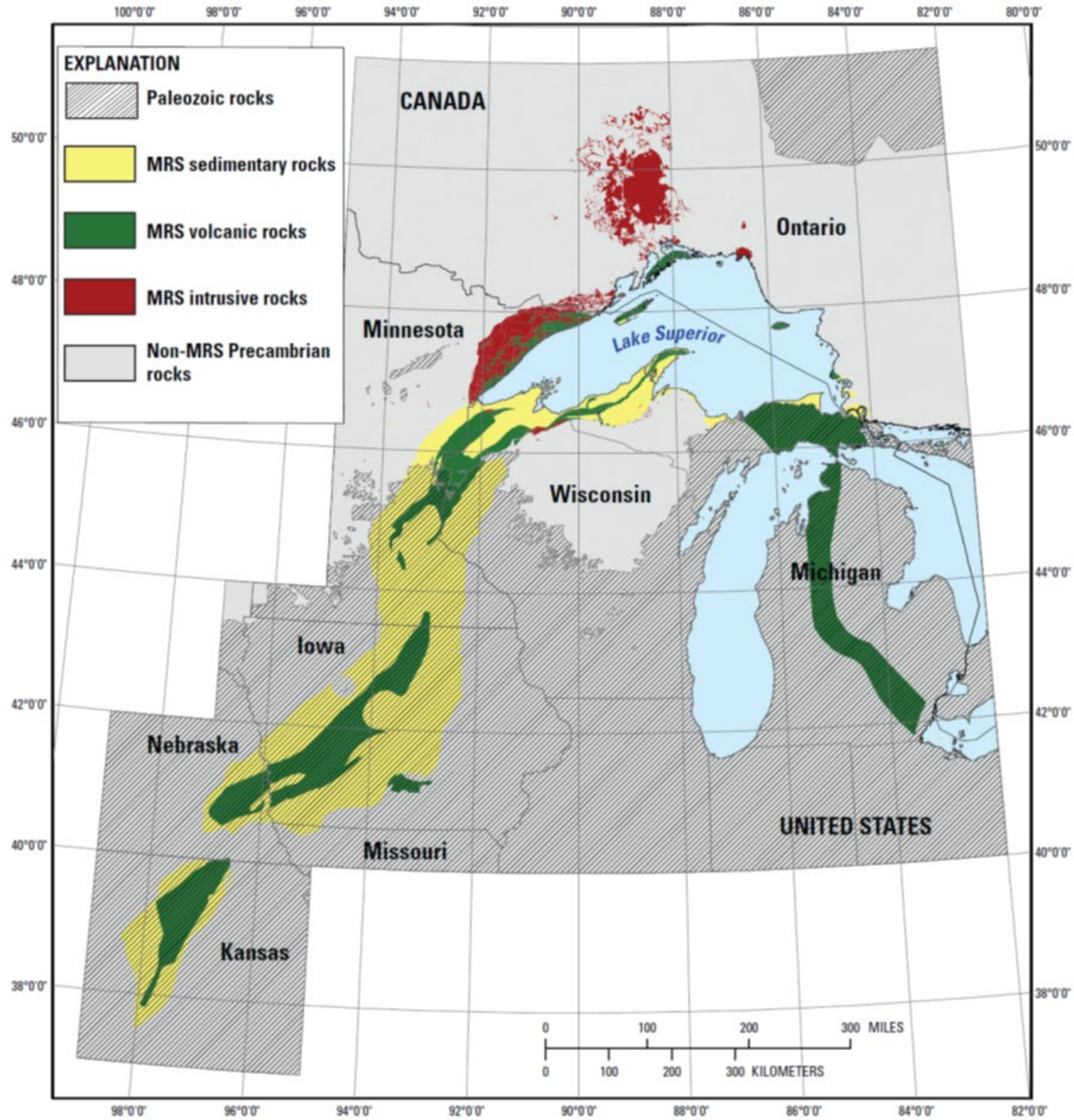

Figure 1. Map showing the extent of Midcontinent Rift (depicted as MRS on map) rocks through the central United States (Woodruff et al. 2020).

Regional Geology

Wawa Subprovince

Rocks of the Wawa subprovince consist of volcanic-dominated stratigraphic sequences which are structurally and stratigraphically separated into two "belts": (1) the southern Soudan belt and (2) the northern Newton belt, collectively known as Vermilion Greenstone Belt (Peterson and Patelke 2003). These belts, or "structural panels" are separated by the informally named Leach Lake structural discontinuity (Jirsa et al. 1992, Peterson and Petelke 2003).

In the withdrawal application area (see figure 2 and figure 3), the Leach Lake structural discontinuity occurs along the Burntside Lake fault Mud Creek shear zone and small segments of the Vermilion, Shagawa Lake, and Wolf Lake faults (as defined by Sims and Southwick 1985; Miller et al. 2002). Peterson and Patelke (2003) described the Soudan belt as containing large, broad folds involving calc-alkalic and tholeiitic volcanic strata overlain by, and locally interdigitated with, turbiditic rocks. In contrast, the Newton belt was described as consisting of elongate, northeast-trending, and mostly northward-younging volcanic and volcaniclastic sequences. Volcanic rocks of the Newton belt differ from those of the Soudan belt; the Newton belt contains locally abundant komatiitic flows and peridotitic sills. The two belts are fault-bounded, and the relationship between stratigraphic units within each belt is largely conformable. Intrusive rocks in both belts vary from gabbroic and felsic porphyries evidently related to volcanism, to large plutons emplaced post-tectonically. Both belts contain unconformable, Timiskaming-type sequences composed of calc-alkalic volcanic rocks, conglomerates, and finer grained sedimentary rocks (Peterson and Patelke 2003).

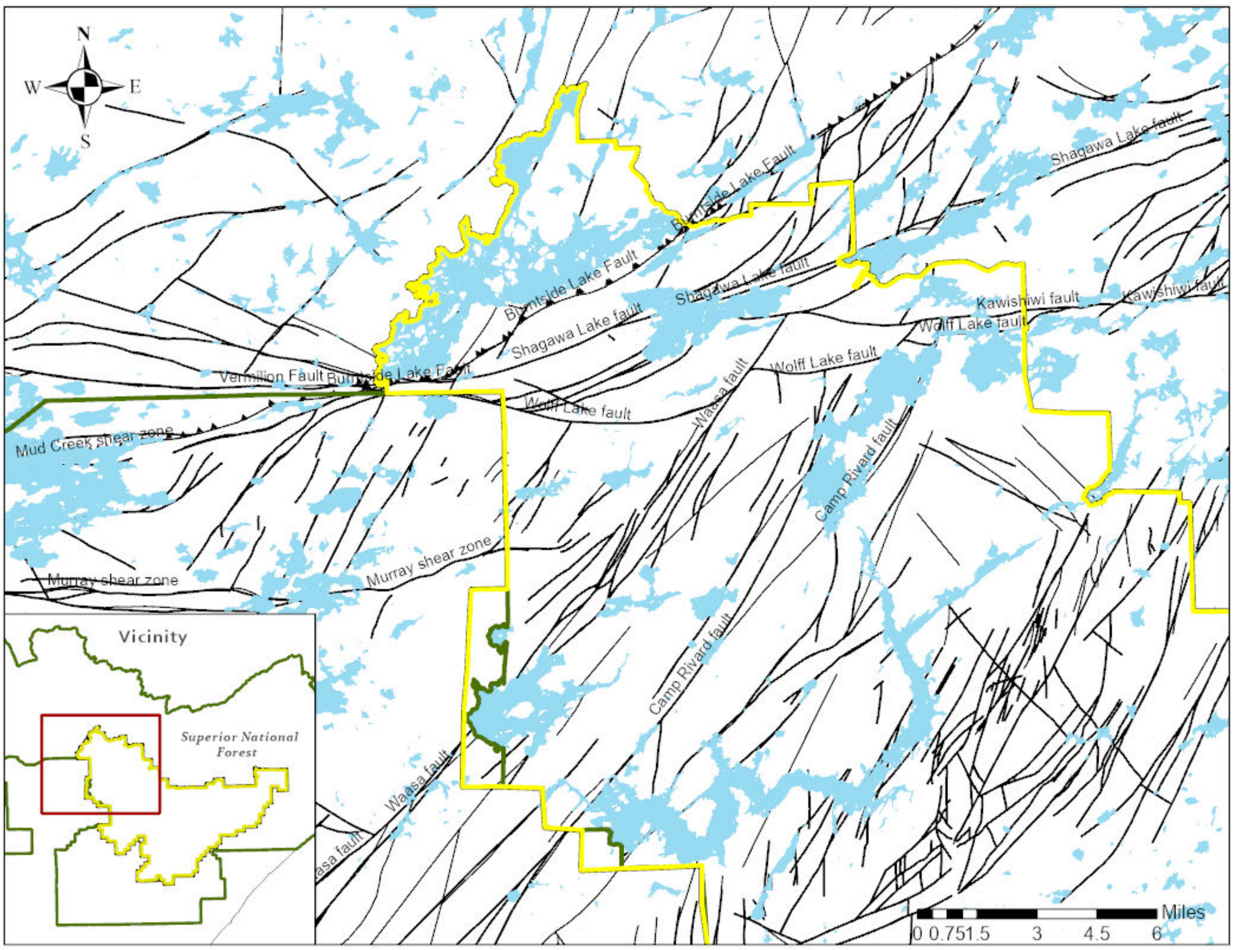

Figure 2. Simplified structural geologic map of the north-central portion of withdrawal application area showing the western extent of the Leach Lake structural discontinuity along the Mud Creek shear zone (Jirsa et al. 2012; Jirsa 2016). Yellow line shows the withdrawal application boundary.

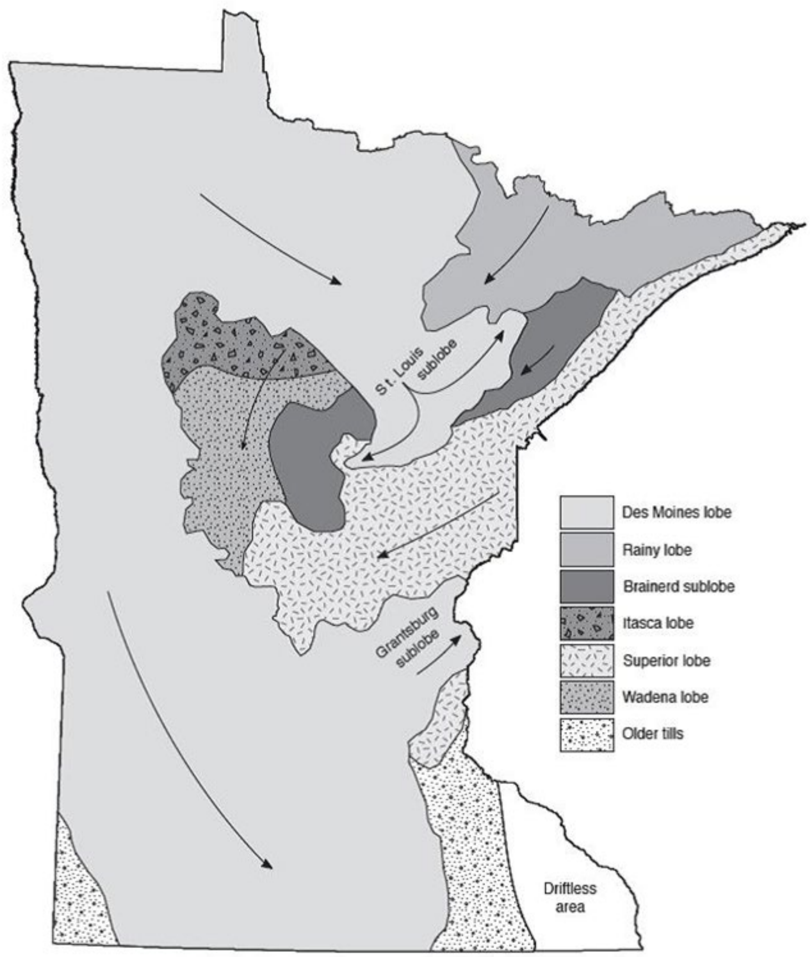

Figure 3. Simplified map showing the extent and flow directions of ice lodes that covered Minnesota during the Ice Age (Lusardi 1994).

Quetico Subprovince

Jirsa and Southwick (2003) described the Quetico subprovince as the former sedimentary basin situated between the Wabigoon and Wawa micro-continents and filled with mostly turbidites. When the Wawa and Wabigoon accreted to each other, the Quetico area was compressed and deformed, and its rocks metamorphosed into metasedimentary schist that extends some 600 miles across Ontario and parts of Minnesota. The rock assemblage consists of various migmatitic rocks derived primarily from sedimentary protoliths, and granitoid intrusions (Jirsa and Southwick 2003). The metamorphism is relatively low-grade on the margins and high-grade toward the center. The low-grade components of the greywackes were derived primarily from volcanic rocks; the high-grade rocks are coarser-grained and contain minerals that reflect higher temperatures. The granitic intrusions within the high-grade metasediments were produced by subduction of the ocean crust and partial melting of metasedimentary rocks. Immediately south of Voyageurs National Park and extending to the Vermilion fault is a broad transition zone that contains migmatite (LaBerge 1994).

The Vermilion Granitic Complex, which is the dominant feature of the terrane within the withdrawal application area, forms the western extension of the Quetico. The Complex grades northward into a broad belt of metagraywacke which has been metamorphosed to biotite schist and is truncated by the Rainy Lake-Seine River fault. The southern contact of the complex is defined by the Vermilion fault, which separated it from the metavolcanic and metasedimentary rocks of the Vermilion district. The complex consists of batholithic intrusions of the massive Lac La Croix Granite (Day and Weiblen 1986).

Midcontinent Rift System

The Midcontinent Rift System developed in response to crustal-scale tectonic extension resulting from a mantle plume approximately 1.1 billion years ago. The western arm of the rift extends southwestward from Lake Superior (where rift-fill rocks are moderately well exposed) to the subsurface of the Twin Cities metropolitan area, and from there to the subsurface of northeastern Kansas. The fill associated with rift development consists mainly of tholeiitic basalt that erupted under subaerial conditions, together with petrologically related sills, dikes, and large layered intrusions that cooled beneath or within the cogenetic volcanic pile. The largest of the layered intrusions is the Duluth Complex, a composite intrusion of troctolite and gabbro derived from periodic tapping of an evolving magma source. During the final stages of rifting, the principal rock types deposited in the rift shifted gradually from magmatic to sedimentary; among the sedimentary sequences are those for which alluvial-fan, fluvial braid-plain, aeolian, and lacustrine depositional environments may be inferred (Jirsa and Southwick 2003).

Quaternary Geology

Beginning approximately 75,000 years ago, the Wisconsin glaciation in Minnesota was dominated by four lobes of the Laurentide Ice sheet in Canada. Over the course of about 65,000 years, these lobes advanced and retreated multiple times (Krippner 2011). Repeated glaciations during the Pleistocene epoch greatly modified the topography of northeastern Minnesota, (for example, surface rocks were scoured and eroded by glacial ice, and new surficial materials were deposited) following the retreat of the ice sheet. During the Late Pleistocene (Late-Wisconsin glaciation), approximately 14 to 12 thousand years ago, the Rainy Lobe of the Laurentide Ice Sheet retreated, depositing sandy till which contained basalt, gabbro, granite, red sandstone, iron formation, slate, and greenstone (Ojakangas and Matsch 1982).

Also, during the late Wisconsin Age, the Superior lobe advanced out of the Lake Superior basin, covering southern and eastern portions of the Superior National Forest with distinct red till containing rocks derived from the Superior Basin and Northshore Volcanics (Ojakangas and Matsch 1982).

Multiple geomorphic land types associated with these glacial advances and retreats can be found within the Superior National Forest and withdrawal application area. Ground moraines, end and terminal moraines, sinuous eskers, glacial outwash plains, and kames provide sources of aggregate across the Forest.

Site Geology

Wawa Subprovince

Neo-Archean lithostratigraphic units found within the Vermilion District of the withdrawal application area are described below with their corresponding stratigraphic position shown in table 2 and depicted in figure 4. Unit descriptions (extracted from Miller et al. 2002) follow.

Late intrusions: Intrusions generally fall into one of three compositional types: syenitic, monzodioritic, and granitic (Boerboom 1994).

Giants Range Batholith: The Giants Range batholith trends east-northeast, is 8 to 40 kilometers wide and approximately 241 kilometers long. This batholith is a composite intrusion containing granite, monzonite, granodiorite, monzodiorite, and gneissic equivalents. Dikes and irregular pods of aplite, and more rarely granite pegmatite, cut major intrusive units. The Giants Range batholith intrudes supracrustal rocks of the Wawa subprovince and forms part of the footwall to the Animikie Group and Duluth Complex.

Newton Lake Formation: This formation is divided into two members: a mafic member, and a felsic to intermediate member (Moret et al. 1970). The mafic member consists mainly of pillowed and massive basalt flows, iron-rich basaltic komatiite flows, and compositionally layered sills of mafic to ultramafic composition (Green and Schultz 1977). The felsic member consists largely of dacitic flows, breccia, tuff-brecca, and tuff with minor amounts of graywacke and siliceous marble. Volcanic textures indicate that the felsic member formed in a shallow, subaqueous setting.

Knife Lake Group: Rock types include greywacke, slate, conglomerate, tuffaceous sandstone, basalt and andesite flows, and intrusions of gabbro and felsic porphyry. Major east-northeast trending shear zones occur throughout the area and have produced well-foliated phyllitic and phyllonitic rocks.

Lake Vermilion Formation: The formation, positioned statigraphically above and interdigitated with the rocks assigned to the Ely Greenstone is a thick sequence of dacitic volcanoclastic rocks and turbiditic greywacke-slate.

Upper member Ely Greenstone: This member consists predominantly of tholeiitic pillowed basalt that overlies the Soudan Iron Formation along much of its strike length. Numerous, thin, iron-formation horizons occur throughout, along with synvolcanic mafic intrusions and carbonaceous fine-grained sediments. In addition, the Upper Ely interfingers with and overlies the Gafvert Lake sequence and underlies and locally interfingers with the Lake Vermilion Formation.

Soudan Iron Formation: This formation consists of laminated Algoma-type magnetite-chert iron-formation, interbedded with basalt flows and fragmental rocks of basaltic to dacitic composition. Thin dikes and sills of quartz-feldspar porphyry are common. In general, the basal contact of the Soudan Iron Formation member is gradational with the top part of the Lower Ely, with a general increase in iron-formation beds as the top of the lower member is approached.

Lower member Ely Greenstone: The Lower Ely consists dominantly of large, shield-like sequences of pillowed and massive basalt and andesite flows of calc-alkalic and locally tholeiitic composition. Rare zones of chert-magnetite iron-formation also occur.

Table 2. Lithostratigraphic unit: Late Archean intrusive rocks within the Late Archean rocks within the withdrawal application area

Late Archean intrusive rocks	Description
Late intrusions	Plutons and stocks of syenite, monzonite, diorite, and lamprophyre
Giants Range batholith	Granite, granodiorite, monzodiorite, schist-rich migmatite

Source: Extracted from Miller et al. 2002.

Table 3. Lithostratigraphic unit: Late Archean supracrustal and hypabyssal intrusive rocks within the Late Archean rocks within the withdrawal application area

Late Archean supracrustal and hypabyssal intrusive rocks	Description
Newton belt: Newton Lake Formation	Komatiitic and tholeiitic lava flows and intrusions, clastic strata
Soudan belt: Knife Lake Group	Graywacke, slate, conglomerate, tuff, and sheared equivalents
Soudan belt: Lake Vermilion Formation	Graywacke, slate, dacitic tuff, and minor conglomerate
Soudan belt: Upper member Ely Greenstone	Tholeiitic basalt flows and iron-formation
Soudan Iron Formation member: Ely Greenstone	Layered cherty iron-formation and tuff
Soudan Iron Formation member: Lower member Ely Greenstone	Calc-alkalic and tholeiitic flows and volcaniclastic strata

Source: Extracted from Miller et al. 2002.

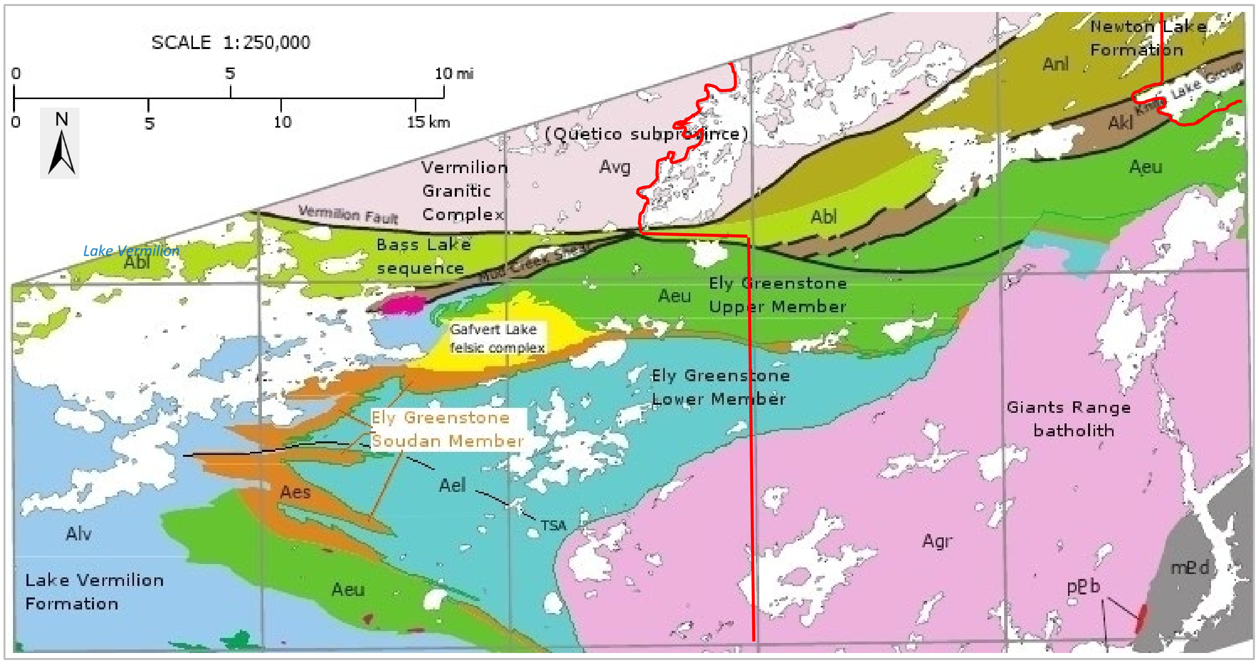

Figure 4. Simplified geologic map of the western Vermilion District showing lithostratigraphic units of the Soudan belt (units Ael, Aes, Aeu, Alv, and Akl) and Newton belt (units Abl and Anl). (Modified from Peterson and Jirsa 1999, and Severson 2011). Red line shows withdrawal application area boundary.

Quetico Subprovince

Within the withdrawal application area, the Quetico Subprovince is composed of biotite-plagioclase schist, granitoid intrusions, and migmatite. The schist was derived from greywacke deposited in an accretionary prism during the collision of the Wawa subprovince island arc in the south. This was followed by multiple episodes of intrusion, migmatization, metamorphism, and deformation (Jirsa et al. 2012). Unit descriptions and associated map 3 units (extracted from Jirsa et al. 2012) follow.

Lac LaCroix Granite (unit Aql): Pink biotite granite that is variably magnetic and locally pegmatitic.

Granite-rich migmatite (unit Aqg): Contains nesome of variable magnetic biotite granite similar to the Lac La Croix Granite, and paleosome of tonalite to granodiorite gneiss and schist.

Migmatite: dominated by tonalitic to granodioritic neosome.

Biotite schist (unit Aqs) of greywacke protolith, and schist-rich migmatite.

Amphibolitic schist and gneiss (unit Aqa) – both intrusive and extrusive protoliths likely.

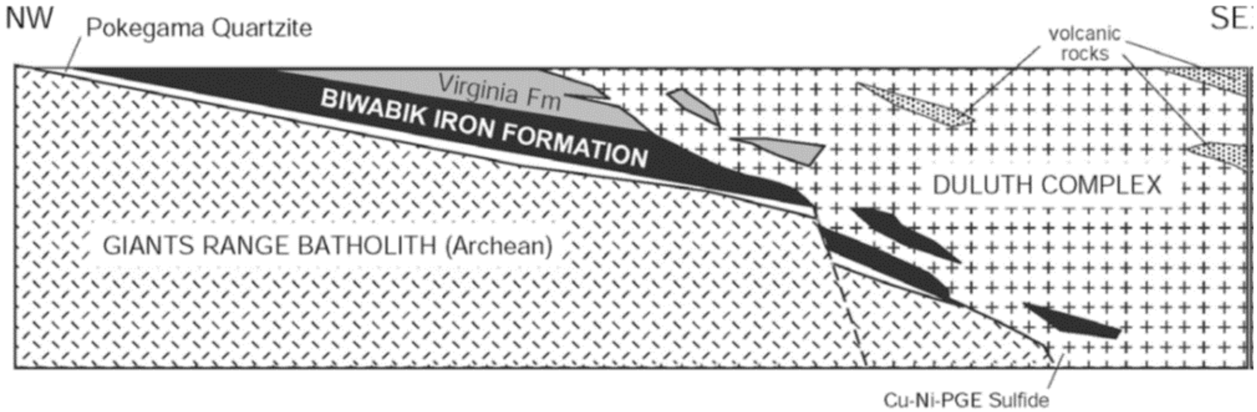

Figure 5. Schematic geologic section showing the basal contact of the Duluth Complex against older host rocks including the Biwabik Iron Formation and capped by volcanic rocks of the North Shore Volcanic Group (Jirsa et al. 2008).

Mesoproterozoic – Duluth Complex of the Midcontinent Rift

The Duluth Complex is defined as the more or less continuous mass of mafic to felsic plutonic rocks that extend for more than 170 miles (275 kilometers) in an arcuate fashion from Duluth nearly to Grand Portage, Minnesota. The complex is comprised of multiple discrete intrusions of mafic to felsic magmas that were episodically emplaced into the base of a comagmatic volcanic edifice between 1,108 and 1,098 million years ago (Miller et al. 2002, Miller et al. 2010). It is the second largest gabbro complex in the world behind the Bushveld Complex in South Africa (Miller et al. 2010). The structure associated with the western boundary of the Duluth Complex is bathtub-shaped, eventually planing out at about 1.5 miles subsurface. The structural shape may be the result of tectonic extension forming half-grabens during the initial continental rift formation. Or it may have resulted from tectonic tilting and compression as a result of the closing of the failed arm of the continental rift.

The lithology of the Duluth Complex includes many types of igneous rocks that formed when hot magma moved toward the surface of the Earth and cooled prior to reaching the surface. Several layered troctolite intrusions exist within the Duluth Complex including the Bald Eagle Intrusion, the Partridge River Intrusion, the South Kawishiwi Intrusion, the Tuscarora Intrusion and the Wilder Lake Intrusion (Miller et al. 2002). The footwall of the Duluth Complex is the Archean Giants Range Batholith and is composed of multiple intrusions of monzonite, monzodiorite, diorite, and granodiorite, with localized gneissic equivalents. The contact of the Giants Range Batholith with the Duluth Complex exhibits areas of contact metamorphism, including partial melting and metasomatism (Miller et al. 2002).

The Duluth Complex is divided into four general rock series, distinguished on the basis of age, dominant lithology, internal structure and structural position (figure 6; Miller et al. 2002).

Felsic series – Massive granophyric granite and smaller amounts of intermediate rock that occur as a semi-continuous mass of intrusions strung along the eastern and central roof zone of the complex and emplaced during early-stage magmatism.

Early gabbro series – Layered sequences of dominantly gabbroic cumulates that occur along the northeastern contact of the Duluth Complex, emplaced during early-stage magmatism.

Anorthositic series – A structurally complex suite of foliated, but rarely layered, plagioclase-rich gabbroic cumulates emplaced throughout the complex during main stage magmatism.

Layered series – A suite of stratiform troctolitic intrusions that comprises at least 11 variably differentiated mafic layered intrusions which occur mostly along the base of the Duluth Complex. These intrusions were emplaced shortly after the Anorthositic series.

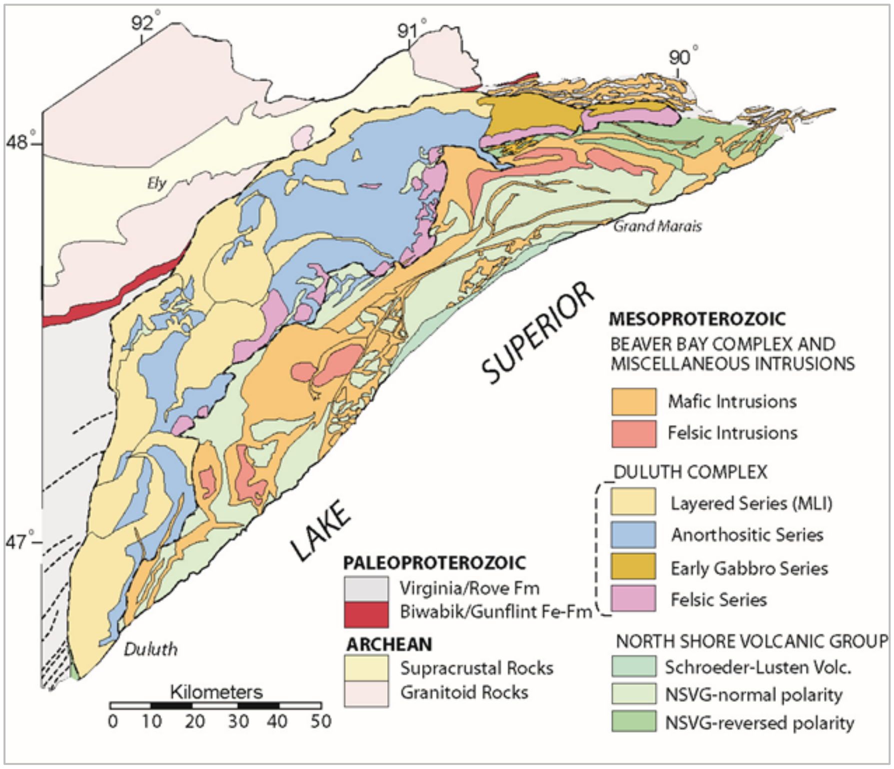

Figure 6. Diagrammatic map of the Duluth Complex and North Shore Volcanic Group (Midcontinent Rift related igneous rocks; Miller et al. 2002).

Further discussion of the Duluth Complex will focus on the rocks associated with the South Kawishiwi Intrusion contained in the Duluth Complex (unit Mlt on map 3). The South Kawishiwi Intrusion, as part of the layered series, was chosen for this discussion because it contains the basal copper, nickel, gold, and platinum-group elements common in the troctolite deposits in the Duluth Complex, as well as the abundance of core samples that have been analyzed. Other intrusions found within Duluth Complex are not discussed in detail as they are largely unexplored and not as well understood, or they are located outside the withdrawal application area.

Miller et al. (2002) summarize five major map units of the South Kawishiwi Intrusion. These are, from the base upward:

1. A basal contact zone that is heterogeneous mix of sulfide-bearing mafic rock (troctolite, gabbro, norite);
2. A thick unit of augite troctolite that contains an internal olivine gabbro unit;
3. A discontinuous and localized layer of leucotroctolite;
4. A thick, homogeneous sequence of troctolite;
5. An uppermost, thick sequence of homogeneous troctolite that contains lensoidal layers and inclusions of anorthositic rocks.

The South Kawishiwi Intrusion is not a single intrusion but a series of discrete intrusive events from the same magma source. Base mineralogy of the intrusive rock includes calcium plagioclase, olivine, and minor pyroxene. Troctolites worldwide commonly contain many additional minerals, especially metals such as copper, and nickel. It is also common for intrusions to contain platinum, palladium, gold, rhodium, ruthenium, iridium, osmium, selenium, and rhenium elements known as platinum-group metals. During the formation of the South Kawishiwi Intrusion, partial melting and mixing with the adjacent banded metasedimentary Biwabik Iron Formation (figure 4) occurred, providing the source for the additional metallic minerals present in the South Kawishiwi Intrusion. The Virginia Formation also contains a pyrrhotite-rich basal member which is a likely source of sulfur that effectively scavenged and concentrated metals from the intrusive body.

Description of Energy and Mineral Resources

Minerals and energy resources are classified into three categories in accordance with Forest Service regulations at 36 CFR Part 228 and will be discussed separately below. These three categories are:

1. Locatable (base metals [copper, lead, zinc], precious metals [gold, silver, platinum], and nonmetallic minerals [mica, gypsum, gemstones]);
6. Leasable (oil and gas, coal, phosphate, geothermal, hardrock minerals within acquired lands, and in Minnesota all hardrock metallic minerals);
7. Salable (common varieties of sand, gravel, clay, and stone).

Locatable Minerals

Locatable minerals are minerals for which statutory rights exists allowing a person to enter onto federal lands open to mineral entry to stake, or "locate," a mining claim, as granted under the General Mining Law of 1872, as amended. Minnesota is unique in the management of federal minerals within the National Forest System. The Act of February 18, 1873 (17 Stat. 465) excepted the states of Michigan, Wisconsin, and Minnesota from the General Mining Law of 1872; that is, the General Mining Law of 1872 does not apply in these three states. This difference in legal status means that locatable minerals, and therefore mining claims, do not occur on national forests in Minnesota.[6]

Leasable Minerals

Leasable mineral and energy resources are commodities that have been excluded from location under the 1872 Mining Law. Leasable commodities have been defined through subsequent legislation, including the Mineral Leasing Act of 1920 and the Geothermal Steam Act of 1970, which authorized the leasing of public lands for a fee. These commodities include coal, oil, gas, phosphate, potash, sulphur, potassium, sodium, and geothermal steam. In addition, hard-rock minerals are subject to leasing on acquired National Forest System lands and lands reserved from the public domain within national forests in Minnesota, as discussed in the land status section of this report. Leasable mineral disposal is regulated on National Forest System lands in Minnesota by the Code of Federal Regulations at 43 CFR Part 3500.

Salable Materials

Salable minerals, also known as mineral materials, have been excluded from location under the 1872 Mining Law by laws such as the Mineral Materials Act of 1947, as amended. These Acts authorized the federal government to sell and dispose of mineral materials through a contract of sale or a free use permit. Salable minerals include materials like ordinary sand, dimension stone, gravel, pumice, pumicite, cinders, clay, and petrified wood. The disposal of these mineral commodities is regulated on National Forest

[6] Because the General Mining Law of 1872 does not apply within the withdrawal application area, there are no mining claims located therein.

System lands by 36 CFR 228 Subpart C and is a discretionary agency action. The withdrawal application does not include salable minerals and would not affect Forest Service discretion to dispose of salable minerals.

Superior National Forest geospatial records indicate 94 Forest Service managed salable (mineral material) sources are located within the withdrawal application boundary; 92 sand and gravel pits and 2 dimension stone quarries. Of the total, 63 mineral material sources consisting of 61 aggregate sources and 2 dimension stone quarries are located on subject lands. See map 6 for distribution of mineral material sources within the withdrawal application area. Forest Service Natural Resource Manager mineral materials database, accessed on March 7, 2022, indicates 34 mineral material permits (including free use, in-service, and contracts) have been issued within subject lands at 22 sites over the last 5 years (2017 to 2021). Of these, 32 permits were issued for sand and gravel totaling 28,456 tons of material, and 2 contracts for dimension stone totaling 51,609 tons of stone. The number of permits issued, and the volume of material disposed of varies by year and location, largely dependent on public demand.

Types of Mineral Deposits Within the Withdrawal Application Area

The following U.S. Geological Survey mineral deposit models are applicable within the withdrawal application area boundary.

Wawa Subprovince:

- Archean Low-Sulfide Au-Quartz Veins: Descriptive model for gold-quartz vein deposits in Archean greenstone belts (Klein and Day 1994).
- Volcanogenic Massive Sulfide: Volcanogenic Massive Sulfide deposits that form at or near the seafloor from circulating hydrothermal fluids driven by magmatic heat. These deposits are important sources of copper, zinc, lead, gold, and silver (Shanks and Thurston 2012).
- Algoma-Type Iron Formation: Precipitation of iron-rich material forming chemical sedimentary rocks. Commonly found in island-arc and submarine environments (Du Bray 1995).

Quetico Subprovince:

- Archean Low-Sulfide Au-Quartz Veins (Klein and Day 1994)
- Lithium-Cesium-Tantalum Pegmatites: Pegmatites – large mineral crystals found in metamorphosed supracrustal granitic rocks – that account for about one-fourth of the world's lithium production, most of the tantalum production, and all the cesium production (Bradley et al. 2017).

Midcontinent Rift Terrane:

- Magmatic Cu-Ni-PGE ore Deposits in Layered Intrusions: Reef-Type PGE and Contact-Type Cu-Ni-PGE: Layered ultramafic and mafic intrusions that contain "reef" or layered rock mineralized with platinum-group elements (PGE) or PGE-enriched mineralization found near contact or margins of layered mafic to ultramafic intrusions (Zientek 2012).
- Magmatic Sulfide-Rich Nickel-Copper Deposits related to Picrite and (or) Tholeiitic Basalt Dike-Sill complexes: Mafic to ultramafic dikes and sills related to picrate and tholeiitic basalt magmatic systems that contain copper, nickel, and platinum-group elements related to sulfide minerals (Schulz et al. 2010).

Known Mineral Deposits

The U.S. Geological Survey (2017) defines a mineral deposit as a mineral concentration of sufficient size and grade that it might, under the most favorable of circumstances, be considered to have potential for economic development. They further define economic as profitable extraction or production under defined investment assumptions that have been established, analytically demonstrated, or assumed with reasonable certainty.

Wawa Subprovince - Archean Greenstone Belt

As described in the "Production History" section of this report, historically, mining has occurred near Soudan and Ely, Minnesota within Algoma-Type iron formations within the Soudan Iron Formation and Upper Ely Greenstone, respectively.

Thin bands of iron formation are present on subject lands in the north-central portion of the withdrawal application area, south of Ely, Minnesota. Stratigraphically overlying the volcanic rocks of the Lower Ely is the Soudan Iron Formation, which consists dominantly of laminated Algoma-Type iron-formation, with lesser basalt flows and detrital rocks of basaltic to dacitic composition. In general, the exhalative nature of many of the rocks of the Soudan Iron Formation (unit Aif on map 3 represent deep-water chemical deposition throughout a period of quiescence, which began during the latest stages of volcanism associated with the Lower Member of the Ely Greenstone. The stratigraphic thickness of the Soudan Iron Formation varies from 50 to 3,000 meters, and averages approximately 700 meters (Peterson and Patelke 2003).

Quetico Subprovince

Available literature does not identify known mineral deposits within the Quetico subprovince.

Midcontinent Rift – Duluth Complex

Mineralogical studies on core samples extracted throughout the Duluth Complex have defined the Duluth Complex as potentially the largest undeveloped copper-nickel deposit in the world (Miller et al. 2010). There are two intrusions along the western margin of the Duluth Complex that are the focus of economic development: the Partridge River Intrusion and the aforementioned South Kawishiwi Intrusion. These intrusions contain at least 11 occurrences of mineralization and are currently being studied and evaluated for economic copper-nickel-iron sulfide deposits with associated platinum-group metals. Located outside the withdrawal application area, the Partridge River Intrusion hosts the NorthMet, Dunka Road, Babbitt, and Mesaba deposits. Known copper-nickel, and platinum-group metal mineralized areas found within the South Kawishiwi Intrusion, which include subject lands, are listed below (from north to south; see map 4):

- Spruce Road Deposit
- Filson Creek Deposit
- Maturi Deposit (including Maturi Extension and Maturi Southwest portions)
- Birch Lake Deposit

The South Kawishiwi Intrusion is dominantly composed of troctolitic cumulates that are exposed in an arcuate band between 8 and 32 kilometers wide. Copper-nickel mineralization consists largely of disseminated sulfides. Footwall rocks include the Virginia Formation in the south, the Biwabik Iron Formation in the Birch Lake deposit area, and the Archean Giants Range batholith in the northern section. The presence of Biwabik Iron Formation as inclusions as far north as the Spruce Road deposit indicates that the majority of Paleoproterozoic units were assimilated and removed from the footwall during emplacement of the South Kawishiwi Intrusion, leaving the Giants Range batholith as the dominant footwall rock type (Miller et al. 2002). These deposits are all located within the basal contact zone between the western margin of the Duluth Complex and Paleoproterozoic and Archean rocks.

Production History

Iron Ore

Soudan Mine

The Vermilion District of the greenstone belt has a long history in iron ore mining. Interest in the geology of the Vermilion District began around 1860, initially for gold around the Lake Vermilion region. The first occurrence of iron ore was referenced by Thomas Clark in 1865. In 1882, the Soudan Mine opened on the southeastern shore of Lake Vermilion. By 1884, a railroad was completed between Duluth and Two Harbors where a load-out dock had been completed. The initial shipment totaled 62,122 tons of iron-ore (Severson 2011; Schwartz 1948). In 1882, the operation went underground mining high-grade hematite ore, containing as much as 65 percent iron, used to make steel in open-hearth furnaces. The underground mine operated for over a century and closed in 1962 when taconite mining on the Mesabi Range took over. When the mine closed, level 27 was being developed at 2,341 feet below the surface with over 50 miles of drifts, adits, and raises (National Historic Landmarks of Minnesota). A total of about 14 million metric tons of ore were removed from Soudan (Ojakangas and Matsch 1982).

Though the Soudan Mine is located outside the withdrawal application area (map 4), the operation extracted ore from the Soudan Iron Formation, which can be found in thin bands within the withdrawal application boundaries.

Ely Mines

Iron ore was initially discovered in Ely, Minnesota on August 1, 1884, which eventually lead to the Chandler, Pioneer, Zenith, Sibley, and Savory mines. Numerous smaller iron-ore prospects were established in the Western Vermilion District during the 1890s and were worked intermittently until the 1920s (Severson 2011). The five mines operated on what proved to be an essentially continuous ore body by both open-pit and mostly underground mining methods. The Chandler mine opened in 1888, the Pioneer Mine in 1889, the Savory Mine in 1889, the Zenith Mine in 1892, and the Sibley Mine in 1899. The last active mine, the Pioneer Mine, closed in 1967. These mines produced over 96,598,000 tons of ore (Ely Mines – It All Began With Mining 2018).

The mines that operated in the Ely area are located within the withdrawal application area (map 4), though none of these historic iron mines are located on lands included in the withdrawal application.

Mineral Exploration and Development Work

Gold Exploration – Greenstone Belts of the Wawa Subprovince

Mining for gold or volcanic massive sulfides in the greenstone belts within the withdrawal application area has not occurred, although favorable lithological and alteration mineral associations are present. To date, no economic discoveries have been established.

Sporadic exploration for lode-gold and massive sulfide deposits has occurred within the Minnesota Archean greenstones since the 1860s, with no economic deposits discovered (Peterson 2001). Overall, the history of gold exploration in Minnesota may be summarized as very brief periods of activity that resulted in the Vermilion Gold Rush of 1865 to 1867; the Rainy Lake Gold Rush of 1893 to 1895; the Raspberry Prospect explorations (west of Ely) around 1900; and, more recently, a brief and intense campaign in the 1980s and 1990s following the discovery of the Hemlo gold deposit in Ontario. There were at least 24 major gold exploration areas which were explored by a multitude of companies from 1981 through 1995. These companies drilled 182 holes and dug 60 trenches at 23 of the prospects. As exploration advanced it became apparent that most of the gold prospects in the western Vermilion District were associated with a host of rock types in close proximity to major shear zones (for example, the Mud Creek Shear zone west and adjacent to the withdrawal application area, the Shagawa Shear zone, the Vermilion Fault, and the Burntside Lake fault). These areas reside within the withdrawal area, while other similar areas within the District are outside the withdrawal area boundary (Severson 2011).

Summarized below from Severson (2011) is past exploration and development work conducted within the withdrawal application area. Though they occur within similar geologic settings, none occur on subject lands (see map 4).

Raspberry Prospect

The Raspberry Prospect represents a gold property that was explored more intensively, and for the longest period, than any other gold property in the entire state of Minnesota. First discovered in 1889, several companies were involved with exploring the site. In total, at least 61 holes were drilled, along with several test pits and shallow test shafts constructed. The highest gold assay for the entire property is 35,600 parts per billion gold at 112 to 114 feet below the surface. Generally, the gold occurs within zones of sericite and iron-carbonate alteration associated with quartz veins. It is generally believed a large gold deposit is unlikely to be present at the prospect.

Burntside River

This site was explored by U.S. Steel and Kerr McGee in the early to mid-1980s where four holes were drilled. Several samples collected were found to contain anomalous arsenic values (up to 800 parts per million), but assay results were disapointing for gold (10 to 50 parts per billion). A few isolated intervals were identified in subsequent relogging of the core with gold values barely greater than 100 parts per billion; however, a maximum of 7,000 parts per billion gold was encountered. No further work has been performed at the site.

Quartz Hill

Believed to be related to the same mineralizing event as at the nearby Raspberry Prospect, most exploration of this site took place during 1984 to 1986. Seven shallow trenches and three holes were drilled based on anomalous gold values found in soil samples, rock, and panned till. This drilling campaign failed to intesect encouraging gold mineralization (maximun of 1,135 parts per billion gold). A recent study by Hudak et al. (2002) delineated semi-massive to massive sulfide mineralization that is indicitive of either a shallow-water Archean “Mattabi-type” Volcanogenic Massive Sulfide system or a shallow subaqueous high-sulfidation epithermal system.

Garden Lake Showing

Four samples were taken in 1982 from a 40-foot long road cut of an iron-formation on the south side of the Fernberg Trail, averaging greater than 2,000 parts per billion gold, with a maximum of 5,180 parts per billion gold. Eight channel samples were also collected in 1986 that averaged over 1,000 parts per billion gold with a maximum of 2,320 parts per billion gold. Similar work in 1987 showed similar results but no further work was conducted.

Recent work completed by the Minnesota Department of Natural Resources includes geochemical glacial till surveys for gold, zinc, copper, and molybdenum (Reed 2017, Larson 2004), drill core evaluation (Frey and Hanson 2008), and numerous investigations and reports by various organizations (Peterson and Patelke 2003).

Iron Ore – Greenstone Belts (Wawa Subprovince)

The success of finding iron ore and the development of mines at Soudan and Ely further encouraged iron ore prospecting in the western Vermilion District. Many of the gold prospects in the western Vermilion District that were looked at in the latter part of the 20th century were associated with lean iron-formations (Ulland 1999). Many of the iron prospects in the Vermilion District went through extended periods of exploration wherein a company would test the prospect and give up the option (state leases) if results were not satisfactory, only to be succeeded by another company that believed they could find ore where others had failed (Severson 2011).

Though the majority of these historic activities took place west of the withdrawal application area, there are several located within the withdrawal area. Summarized from Severson (2011) below, none of the historic works occur on subject lands but are located within geologic settings commonly found on subject lands within the Archean greenstone belts (Newton and Soudan Belts) of the withdrawal application area (map 4).

Lucky Boy-Anderson-Camp Mines

Starting out as individual prospects, exploration on the Camp Mines started in 1887 followed by the adjoining Anderson property in 1890. Activities included several trenches, test pits, and a 70 feet deep shaft. In all, five shafts were completed but were abandoned by 1925. There are no records of any ore ever being shipped from these sites.

Raspberry Prospect

Several shallow shafts into iron-formation exposures attest to iron ore exploration. This site received several phases of gold exploration activities.

White Iron Lake Mine

The White Iron Lake Company began drilling favorable iron-formation occurrences in 1903. Ore was reportedly found by early 1904 and an exploration shaft was sunk in 1905, reaching a depth of 175 feet by the end of 1907. A second shaft was sunk in 1911 to 1913 to a depth of 67 feet. In 1916, an evaluation of "ore" was found to be exceedingly lean, and all further activities were discontinued.

Romberg Mine

This property was originally established in 1895 and intermittent exploration work continued through 1911. By 1912, a 252-foot shaft and three drifts were reported to be present. There are no records of any additional work conducted, and in 1932 it was reported that no ore was ever shipped from the site.

Section 30 Mine

Discovered in 1885 and adjacent to the Romberg Mine, the Section 30 Mine reportedly shipped almost 1.5 million tons of ore by 1923. Ore was mined from two open pits as well as by underground methods down to the 535 feet level. High shipping costs forced the mine to close in 1932. The site was evaluated for taconite potential in the 1950s, but no records indicate success. Prospecting for gold took place at the site in the 1980s. Some of the core was sampled and assayed for gold by American Shield.

Chippewa Mine

Records indicate that several exploration holes were drilled on the property in 1902 and 1907. A 345 feet deep shaft was sunk in 1917 and served as access to workings that were eventually developed on the 100-foot level, 200-foot level, and 300-foot level. Ore was reportedly stockpiled, but there are no records that any ore was ever shipped. The mine shut down in 1920.

Garden Lake Mine

Little information is known with respect to the Garden Lake area. Geologic maps depict several thin iron-formation horizons in the vicinity. The Garden Lake Company drilled 14 exploration holes and were active around 1958, possibly to evaluate taconite potential. Records do not indicate any further activity at the site.

Copper-Nickel-Platinum-Group Metals of the Duluth Complex (Midcontinent Rift)

Exploration for copper-nickel deposits along the base of the Duluth Complex, near the contact with the Wawa subprovince (see map 4), dates to the late 1940s with the initial discovery of copper-nickel mineralization. Over 2,100 exploration holes have been drilled, totaling well over one million feet of drill core (map 4). Actual total exploration holes depend on how wedge offsets and re-drills are counted. Drilling has defined at least eleven copper-nickel deposits, as well as oxide-bearing ultramafic intrusions that are pod-like bodies that have iron-titanium, vanadium, copper, and nickel potential. At least 22 exploration companies have been involved in drilling along the basal zone of the Duluth Complex (Miller et al. 2002).

Prior to 1980, exploration companies interested in the copper-nickel mineralization recognized potential for precious metals, especially platinum-group metals. In 1985, the Minnesota Department of Natural Resources and University of Minnesota (Minerals Resource Research Center) conducted a geochemical evaluation on an exploration hole at the Birch Lake deposit. Substantial values of combined platinum and palladium were discovered in portions of the hole. It was later discovered that they were associated with high copper contents. These discoveries sparked renewed interest in the copper-nickel deposits of the Duluth Complex as potential polymetallic deposits (Miller et al. 2002).

The copper-nickel and oxide-bearing ultramafic intrusion deposits associated with rocks of the Duluth Complex have had a number of large bulk samples removed for metallurgical testing since the 1950s. There are at least 6 bulk sample sites in the South Kawishiwi Intrusion within the withdrawal application area, and about 14 bulk sample sites in the Partridge River intrusion (southern portion of unit Mlt on map 3) southwest of the withdrawal area. Most of these bulk samples have displayed erratic grades, relative to what had been outlined by prior drilling, which has resulted in difficulty in defining and producing an "average" or "typical" mineral sample (Patelke and Severson 2007). See table 4 and table 5 for a summary of bulk sampling within the Duluth Complex.

Two projects covered by federal mineral leases MNES1352 and MNES1353, located within the withdrawal application area, have received development work in addition to exploration drilling and bulk sampling. In the 1960s and 1970s, INCO did extensive work on the Maturi (MNES1352) and Spruce Road (MNES1353) deposits in the South Kawishiwi Intrusion. This work included drilling, test pits, metallurgical sampling, a 1,095-foot test shaft with a lateral drift at the 1,000-foot level, and mine planning. They applied for open-pit mining at the Spruce Road deposit with the Forest Service on January 7, 1974. This eventually led to Minnesota's "moratorium" on copper-nickel mining while the state completed the "Regional Copper-Nickel Study"[7](Patelke and Severson 2007). By the time this study was published in 1979, copper prices had declined to a point where INCO was no longer interested in pursuing mining at Spruce Road.

[7] In 1974, the Minnesota Environmental Quality Council adopted a resolution requiring a regional study examining environmental, social, and economic impacts of non-ferrous (base metal) mining. This resolution led to the Minnesota Regional Copper-Nickel Study which effectively put a moratorium on copper-nickel mining in the region until the study's completion.

Table 4. General records for major bulk samples and test pits in South Kawishiwi Intrusion (within withdrawal application area) of the Duluth Complex

Project	Responsible Party	Year(s)	Tonnage (Ore)	Comment
Spruce Road (MNES1353)	USBM	3 holes drilled in 1953	None, or unknown	Lab or bench tests on composite from three drill cores.
Spruce Road (MNES1353)	INCO	1966 to 1967	1,150 tons	Source of sample uncertain, test work done uncertain.
Spruce Road (MNES1353)	INCO	1974	10,000 tons	Pit along south side of Spruce Road.
Maturi (MNES1352)	INCO	1968	700 tons(?)	Shaft (1,090 feet deep) and drift at Maturi, sample sent to INCO lab.
Serpentine (Private mineral estate)	Reserve Mining	1980s	Uncertain tonnage	Exposure of massive sulfide assumed to be similar or related to Serpentine deposit as seen in Peter Mitchell Mine (iron-ore of Biwabik Iron-Formation).
Dunka Pit (Private mineral estate)	Erie/LTV	1960s to 1999	14 to 20 million tons	Stockpiles at Dunka Pit, moved for iron-ore mining, and reclaimed.

Source: Modified from Patelke and Severson 2007.

Table 5. General records for major bulk samples and test pits in Partridge River Intrusion (outside the withdrawal application area) of the Duluth Complex

Project	Responsible Party	Year(s)	Tonnage (Ore)	Comment
Babbitt (aka Mesaba)	AMAX	1976 to 1978	1,150 tons excavation, 560 tons sent as sample	Surface pit, shaft, and drift samples.
Babbitt (aka Mesaba)	Arimetco	1994 to 1996	350 total. A 200 tons sample split into 85 and 115 ton portions	Surface pits.
Babbitt (aka Mesaba)	Teck Cominco (Teck American)	2001 to present	5,000 tons and planned 50,000 tons	Not applicable
Dunka Road – Site of proposed PolyMet NorthMet mine currently in state permitting process.	USS	1971	Total unknown	Surface pits. Three samples, 320 tons reported in two samplings.
Dunka Road – Site of proposed PolyMet NorthMet mine currently in state permitting process.	Fleck/Nerco	1990	Two large diameter core holes	Not applicable
Dunka Road - Site of proposed PolyMet NorthMet mine currently in state permitting process.	PolyMet Composite	1998-2000	At least 37 tons	Sample shipped for laboratory testing for about 55 reverse circulation drilling composite.
Longnose iron-titanium oxide	American Shield (?)	1984 and 1999	Believed to be 60 tons	Surface pits, sample sent for process testing

Project	Responsible Party	Year(s)	Tonnage (Ore)	Comment
Water Hen iron-titanium oxide	USBM	1975	About 400 feet of drill core	Samples to test reduction processes on iron-titanium ore; with goal of producing salable or processable titanium slag product.

Source: Modified from Patelke and Severson 2007.

Interest in the Maturi Deposit was reinvigorated following the discovery of platinum-group metals in the South Kawishiwi Intrusion (at the Birch Lake Deposit) in 1985. Various companies, including Wallbridge, Franconia Minerals, LLC, Lehmann Exploration Management, Inc., Encampment Minerals, Inc., Duluth Metals Limited, DMC, LLC, and others completed exploration activities throughout the 1990s and early 2000s. In December 2006, Lehmann Exploration Management Inc. applied for a preference right lease for a portion of the Birch Lake Deposit. Duluth Metals Limited and eventually Twin Metals Minnesota, LLC completed considerable work at Maturi. Over 400 exploration holes have been drilled within two federal mineral leases since they were issued in 1966 (map 5). In 2013, Twin Metals Minnesota applied for a preference right lease within the Maturi Deposit. In August of 2014, Twin Metals Minnesota submitted a National Instrument 43-101[8] compliant Pre-feasibility report (AMEC 2014) for the development of an underground mine. In December 2019, Twin Metals Minnesota submitted a mine plan of operation to federal and state agencies for the construction and operation of a 20,000 ton per day copper, nickel, cobalt, and platinum-group metal mine. In January 2022, this proposed mine plan was rejected by federal agencies due to cancellation of federal mineral leases MNES 1352 and MNES 1353.

Known Prospects, Mineral Occurrences, and Mineralized Areas

Map 4 displays known mineral deposits, prospects, and exploration and development activity within the withdrawal application area.

Wawa Subprovince

A widespread area of gold mineralization occurs in numerous prospects east of Lake Vermilion, within the Vermilion greenstone belt. This zone of mineralization is bounded to the south by the Mud Creek sheer zone and to the north by the Vermilion fault (Peterson and Patelke 2004).

In the last 20 years, numerous gold prospects have been discovered in the eastern portion of the Vermilion district (figure 2 and map 4). These prospects generally fall into one of three categories; (1) auriferous quartz-carbonate-pyrite veins and sulfidized zones in iron-formation; (2) auriferous quartz-sericite-ankerite-pyrite schists; and (3) felsic intrusive-hosted auriferous quartz veins and stockworks. All the prospects are found within areas of moderate to strong iron-carbonate alteration, with the best mineralization commonly found within sericitic alteration zones. The gold mineralization is generally related to deformation in subsidiary structures associated with movement along the Mud Creek shear zone (Peterson and Patelke 2004).

In addition, surveys by Larson (2004) identified several areas with anomalous precious and base metal concentrations. A prominent zinc anomaly is present in the Five Mile Lake area, representing the potential for zinc mineralization. This survey also identified within the Lower Ely member, anomalous copper,

[8] National Instrument 43-101 reports are created for the Standards of Disclosure for Mineral Projects within Canada. The Instrument is a codified set of rules and guidelines for reporting and displaying information related to mineral properties owned by, or explored by, companies which report these results on stock exchanges within Canada. Disclosures covered by the National Instrument 43-101 code include press releases of mineral exploration reports, reporting of resources and reserves, presentations, oral comments, and websites.

gold, molybdenum, and zinc in glacial till near the Needleboy and Armstrong Lake area, suggesting the presence of substantial volcanic-hosted zinc-copper mineralization. These areas are located west of the withdrawal application lands but may be representative of the potential for mineralization of the Lower Ely member (unit Acv on map 3) found within the withdrawal application area. Volcanogenic Massive Sulfide mineralization is also present at the Quartz Hill prospect west of Shagawa Lake within the withdrawal area, though not included in subject lands.

The lack of economic discoveries of gold or Volcanogenic Massive Sulfide deposits in northern Minnesota may be the result of (a) the difficulties encountered in performing accurate and efficient mineral exploration in areas of well dispersed glacial deposits, and (b) previous exploration programs were largely reconnaissance programs based on poorly developed volcanological and mineral deposit models (Hocker et al. 2003).

Iron-ore mineral occurrences are also known to be present within the Wawa greenstone belt found in the withdrawal application area. Thin bands of Algoma-type iron formation can be found within select subject parcels in the Mitchell and Twin Lake area, seen on map 7.

Quetico Subprovince

The geology of Minnesota limits the types of rocks available for rare earth element analysis. Given this limitation, igneous rocks (for example, granites, pegmatites, or carbonatites) are most likely to contain anomalous rare earth element contents within the area (Hauck et al. 2014).

Hauck et al. (2014) reported anomalous rare earth element values in samples taken from the Quetico subprovince, including the Lac La Croix granite (unit Aql on map 3) and other metamorphic and intrusive formations found within the withdrawal application area, with the four highest anomalous samples coming from the Vermilion Granitic Complex.

Breaks et al. (2003), Blackburn et al. (2002), and Selway et al. (2005) also describe peraluminous granites and rare metal pegmatites (for example, the Big Whopper lithium pegmatite) that occur in southwestern Ontario, just north of the Minnesota border. The near proximity of these intrusions and pegmatites that can contain rare earth elements or rare metal mineralization (for example, lithium, niobium, tantalum, tin, and tungsten) does not exclude similar intrusions and pegmatites from occurring in northern Minnesota. The only difference between the two areas is the thicker glacial overburden that occurs in Minnesota, making mineral exploration more difficult and costly (Hauck et al. 2014).

Reports on the rock chemistry of the Late Archean intrusive granites of the Vermilion Granitic Complex (units Aql, Aqg, Aqs, and Aqa on map 3) indicate elevated rare earth element concentrations compared to other granitic rocks. Elevated rare earth element concentrations generally accompany higher uranium and thorium values. Additional work would be needed to provide additional detail (Klenner et al. 2012).

Midcontinent Rift – Duluth Complex

Aside from the known "deposits discussion," the Duluth Complex and the South Kawishiwi Intrusion also contain many small diameter, 10- to 50-feet-wide tubes of oxide-bearing ultramafic rich rock called dikes. Some of these dikes may contain rare earth elements. All of these dikes contain either titanium-magnetite or a titanium ore called ilmenite. Most of the analysis for the dikes have been based on small infrequent surface outcrops, new core analysis on 100 cores drilled from 2011 to 2013, and the re-logging of more than 88,000 feet of old core (Severson 1995). These dikes may not be commercially economic unless mined in tandem with other mining projects. If larger dikes are found during the mining of the troctolites, they may become commercially economic at that time.

Critical and Strategic Minerals

Critical minerals are a select group of minerals that can change depending on several factors, including but not limited to, advances in technology, changing political climates, and global economics. This select group of minerals are those that are considered essential for use in defense, civilian, and industrial applications under the National Defense Stockpile Program and in compliance with the Strategic and Critical Materials Stock Piling Act of 1939 (50 USC § 98 et seq) (US DOD, 2017). The primary purpose of the National Defense Stockpile Program is to decrease the risk of dependence on foreign suppliers or single source suppliers of critical and strategic minerals by encouraging the acquisition, retention, conservation, and development of sources of materials within the US. The recent Presidential Executive Order 13817 "Federal strategy to ensure secure and reliable supplies of critical minerals" (December, 2017) states that it is the nation's priority to reduce its dependence on certain mineral imports by identifying new sources, increasing efforts to obtain those identified minerals, and to streamline the permitting process for such activities.

Critical minerals have been defined as (i) a non-fuel mineral or mineral material essential to the economic and national security of the United States, (ii) the supply chain of which is vulnerable to disruption, and (iii) that serves an essential function in the manufacturing of a product, the absence of which would have significant consequences for our economy or our national security (Executive Order 13817, 2017).

In December of 2017, the U.S. Geological Survey published Professional Paper 1802, which details 23 minerals determined to be important for the national economy and security, entitled "Critical mineral resources of the United States—Economic and environmental geology and prospects for future supply." Pursuant to Executive Order 13817, the U.S. Geological Survey published in the Federal Register a list of 35 minerals and mineral commodities (or commodity groups) determined to be critical (May, 2018).

In February of 2022, the U.S. Geological Survey published a Federal Register Notice (87 FR 10381, p. 10381 to 10382) presenting the final list of critical minerals and the methodology used to develop the list. The 2022 final list of critical minerals revised the final list published by the Secretary in 2018 and includes 50 minerals as shown in table 6. The critical minerals list was developed in response to Section 7002 of Title VII of the Energy Act of 2020 (P.L. 116-260) The number of minerals increased the total number of commodities from 35 in 2018, to 50 commodities on the 2022 list. This increase is in part the result of splitting the rare earth elements and platinum-group metals into individual commodities rather than including them as mineral groups. Compared to the 2018 list, the 2022 list adds nickel and zinc and removes helium, potash, rhenium, and strontium. Uranium was also excluded from the 2022 list due to Energy Act of 2020 explicitly excluding fuels from the definition of critical minerals. The Mineral Policy Act of 1970 (30 U.S.C. 21a) formally defines uranium as a mineral fuel.

Thirty rare earth elements and other critical minerals (table 6) have been identified in exploration activities within the South Kawishiwi Intrusion of the Duluth Complex and granite complexes of the Quetico subprovince and are potentially present within the withdrawal application area. Within the South Kawishiwi Intrusion, high concentrations of these minerals are found within 10 miles of the western contact of the Duluth Complex and the Wawa subprovince (map 3), though may extend further east. To date, exploration activities have focused on copper-nickel and associated cobalt and platinum-group metals; there are no defined rare earth element or critical mineral exploration programs by industry. If economic deposits of rare earth elements and other critical minerals are identified, it is expected they would be developed in conjunction with any mining of Midcontinent Rift Duluth Complex.

Similarly, anomalous occurrences of rare earth elements and other critical minerals have been identified within the Quetico subprovince (Hauck et al. 2014). While evidence from similar subprovince boundaries associated with granitic intrusions suggests rare earth elements and other critical mineral mineralization may be present in minable quantities within the Quetico, there has not been active exploration and no economic deposits have been identified.

Table 6. List of critical minerals pursuant to Section 7002 of Title VII of the Energy Act of 2020 (P.L. 116-260) and potential for commodity within the withdrawal application area by geologic terrane

20201 Draft USGS Critical Minerals Commodity	Midcontinent Rift	Quetico Subprovince	Wawa Subprovince
Aluminum (bauxite)	No potential, or unknown	No potential, or unknown	No potential, or unknown
Antimony	No potential, or unknown	No potential, or unknown	No potential, or unknown
Arsenic	No potential, or unknown	No potential, or unknown	No potential, or unknown
Barite	Potential	No potential, or unknown	No potential, or unknown
Beryllium	No potential, or unknown	No potential, or unknown	No potential, or unknown
Bismuth	No potential, or unknown	No potential, or unknown	No potential, or unknown
Cerium[1]	No potential, or unknown	Potential	No potential, or unknown
Cesium	No potential, or unknown	No potential, or unknown	No potential, or unknown
Chromium	Potential	No potential, or unknown	No potential, or unknown
Cobalt	Potential	No potential, or unknown	No potential, or unknown
Dysprosium[1]	No potential, or unknown	Potential	No potential, or unknown
Erbium[1]	No potential, or unknown	Potential	No potential, or unknown
Europium[1]	No potential, or unknown	Potential	No potential, or unknown
Fluorspar	No potential, or unknown	No potential, or unknown	No potential, or unknown
Gadolinium[1]	No potential, or unknown	Potential	No potential, or unknown
Gallium	Potential	No potential, or unknown	No potential, or unknown
Germanium	No potential, or unknown	No potential, or unknown	No potential, or unknown
Graphite (natural)	No potential, or unknown	No potential, or unknown	No potential, or unknown
Hafnium	No potential, or unknown	No potential, or unknown	No potential, or unknown
Holmium[1]	No potential, or unknown	Potential	No potential, or unknown
Indium	No potential, or unknown	No potential, or unknown	No potential, or unknown
Iridium[2]	Potential	No potential, or unknown	No potential, or unknown
Lanthanum[1]	No potential, or unknown	Potential	No potential, or unknown
Lithium	No potential, or unknown	No potential, or unknown	No potential, or unknown
Lutetium[1]	No potential, or unknown	Potential	No potential, or unknown
Magnesium	No potential, or unknown	No potential, or unknown	No potential, or unknown
Manganese	Potential	No potential, or unknown	No potential, or unknown
Neodymium[1]	No potential, or unknown	Potential	No potential, or unknown
Nickel	Potential	No potential, or unknown	No potential, or unknown
Niobium	No potential, or unknown	No potential, or unknown	No potential, or unknown
Palladium[2]	Potential	No potential, or unknown	No potential, or unknown
Platinum[2]	Potential	No potential, or unknown	No potential, or unknown
Praseodymium[1]	No potential, or unknown	Potential	No potential, or unknown
Rhodium[2]	Potential	No potential, or unknown	No potential, or unknown

20201 Draft USGS Critical Minerals Commodity	Midcontinent Rift	Quetico Subprovince	Wawa Subprovince
Rubidium	Potential	No potential, or unknown	No potential, or unknown
Ruthenium[2]	Potential	No potential, or unknown	No potential, or unknown
Samarium[1]	No potential, or unknown	Potential	No potential, or unknown
Scandium	No potential, or unknown	No potential, or unknown	No potential, or unknown
Tantalum	No potential, or unknown	No potential, or unknown	No potential, or unknown
Tellurium	No potential, or unknown	No potential, or unknown	No potential, or unknown
Terbium[1]	No potential, or unknown	Potential	No potential, or unknown
Thulium[1]	No potential, or unknown	Potential	No potential, or unknown
Tin	Potential	No potential, or unknown	No potential, or unknown
Titanium	Potential	No potential, or unknown	No potential, or unknown
Tungsten	No potential, or unknown	No potential, or unknown	No potential, or unknown
Vanadium	No potential, or unknown	No potential, or unknown	No potential, or unknown
Ytterbium[1]	No potential, or unknown	Potential	No potential, or unknown
Yttrium[1]	No potential, or unknown	Potential	No potential, or unknown
Zinc	No potential, or unknown	No potential, or unknown	Potential
Zirconium	No potential, or unknown	No potential, or unknown	No potential, or unknown

Note: See "Potential for the Occurrence of Mineral Resources" for further discussion. USGS = U.S. Geological Survey.

1. A rare earth element.
2. A platinum-group metal.

Mineral Economics

Formations found within the Duluth Complex, especially those of the South Kawishiwi Intrusion within the withdrawal application area, are known to host vast quantities of copper, nickel, cobalt, and platinum-group metals (see figure 7 and figure 8). Ascertaining the economic significance of these deposits is difficult at best. Many variables and assumptions need to be considered. Rather than attempting to place value, existing information was used in making a qualitative judgement on the economic importance of these deposits.

Described throughout this report, the Duluth Complex has seen 70 years of study generating federal mineral leases, preference right lease applications in 2006 and 2013, mine development proposals as recent as 2019, in addition to efforts on non-federal lands. As a part of the preference right lease applications review process, Bureau of Land Management is required to assess whether the applicant has discovered a valuable deposit. Regulation 43 CFR 3501.5 defines a valuable deposit as "*…an occurrence of minerals of such character that a person of ordinary prudence would be justified in the further expenditure of his or her labor and means, with a reasonable prospect of success in developing a profitable mine."* The intent of this review is not to determine value of the deposit or the soundness of investing in the operations. Rather, it is to determine whether an economic grade ore exists so that there is a reasonable likelihood of a profitable mine developing if a lease were to be issued.

In both the 2006 preference right lease application for a portion of the Birch Lake Deposit and the 2013 preference right lease application for a portion of the Maturi Deposit, the Bureau of Land Management concluded the preference right lease application lands had a reasonable prospect of success in developing a profitable mine (U.S. DOI Bureau of Land Management to Twin Metals Minnesota, LLC [Letter], 2018 and U.S. DOI Bureau of Land Management to Twin Metals Minnesota, LLC [Letter], 2020).

This, coupled with evidence on quantity and grade (see figure 8) and historical and current industry investment and interest in exploration and development of these deposits, suggest the Duluth Complex may be highly valuable and constitute a substantial domestic source of base and precious metals.

Industry interest in identifying copper, gold, and zinc mineralization in the formations of the Wawa subterrain has been sporadic. While potential for these deposits exist (as described in the "Potential for the Occurrence of Mineral Resources" section), the punctuated nature of efforts to identify economic quantities makes a qualitative valuation difficult.

Conversely, if the subject lands are withdrawn from operation of the mineral leasing laws, exploration and development on known deposits may be limited to areas of valid existing rights. Restricting activities to valid existing rights could hinder future development of any such rights for up to 20 years, as mineralized deposits may not be economically viable in such a spatially limited scenario. Refer to the socioeconomics report for a more detailed discussion on mineral economics.

The Rainy River withdrawal application area has a long history of mineral prospecting, exploration, and development-related activities, though no mining has occurred on subject lands.

Table 7 displays approximate contained metals found within the withdrawal application area subject lands of the Duluth Complex, along with corresponding percentages of domestic and world reserves the estimated commodities represent. Deposits included are those of the Duluth Complex with reported contained metal and represent the approximate area of subject lands within each deposit (see figure 8): Birch Lake (2 percent); Maturi Southwest (86 percent); Maturi (38 percent); and Spruce Road (89 percent). Reported contained metals includes measured, indicated, and inferred resources (Burger et al. 2018). The volumes of commodities are theoretical; they do not consider ore and metal recovery rates and other aspects that necessarily reduce production from an ore body.

Table 7. Approximate contained metals found within the withdrawal application area subject lands of the Duluth Complex, along with corresponding percentages of domestic and world reserves the estimated commodities represent. Data is displayed in metric tons unless otherwise noted.

Commodity[1]	Contained Metals within Subject Lands	Domestic Reserves[2] (% within Subject Lands)	World Reserves[2] (% within Subject Lands)
Platinum-group metals (platinum and palladium)	279,923 kg	900,000 kg (31%)	100,000,000 kg (0.4%)
Copper	5,599,407	48,000,000 (12%)	2,100,000,000 (0.6%)
Gold	46	33,000 0 (0.1%)	54,000 (<0.1%)
Nickel	1,836,804	340,000 (540%)	95,000,000 (2%)
Cobalt	12,376	1,000,000 (18%)	25,000,000 (0.2%)
Silver	1,209	26,000 (5%)	530,000 (0.2%)

1. Information on contained metals not available for all commodities within identified deposits.

2. Definition of reserves: That part of the reserve base that could be economically extracted or produced at the time of determination. The term "reserves" need not signify that extraction facilities are in place and operative. Reserves include only recoverable materials (U.S. Geological Survey 2022).

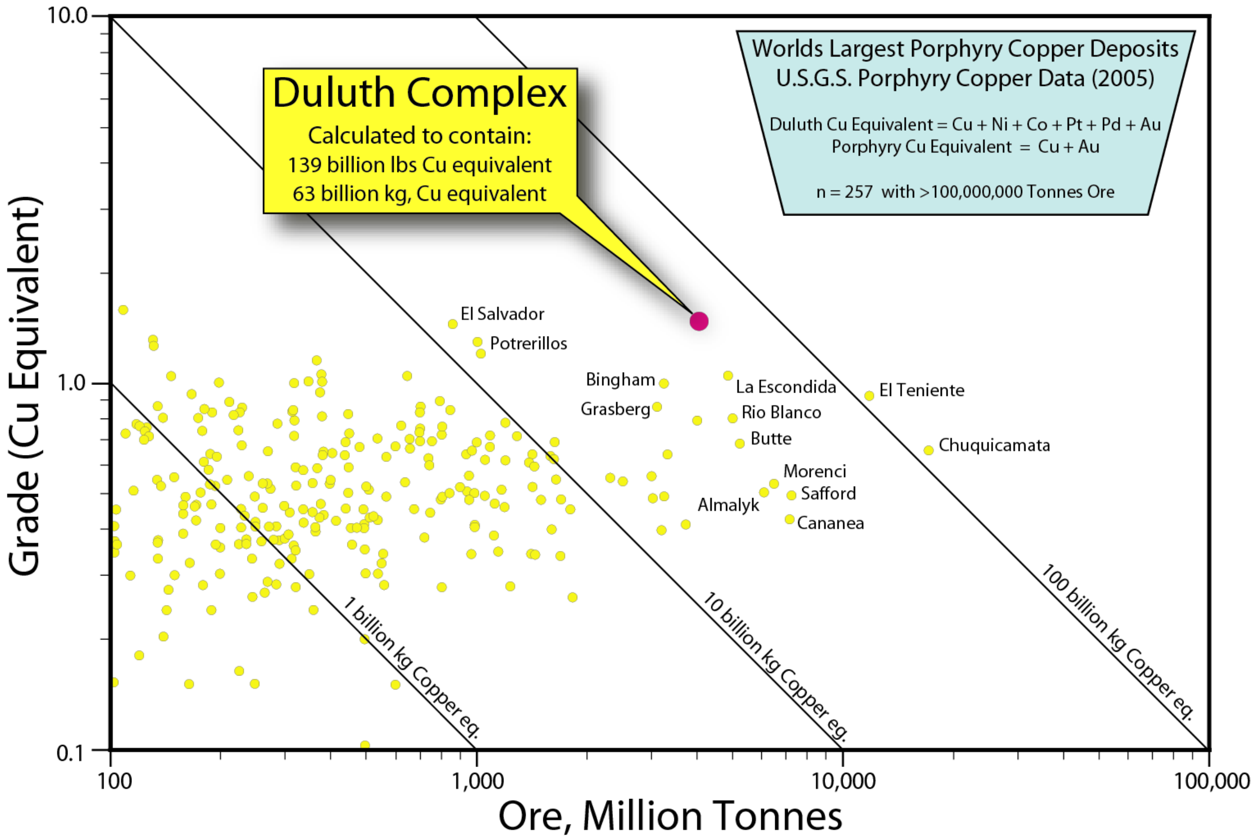

Figure 7. Graph comparing the estimated contained copper equivalent (Cu + Ni + Co + Pt + Pd + Au) of Duluth Complex deposits against the World's largest porphyry copper deposits. The South Kawishiwi Intrusion discussed throughout this report hosts a number of mafic copper, nickel, and platinum-group metal deposits located within the withdrawal application area and a part of the Duluth Complex Midcontinent Rift subterrane. Duluth Complex deposits are considered higher grade with more contained metal than the largest copper deposits in the United States and among the largest undeveloped copper deposits in the world (Miller 2015). Tonnes = metric tons.

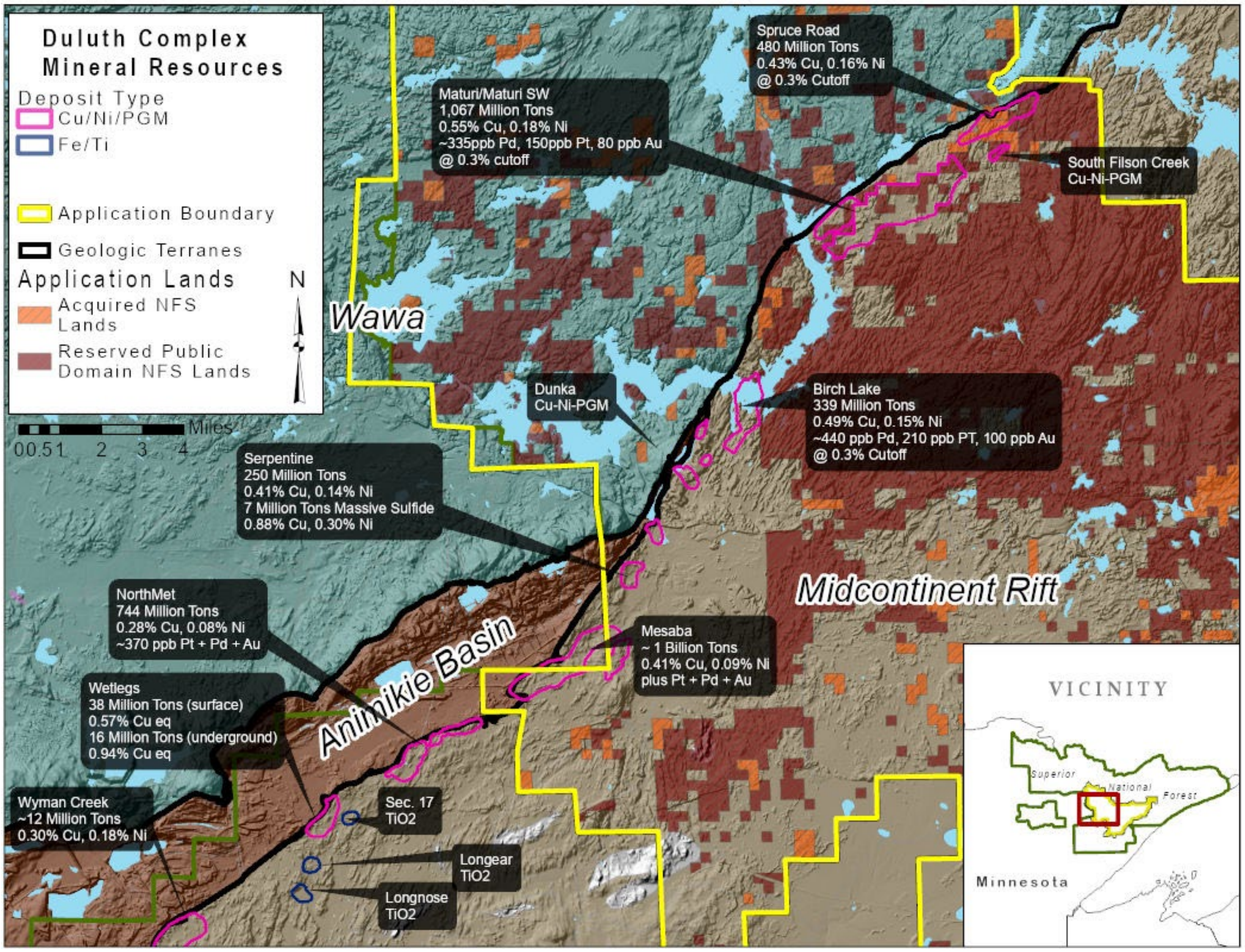

Figure 8. Identified deposits of the Midcontinent Rift Duluth Complex found within the withdrawal application area boundary and adjacent areas. Base and precious metal deposits of the Duluth Complex are considered a world class mineral resource. Tonnages and contained metal estimates are based on available data (modified from Miller 2015, AMEC 2014, Severson and Hauck 2003).

Mineral Commodities Trends

Information on mineral commodity trends was extracted on March 9, 2022 from U.S. Geological Survey Commodity Statistics and Information website.[9] These mineral commodity summary periodicals provide recent statistical information on the worldwide supply, demand, and flow of minerals and materials essential to the U.S. economy, the national security, and the protection of the environment. The commodity information presented is not intended to evaluate the economic trade-offs of any particular mining project, but, rather, to provide a broader economic context within which withdrawal application area deposits may fall.

Copper

In 2021, the recoverable copper content of U.S. mine production was an estimated 1.2 million tons, unchanged from that in 2020, and was valued at an estimated $12 billion, 58 percent greater than $7.61 billion in 2020. Production at domestic copper mines increased in 2021 because of higher ore grades, but the increases were offset by significant decreases in output at several major mines in Arizona. Arizona

[9] See https://minerals.usgs.gov/minerals/pubs/commodity/.

was still the leading copper-producing state and accounted for an estimated 71 percent of domestic output. Copper was also mined in Michigan, Missouri, Montana, Nevada, New Mexico, and Utah. Copper was recovered or processed at 25 mines (19 of which accounted for 99 percent of mine production), 2 smelters, 2 electrolytic refineries, and 14 electrowinning facilities. An additional smelter and electrolytic refinery have been temporarily closed since October 2019. Refined copper and scrap were used at about 30 brass mills, 14 rod mills, and 500 foundries and miscellaneous consumers. Copper and copper alloy products were used in building construction (46 percent), electrical and electronic products (21 percent), transportation equipment (16 percent), consumer and general products (10 percent), and industrial machinery and equipment (7 percent).

Imports of refined copper increased from a recent low of 663,000 metric tons in 2019 to 920,000 metric tons in 2021. Imports from 2016 to 2020 were sourced as follows: copper content of blister and anodes (Finland, 81 percent; Malaysia, 13 percent; and other, 6 percent); copper content of matte, ash, and precipitates (Canada, 28 percent; Mexico, 20 percent; Belgium, 14 percent; Spain, 11 percent; and other, 27 percent); copper content of ore and concentrates (Mexico, 97 percent; and other, 3 percent); copper content of scrap (Canada, 54 percent; Mexico, 34 percent; and other, 12 percent); and refined copper (Chile, 62 percent, Canada, 23 percent; Mexico, 11 percent; and other, 4 percent). Refined copper accounted for 85 percent of all unmanufactured copper imports. U.S. net import reliance, as a percentage of apparent consumption, was 38 percent in 2020 and 45 percent in 2021.

United States consumption of reported refined copper remained relatively consistent from 2017 to 2021 at 1,800,000 metric tons.

Based on data through October 2021, the annual average COMEX copper price was projected to be about $4.20 per pound in 2021, an increase of 50 percent from that in 2020 and 5 percent greater than the previous all-time high of $4.01 per pound in 2011. Strong global manufacturing activity, constrained growth in world copper production, low stockpiles, and supply constraints owing to shipping delays contributed to the increased copper price (U.S. Geological Survey 2022).

The International Copper Study Group (ICSG) reported in 2021 that world copper mine production has grown by 3.2 percent per annum since 1960 to 20.6 million metric tons in 2020. Latin America accounted for 41 percent of the 2020 global total, Asia accounted for 16 percent, Europe accounted for 14 percent, North America and Africa accounted for 12 percent each, and Oceania accounted for the remaining 5 percent. From 1960 through 2020, Asia has exhibited significant growth with the region share of global production increasing from 6 percent to 16 percent. During the same period, North America's share has declined from 36 percent to 12 percent (ICSG 2021).

A 1998 U.S. Geological Survey assessment estimated 550 million tons of copper were contained in identified and undiscovered resources in the United States. A 2014 U.S. Geological Survey global assessment of copper deposits indicated that identified resources contain about 2.1 billion tons of copper (porphyry deposits accounted for 1.8 billion tons of those resources), and undiscovered resources contained an estimated 3.5 billion tons (U.S. Geological Survey 2017).

Cobalt

In 2021, only two mines were producing cobalt domestically. The nickel-copper Eagle Mine in Michigan produced cobalt-bearing nickel concentrate, which was exported to Canada or overseas for processing. In Missouri, a company produced nickel-copper-cobalt concentrate from historic mine tailing and was building a hydrometallurgical processing plants near the mine site. Most U.S. cobalt supply consists of imports and secondary (scrap) materials. Approximately six companies in the United States produced cobalt chemicals. An estimated 42 percent of the cobalt consumed in the United States was used in superalloys, mainly in aircraft gas turbine engines; 9 percent in cemented carbides for cutting and wear-resistant applications; 16 percent in various other metallic applications; and 33 percent in a variety of chemical applications. The total estimated value of cobalt consumed in 2021 was $340 million.

The average spot price in 2021 was $23.00 per pound. This price is up from the 2020 average price of $15.70, yet lower than a recent high of $37.43 per pound in 2018.

In 2021, Congo (Kinshasa) continued to be the world's leading source of mined cobalt, supplying approximately 70 percent of world cobalt mine production. Except for production in Morocco and artisanally-mined cobalt in Congo (Kinshasa), most cobalt is mined as a byproduct of copper or nickel. China was the world's leading producer of refined cobalt, most of which was produced from partially refined cobalt imported from Congo (Kinshasa). China was also the world's leading consumer of cobalt, with more than 80 percent of its consumption being used by the rechargeable battery industry. United States net import reliance, as a percentage of apparent consumption, was 76 percent for 2020 and 2021.

Identified cobalt resources of the United States are estimated to be about 1 million tons. Most of these resources are in Minnesota, but other important occurrences are in Alaska, California, Idaho, Michigan, Missouri, Montana, Oregon, and Pennsylvania. With the exception of resources in Idaho and Missouri, any future cobalt production from these deposits would be as a byproduct of another metal. Identified world terrestrial cobalt resources are about 25 million tons. The vast majority of these resources are in sediment-hosted stratiform copper deposits in Congo (Kinshasa) and Zambia; nickel-bearing laterite deposits in Australia and nearby island countries and Cuba; and magmatic nickel-copper sulfide deposits hosted in mafic and ultramafic rocks in Australia, Canada, Russia, and the United States. More than 120 million tons of cobalt resources have been identified in manganese nodules and crusts on the floor of the Atlantic, Indian, and Pacific Oceans (U.S. Geological Survey 2022).

Nickel

In 2021, the underground Eagle Mine in Michigan produced approximately 18,000 tons of nickel in concentrate, which was exported to smelters in Canada or overseas. The Madison Mine Project in Missouri recovered metals, including nickel, from mine tailings as part of the Superfund Redevelopment Initiative. Nickel in crystalline sulfate was produced as a byproduct of smelting and refining platinum-group metal ores in Montana. In the United States, the leading uses for primary nickel are stainless and alloy steels, nonferrous alloys and superalloys, electroplating, and other uses including catalysts and chemicals. Stainless and alloy steel and nickel containing alloys typically account for more than 85 percent of domestic consumption.

In 2021, the annual average London Metal Exchange cash price [for nickel] was estimated to have increased by 30 percent to $8.30 per pound compared to $6.25 in 2020, which was attributed to expectation of increased use of nickel in electric vehicle batteries and continued strong demand for stainless steel. Recently the nickel market has been volatile and is expected to remain so for some time, due primarily to options that were committed prior to the sanctions imposed on Russia. It can be reasonably assumed that the nickel price will increase higher than projections estimated in 2021.

Imports from 2017–2020 were sourced as follows: Nickel contained in ferronickel, metal, oxides, and salt (Canada, 43 percent; Norway, 10 percent; Finland, 9 percent; Australia, 8 percent; and other, 30 percent); nickel-containing scrap, including nickel content of stainless-steel scrap (Canada, 37 percent; Mexico, 26 percent; United Kingdom, 9 percent, and other, 28 percent). United States net import reliance, as a percentage of apparent consumption, was 49 percent in 2020 and 48 percent in 2021.

Domestic reported consumption of primary nickel decreased by an estimated 20 percent in 2020, owing primarily to reduced demand related to the global COVID-19 pandemic. Approximately 70 percent of the decrease was attributed to reduced consumption of nickel alloys, primarily those used in the aviation and oil and gas sectors. Domestic production of stainless steel and related nickel consumption decreased substantially in the first half of 2020, but most of the leading domestic stainless-steel producers reported relatively robust recovery in the third quarter. Total domestic production of stainless steel in 2020 was estimated to have decreased by approximately 10 percent.

Globally, nickel mine production was estimated to have decreased by 5 percent. Although stainless-steel production in most leading producing countries or localities decreased, these were mostly offset by a rapid recovery in China’s production of nickel-bearing stainless-steel grades after the first quarter, and the continued ramp up of nickel pig iron and stainless-steel projects in Indonesia (U.S. Geological Survey 2022).

Platinum-Group Metals

Platinum-group metals include platinum, palladium, rhodium, ruthenium, iridium, and osmium. The Stillwater Mine in Montana produced slightly more than 18,000 kilograms of platinum-group metals in 2021, with an estimated value of about $1.4 billion. Small quantities of primary platinum-group metals also were recovered as byproducts of copper-nickel mining in Michigan; however, this material was sold to foreign companies for refining. The leading domestic use for platinum-group metals was in catalytic converters to decrease harmful emissions from automobiles. Platinum-group metals are also used in catalysts for bulk-chemical production and petroleum refining; dental and medical devices; electronic applications, such as in computer hard disks, hybridized integrated circuits, multilayer ceramic capacitors; glass manufacturing; investment; jewelry; and laboratory equipment.

The 2021 estimated annual average prices of palladium, platinum, and ruthenium increased by 18 percent, 35 percent, and 88 percent respectively, compared with those in 2020. The estimated prices for rhodium doubled and iridium more than tripled. In addition, the prices of iridium, rhodium, and ruthenium all reached record highs in 2021.

2021 production of platinum-group metals in South Africa, the world’s leading supplier of mined material, increased by 13 percent compared with that in 2020, owing to increased mining of the Bushveld Complex. World resources of platinum-group metals are estimated to total more than 100 million kilograms. The largest reserves are in the Bushveld Complex in South Africa. Imports for platinum-group metals from 2017 to 2020 were sourced as follows: palladium (Russia, 35 percent; South Africa, 31 percent, Germany, 9 percent; and other, 25 percent); and platinum (South Africa, 38 percent; Germany, 20 percent; Switzerland, 12 percent; Italy, 6 percent; and other, 24 percent). United States net import reliance of palladium, as a percentage of apparent consumption, was 35 percent for 2020 and 37 percent 2021. United States net import reliance of platinum was 77 percent in 2020 and 70 percent in 2021 (U.S. Geological Survey 2022).

Gold

In 2021, domestic gold mine production was estimated to be 180 tons, 7 percent less than that in 2020, and the value was estimated to be about $10 billion. Gold was produced at more than 40 lode mines in 11 States, at several large placer mines in Alaska, and at numerous smaller placer mines (mostly in Alaska and in the Western States). Nevada was the leading gold-producing State, accounting for about 74 percent of total, domestic production. About 6 percent of domestic gold was recovered as a byproduct of processing domestic base-metal ores, chiefly copper ores. The top 26 operations yielded about 98 percent of the mined gold produced in the United States. Estimated global gold consumptions was jewelry, 47 percent; physical bar, 21 percent; central banks and other institutions, 14 percent; official coins and medals and imitation coins, 10 percent; electrical and electronics, 7 percent, and other, 1 percent.

The United States was not a net exporter of gold in 2020 for the first time since 2010 owing to a significant increase in imports of high-purity gold bullion. The estimated gold price in of $1,800 per troy ounce in 2021 was slightly higher than the previous record-high annual price of $1,774 per troy ounce in 2020. Several factors were reported to have caused the increase in price: gold demand for safe-haven buying increased due to the continued global COVID-19 pandemic, global investor uncertainty, and the U.S. Federal Reserve Board low interest rates.

Worldwide gold production in 2021 was estimated to be slightly less than that in 2020. Decreased production in Papua New Guinea, Russia, and the United States more than offset production increased in China, Ghana, Indonesia, South Africa, and Tanzania (U.S. Geological Survey 2022).

Potential for the Occurrence of Mineral Resources

The following mineral and energy resource potential evaluations were determined for both the potential of the mineral occurrence and for the potential development of a mineral resource.

Mineral Occurrence

The determination of potential for the occurrence of mineral deposits in the withdrawal application area were based on a number of factors including: (1) evidence of the existence of a favorable geologic setting, either lithologic or structural; (2) evidence of the existence of a mineralized process; (3) evidence of the existence of minerals of importance in known geologic host rock or structures; (4) the existence of sufficient mining-related activities (that is, shafts, adits, dumps, exploration holes, and wells) within or adjacent to the area; (5) the existence of historical production; (6) proximity to active or closed mining claims and mineral leases, and (7) proximity to areas where the mineral potential has already been determined (Bureau of Land Management Manual 3031).

The mineral occurrence classification used in this report follows the direction provided by the Bureau of Land Management's Mineral Classification System found in Bureau of Land Management Manual 3031 – Energy and Mineral Resource Assessments - § .34 I and II. This classification system uses a two-part rating: level of potential and level of certainty.

Level of Potential

O: The geologic environment, and the inferred geologic processes, have **no mineral occurrences** and do not indicate potential for accumulation of mineral resources.

L: The geologic environment, and the inferred geologic processes, indicate **low potential** for accumulation of mineral resources.

M: The geologic environment, the inferred geologic processes, and the reported mineral occurrences and/or valid geochemical/geophysical anomalies indicate **moderate potential** for accumulation of mineral resources.

H: The geologic environment, the inferred geologic processes, the reported mineral occurrences and (or) valid geochemical or geophysical anomalies, and the known mines or deposits indicate **high mineral potential** for accumulation of mineral resources. The "known mines and deposits" do not have to be within the area that is being classified but have to be within the same type of geologic environment.

ND: Mineral(s) potential **not determined** due to lack of useful data. This notation does not require a level-of-certainty qualifier.

Level of Certainty

Limited: The available data are insufficient or **limited** and cannot be considered as direct or indirect evidence to support or refute the possible existence of mineral resources within the respective area.

Indirect: The available data provide **indirect** evidence to support or refute the possible existence of mineral resources.

Direct: The available data provide **direct** evidence but are quantitatively minimal to support or refute the possible existence of mineral resources.

Abundant: The available data provide **abundant direct** and **indirect evidence** to support or refute the possible existence of mineral resources.

For the purposes of this report, prediction of development potential follows the level of potential ratings scale, though will not include a level of certainty.

The following tables summarize the minerals occurrence and development potential for National Forest System lands within the Rainy River withdrawal application area.

Table 8. Wawa subprovince[1]—leasable commodities occurrence and development potential within the subprovince subject lands, by acreage and percentage of total subject lands

Occurrence Potential[2]	Gold, Copper, Zinc, Iron-Ore	Geothermal
High	1,218 acres (0.5%)	0 acres (0%)
Moderate	0 acres (0%)	21,201 acres (9.4%)
Low	21,201 acres (9.4%)	1,218 acres(0.5%)
Development Potential	Low	Low

1. Wawa subprovince contains 21,201 acres of subject National Forest System Lands that fall within the application area.
2. Mineral occurrence classification rating system in accordance with Bureau of Land Management’s Mineral Classification System cited in Bureau of Land Management Manual 3031. See map 7 through map 11 for mineral occurrence potential locations.

Table 9. Quetico subprovince[1]—leasable commodities occurrence and development potential within the subprovince subject lands, by acreage and percentage of total subject lands

Occurrence Potential[2]	Rare Earth Elements	Geothermal
High	0 acres (0%)	0 acres (0%)
Moderate	2,030 acres (0.9%)	2,030 acres (0.9%)
Low	0 acres (0%)	0 acres (0%)
Development potential	Low	Low

1. Quetico subprovince contains 2,030 acres of subject National Forest System Lands that fall within the application area.
2. Mineral occurrence classification rating system in accordance with Bureau of Land Management’s Mineral Classification System cited in Bureau of Land Management Manual 3031. See map 7 through map 11 for mineral occurrence potential locations.

Table 10. Midcontinent Rift[1]—leasable commodities occurrence and development potential within the subprovince subject lands, by acreage and percentage of total subject lands

Occurrence Potential[2]	Copper, Nickel, Cobalt, Platinum-Group Elements (platinum-group metals)	Geothermal
High	67,663 acres (30%)	0 acres (0%)
Moderate	0 acres (0%)	0 acres (0%)
Low	135,326 acres (60%)	0 acres (0%)
Development potential	High	No data

1. Midcontinent Rift contains 202,989 acres of subject National Forest System Lands that fall within the application area.
2. Mineral occurrence classification rating system in accordance with Bureau of Land Management's Mineral Classification System cited in Bureau of Land Management Manual 3031. See map 7 through map 11 for mineral occurrence potential locations.

Table 11. Across all geologic terranes—salable commodities occurrence and development potential within the withdrawal application area subject lands, by acreage and percentage of total subject lands

Occurrence potential[1]	Aggregate (sand and gravel)
Moderate to High	49,620 acres (22%)
Low to Moderate	189,457 acres (84%)
Development potential	Moderate to High

1. Mineral occurrence classification rating system in accordance with Bureau of Land Management's Mineral Classification System cited in Bureau of Land Management Manual 3031. See map 6 for mineral occurrence potential locations.

Leasable Minerals

Hardrock Metallic Minerals

In keeping with the format of this report, potential for hard-rock leasable mineral resource occurrences is described by commodity, separated by each major geologic terrane of the withdrawal application area.

Iron-Ore

Terrane – Wawa Subprovince

The sequence of metamorphosed volcanic, intrusive, and sedimentary rocks of the Vermilion greenstone belt is known to host deposits and occurrences of Algoma-type iron formation, including historical mines in the Soudan and Ely areas. Potential for iron ore deposits is high in spatially limited areas where known occurrences of these formations have been identified on geologic maps (see map 7 for locations). Potential for the development of these mineral occurrences is likely low due to low volumes of ore and high production cost, as compared to taconite mining found in the Mesaba Iron Range. **Mineral Occurrence Potential – High; Certainty – Abundant. Development Potential – Low.**

Iron-Titanium – Critical Mineral

Terrane – Midcontinent Rift – Duluth Complex

Several mineralized areas (section 17, Waterhen, Skibo, and others) of titanium bearing oxide-ultramafic-intrusions have been identified within the southwestern margins of the Duluth Complex and may also contain rare earth elements. While the potential for mineral occurrence of iron-titanium oxide-bearing ultramafic intrusions in these portions of the Duluth Complex is considered high, data to support the existence of such geologic features within the withdrawal application area is limited. The small diameter, 10- to 50-feet-wide tubes of oxide rich rock called dikes may be economic if mined in tandem or as a byproduct of other host minerals. Mapping of these dikes has mostly been based on rare surface exposure and core analysis. **Mineral Occurrence Potential – Moderate; Certainty – Indirect. Development Potential – Low.**

Rare Earth Elements Critical Mineral

Terrane – Wawa Subprovince

Severson, et al. (2012) reported that the Giants Range Batholith (units Aqm, Agm on map 3) has likely low to moderate potential for hosting spatially-limited rare earth element deposits. However, there is a scarcity of data and the overall status is unknown (see map 10). This potential is demonstrated by the lack of mineral exploration and other core holes drilled in the area by mineral exploration companies. Given the limited data reported in literature and scarce interest by the mining industry, ocurrence and development potential is considered low. **Mineral Occurrence Potential – Low; Certainty – Limited. Development Potential – Low.**

Terrane – Quetico Subprovince

Rare metal deposits, such as lithium-cesium-tantalum pegmatites, are known along and near similar subprovince boundaries associated with granitic intrusions, analogous to those found within the withdrawal application area. The University of Minnesota Duluth Natural Resources Research Institute published a comparison of ore grades of known rare earth elements to a prospect near Ray, Minnesota (found north and west of the withdrawal area, located within layered migmatites of the Quetico subprovince) in 2014 (Hauck et al. 2014). The Ray prospect had a total rare earth element analysis of greater than 11,000 parts per million (1.1 percent total rare earth element), suggesting there may be potential for similar or higher grade occurences in the Vermilion Granitic Complex (units Aql, Aqs, Aqg, Aqt, Aqa on map 3) (Hauck et al. 2014). Evidence suggests rare earth element mineralization may be present, though to date, none have been identified within the withdrawal application area (see map 10). **Mineral Occurrence Potential – Moderate; Certainty – Indirect. Development Potential – Low.**

Zinc-Copper

Terrane – Wawa Subprovince

Hocker et al. (2003), Hudak et al. (2002), and Hudak and Morton (1999) suggest that the uppermost several hundred meters of the Lower Member of the Ely Greenstone (unit Acv on map 3) has excellent potential for volcanic-host Volcanogenic Massive Sulfide zinc-copper mineralization, including Noranda-type deep water, flow dominated, as well as Mattabi-type shallow water volcaniclastic-dominated Volcanogenic Massive Sulfide systems. Therefore, potential for zinc-copper mineral occurrence is considered high (see map 9). There is ample data and documentation available in literature for the potential for mineral occurrence. While the potential for occurrence is considered high, areas of mineralization have been identified within subject lands. Therefore, development potential in considered low. **Mineral Occurrence Potential – High; Certainty – Abundant. Development Potential – Low.**

Copper-Nickel-Platinum-Group Metal and other Critical Minerals

Terrane – Midcontinent Rift – Duluth Complex

Sulfide mineralization in Duluth Complex deposits is cubanite, chalchopyrite, pentlandite, and pyrrhotite, with lesser bornite, other copper-iron sulfides, and a wide range of platinum-group minerals. In mineralized zones, copper is usually about 0.5 percent and seldom over 1.5 percent. Copper to nickel ratios range from 2:1 to 5:1, but tend to float around 3:1. The platinum + palladium + gold (platinum-group metal) content of these deposits is about 300 parts per billion on average, with higher local concentrations. The available data from tens of thousands of feet of core show that some platinum-group metal-enriched zones could add value to a copper-nickel mine, however it is unlikely platinum-group metal-enriched zones exist that could support a platinum + palladium + gold operation without some copper and nickel recovery (Patelke and Severson 2007). In addition, several other metals (the U.S. Geological Survey Mineral Resource Data System identifies varying concentrations of rhodium, ruthenium, iridium, osmium, cobalt, rhenium, titanium) exist in the analyzed core and may be commercially viable. The potential for development is considered high for the area within approximately 10 miles of the western contact with Archean terranes (see map 11). Beyond this, information is limited, and mineralization may be found at depths beyond current and viable extraction methods.**Mineral Occurrence Potential – High; Certainty – Abundant. Development Potential – High.**

Gold

Terrane – Wawa Subprovince

As evidenced by numerous exploration campaigns, the Newton belt (units Aag, Auv, Amv, and Acv on map 3) found within the withdrawal application area, hosts multiple prospects and other occurrences of gold mineralization. Extensive research and reporting have been conducted in recent years by the Minnesota Department of Natural Resources Minerals Division and the University of Minnesota, all of which suggest that the Vermilion District contains favorable lithological and alteration mineral associations often found to host gold mineralization. The discovery of the Hemlo gold deposits in Ontario, Canada, and correlated to greenstone belts in and around the withdrawal application lands, increases the likelihood that gold deposits may yet be discovered in the Vermilion district (see map 9 for mineral potential occurrence on subject lands). To date, no economic gold deposits have been identified. Though there is ample data and documentation available in literature for the potential for mineral occurrence, discovery of a minable deposit has not been made in the 100 plus years prospecting and exploration has occurred. **Mineral Occurrence Potential – High; Certainty – Direct. Development Potential – Low.**

Coal

Terrane – All

No known coal deposits have been identified or located on the subject lands. Lands involved are not classified as prospectively valuable for coal resources. Geologic conditions are not favorable for coal formation, and depositional environments present were not such that coal could be formed. **Mineral Occurrence Potential – None; Certainty – Direct.**

Oil and Gas

Terrane – All

There are no known oil or gas deposits on the subject lands. Lands involved are not classified as prospectively valuable for oil and gas because geologic formations are not favorable for oil and gas deposition or production. Additionally, no oil or gas leases or permits have been issued by the Bureau of Land Management within the subject area. **Mineral Occurrence Potential – None; Certainty – Abundant.**

Geothermal

Terrane – Wawa and Quetico Subprovinces

Late Archean intrusive granites of the Giants Range Batholith and the Vermilion Granitic Complex have moderate potential for geothermal development in Minnesota, due to higher heat flow than much of the state (Kenner et al. 2012). Additional investigation utilizing traditional heat flow observations will further quantify this resource and determine if heat flow may be higher in some areas. Follow-up sampling, chemical and radionuclide, and thermal conductivity analyses will be needed to provide additional detail (Klenner et al. 2012). The withdrawal application area has not been designated by U.S. Geological Survey as a known geothermal resource area. See map 8. Due to the high cost of drilling in crystalline bedrock, developing geothermal resources is currently a high risk (Klenner et al. 2012). There are no records of geothermal leases or wells on subject lands, and the area has not been classified by the Bureau of Land Management or U.S. Geological Survey as potentially valuable for geothermal production. **Mineral Occurrence Potential - Moderate; Certainty – Direct. Development Potential – Low.**

Other Leasable Resources

Terrane – All

A literature search did not identify the potential for any other leasable resources (for example, sodium, potassium, potash, et cetera). There is no known potential, current or historical leasing, or history of interest in the area.

Salable Minerals

Potential for aggregate material within the central portion of the withdrawal application area is moderate to high, focused mainly within and near the Vermilion and Highland moraines. Many geomorphic features such as eskers, outwash fans, kames, till, and various moraine types occur within and near the Vermilion and Highland moraines that may provide sources of aggregate material. The remainder of the withdrawal area is considered moderate, since geomorphic features that may potentially prove as adequate sources may exist. Detailed terrain analysis and field checking would be required to reduce uncertainty and to further define usable material before new development could occur. National Forest System lands constitute a large percentage of ownership in the area. Consequently, a substantial percentage of demand for aggregate comes from National Forest System lands. Therefore, development potential is considered moderate to high. See map 6 for distribution of salable mineral occurrence potential. **Mineral Occurrence Potential – Moderate to High; Certainty – Abundant. Development Potential – Moderate to High.**

Potential for dimension stone within the withdrawal application area is moderate (see map 6). The Minnesota Department of Natural Resources published an updated inventory for dimension stone in January of 2018 for the northern portion of the state, including the withdrawal application area. This inventory identifies locations of stone suitable for quarrying. Any attempts to develop a potential source would require detailed field work to identify favorable attributes (for example, wide joint spacing or favorable texture and color). Important factors that also need to be considered in any attempt to market dimension stone is shipping and freight costs. Most of the identified locations are far-removed from primary markets or have remote and difficult access. These issues can drastically increase production costs, thereby limiting marketability and development potential to moderate. **Mineral Occurrence Potential - Moderate; Certainty – Direct. Development Potential – Moderate.**

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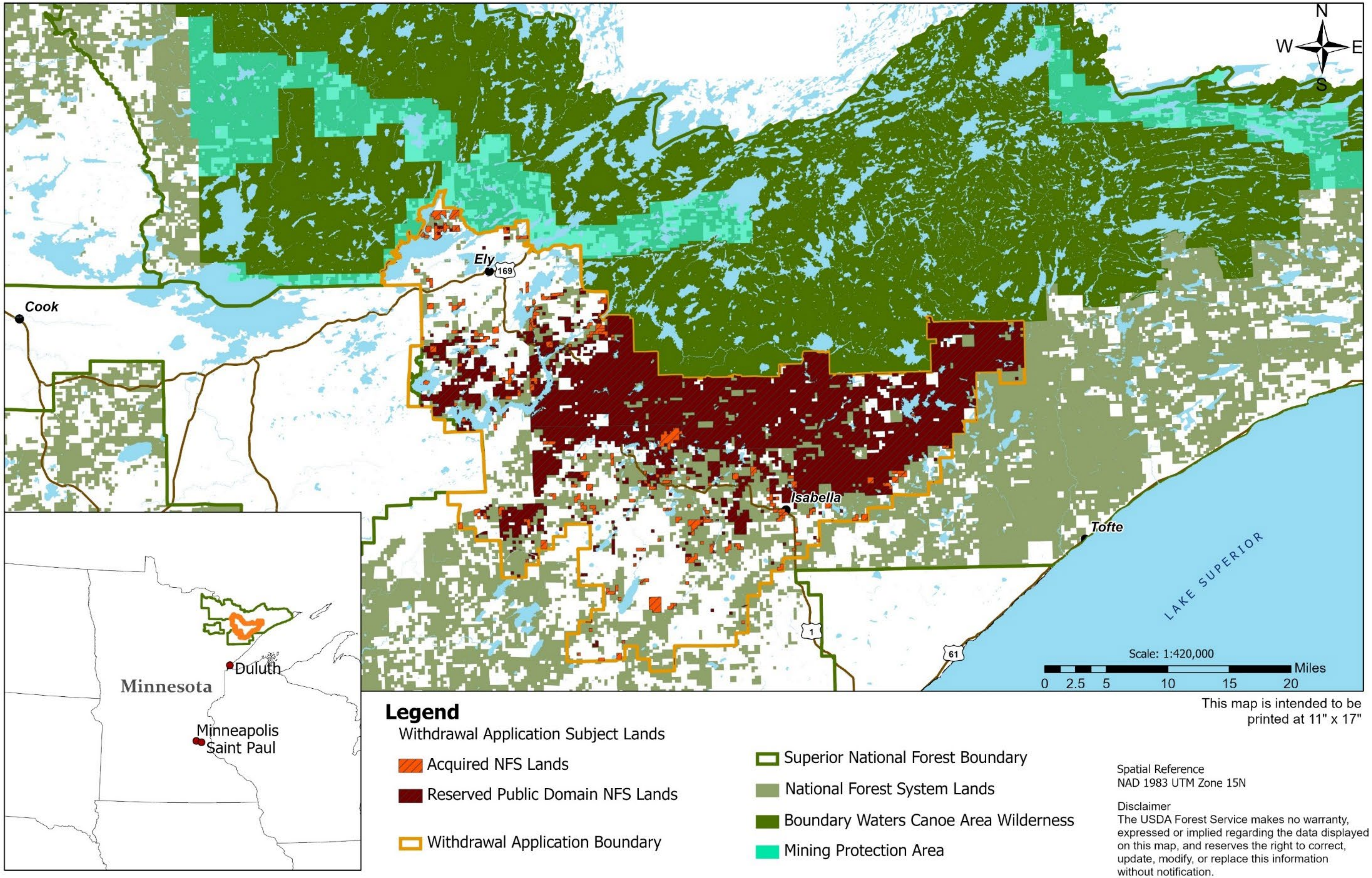
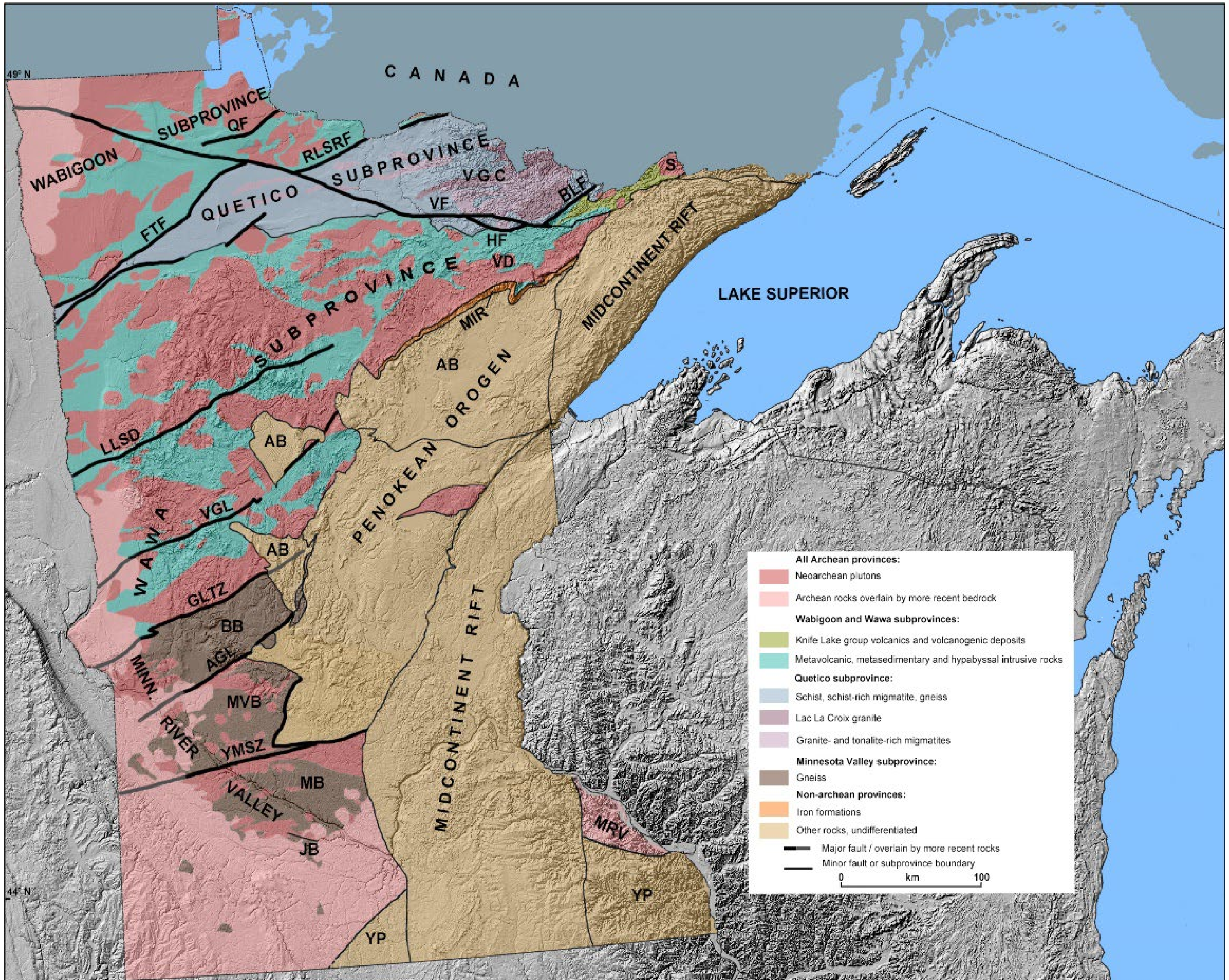
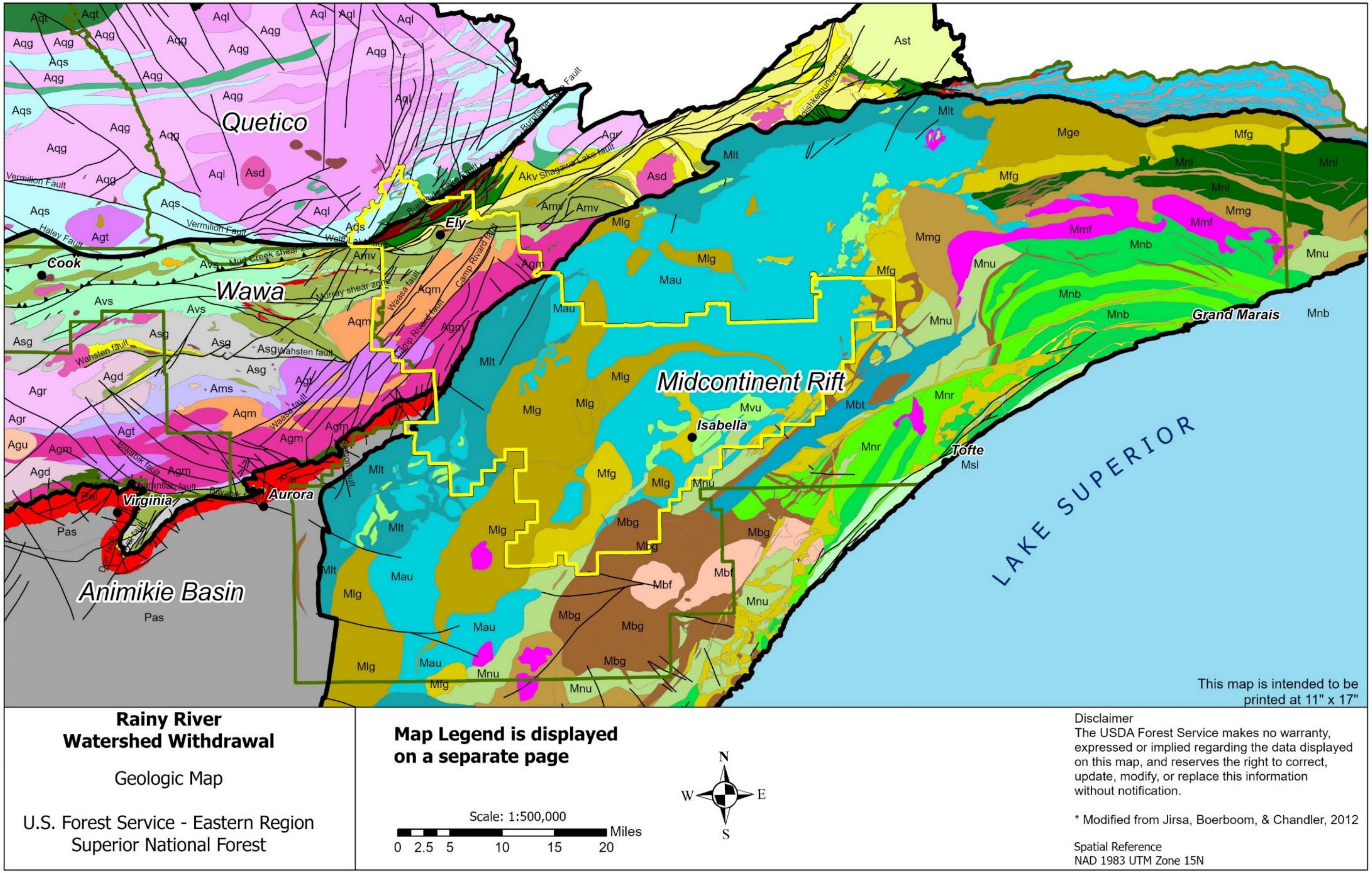
Maps



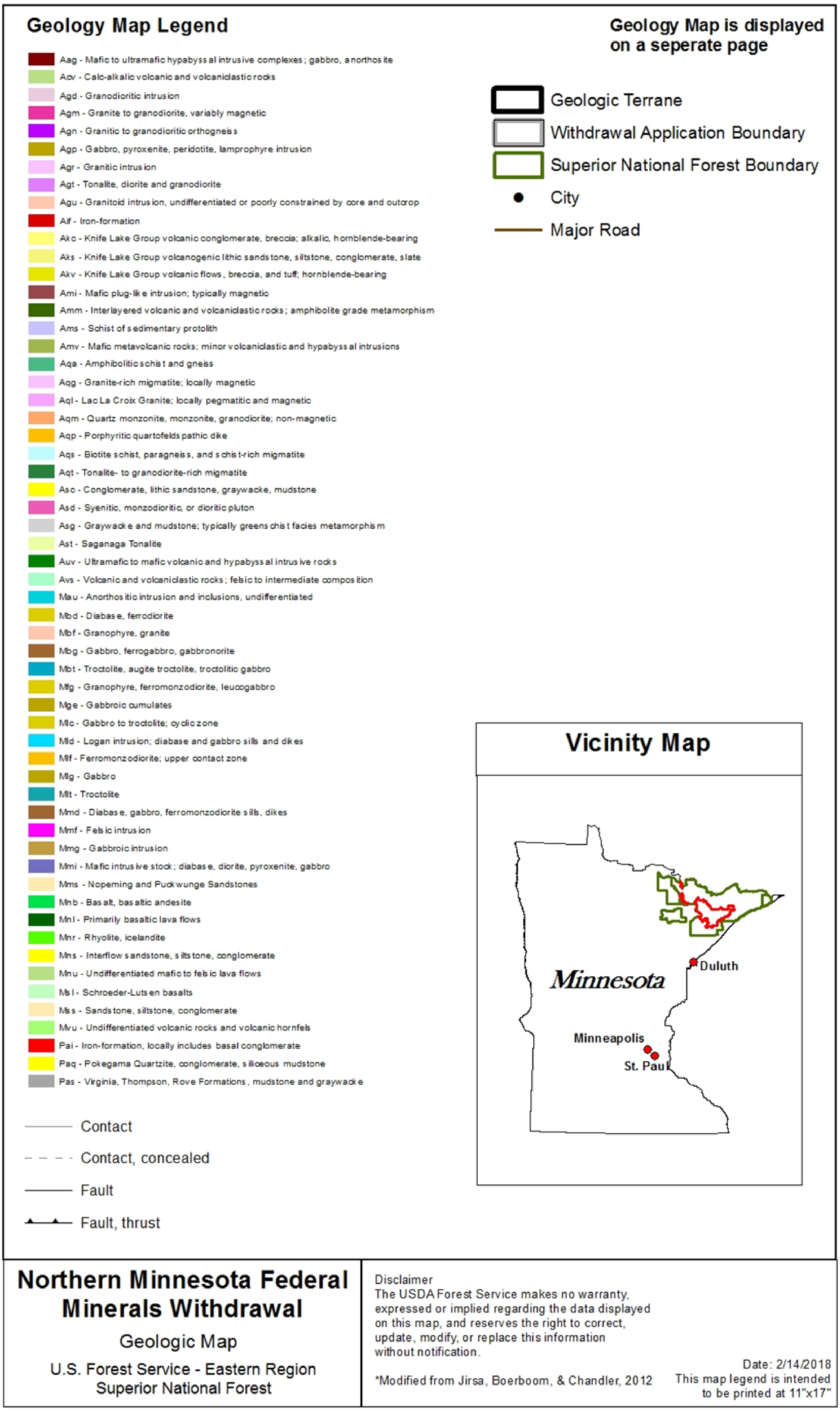
Map 1. Rainy River withdrawal—general location and application lands.



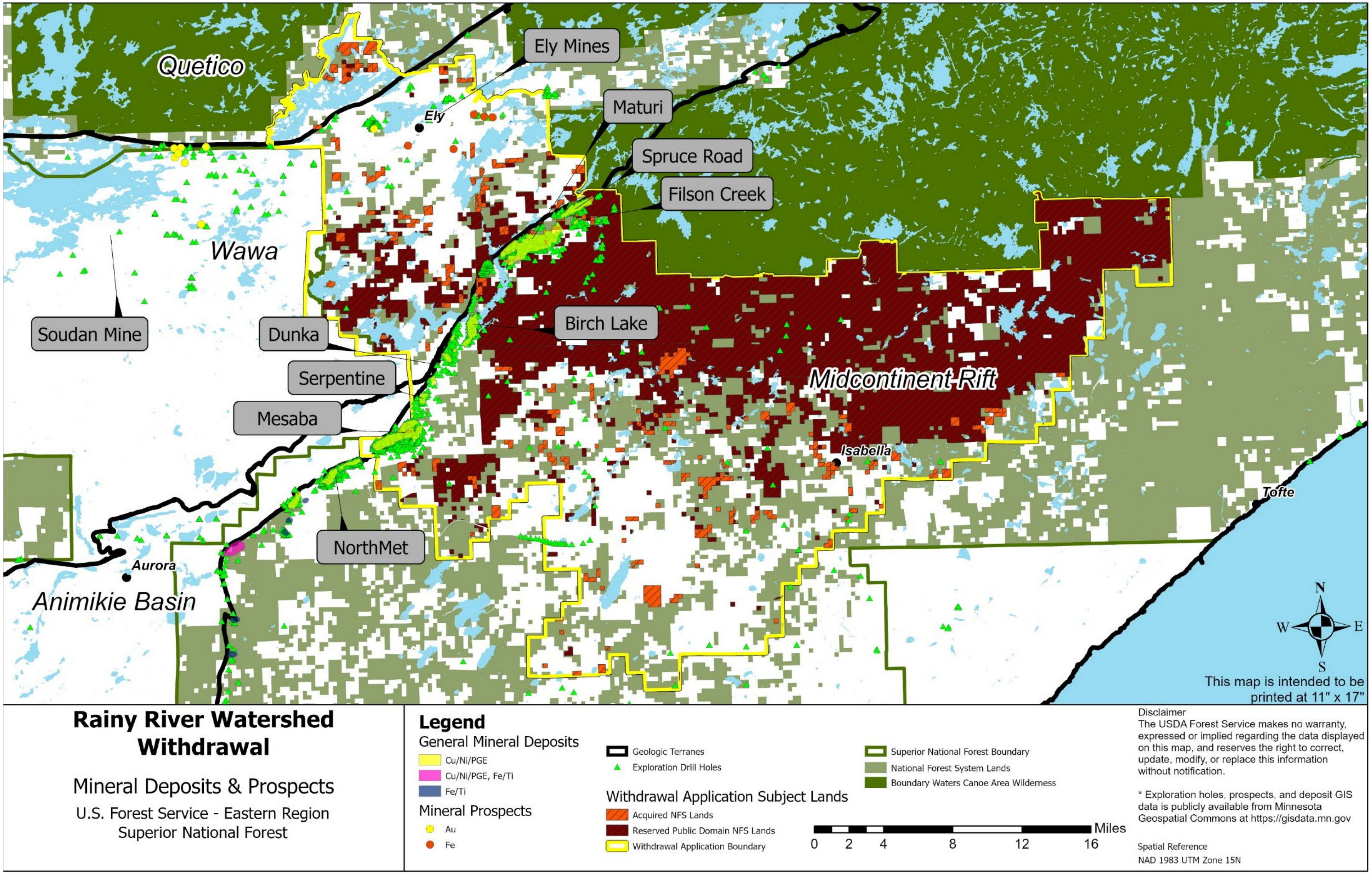
Map 2. Geologic terranes of Minnesota (used with permission from Mangou 2017).



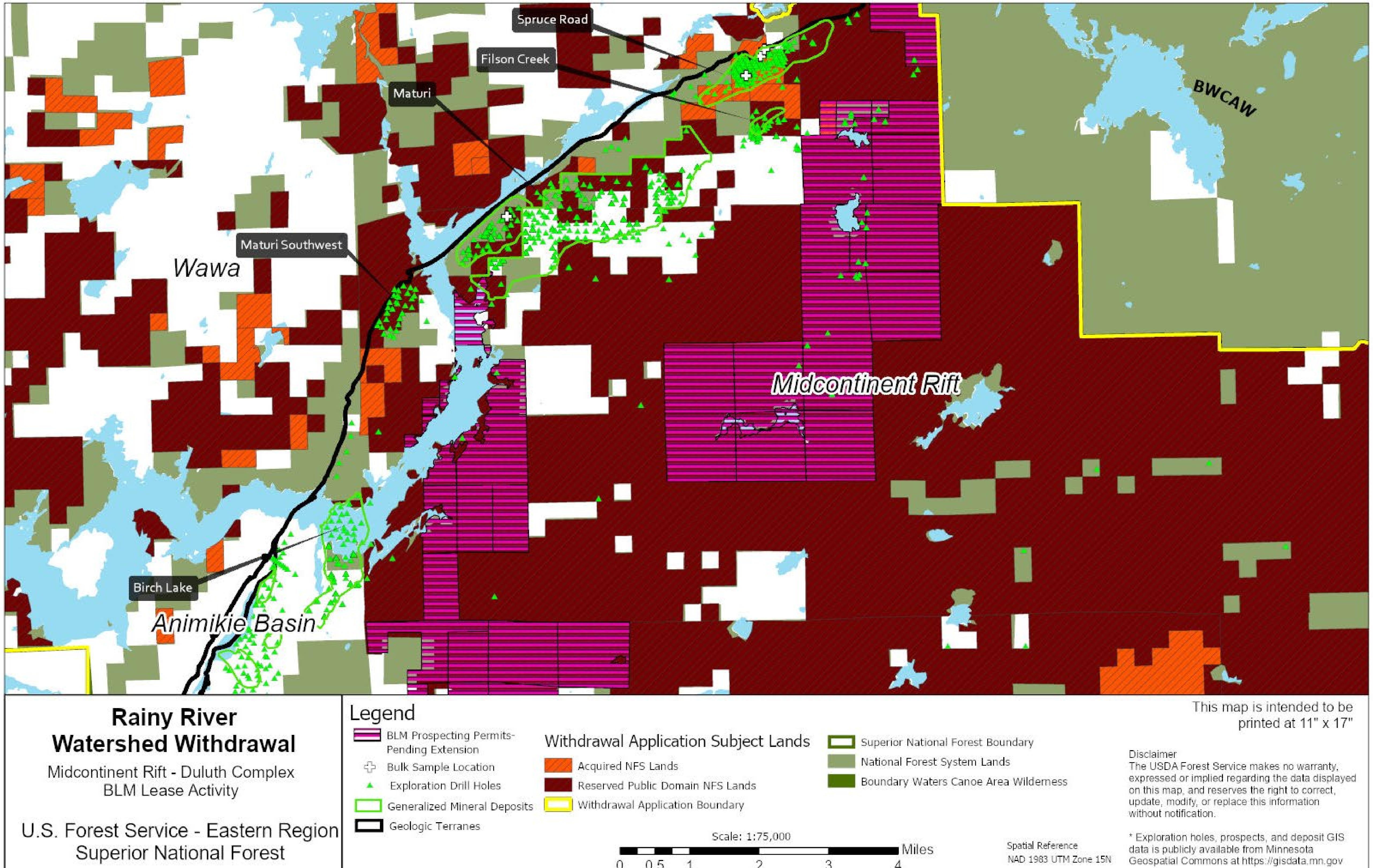
Map 3. Precambrian geologic map of withdrawal application area outlined in black (modified from Jirsa et al. 2012). See legend on next page.



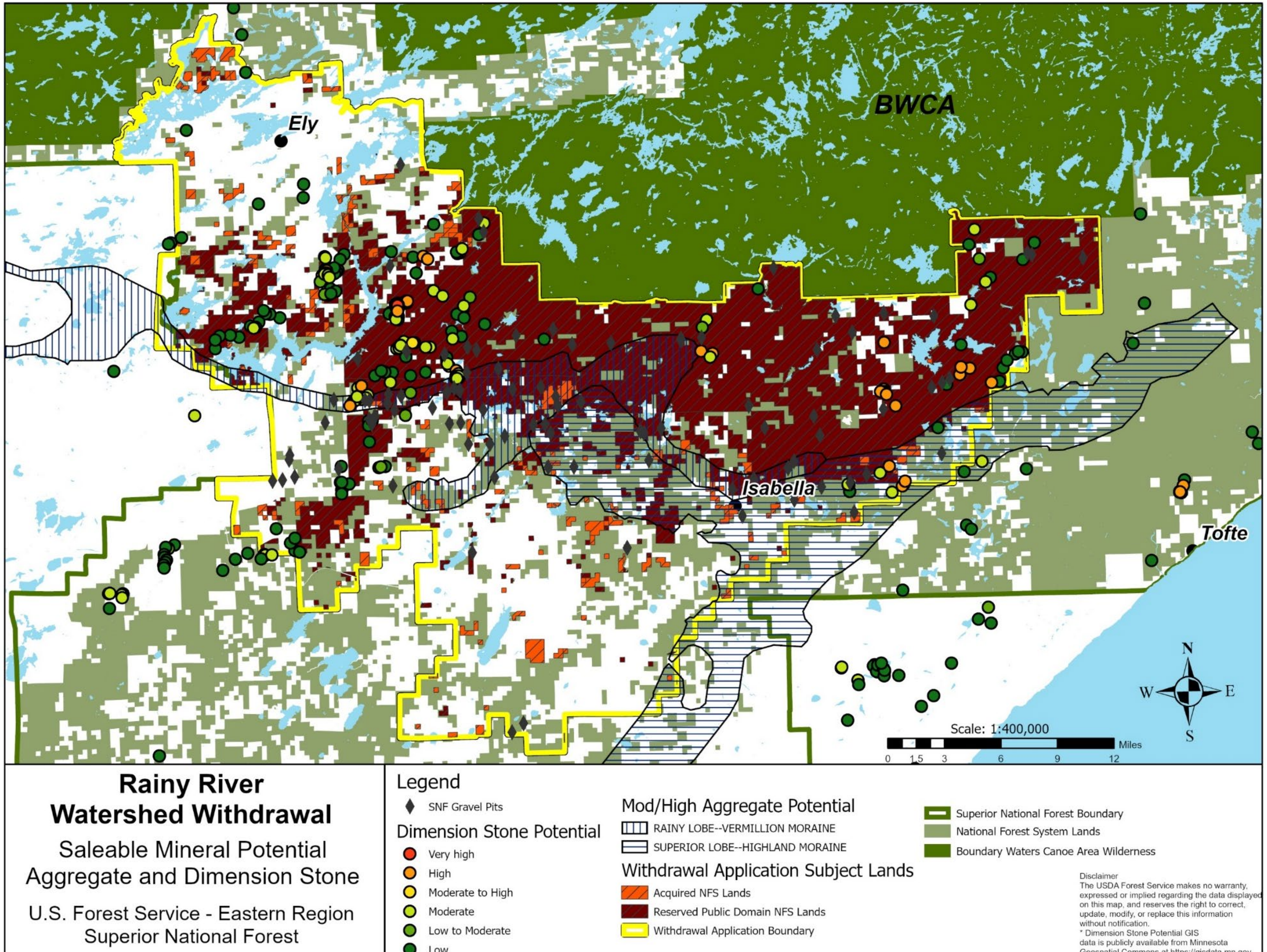
Legend for map 3.



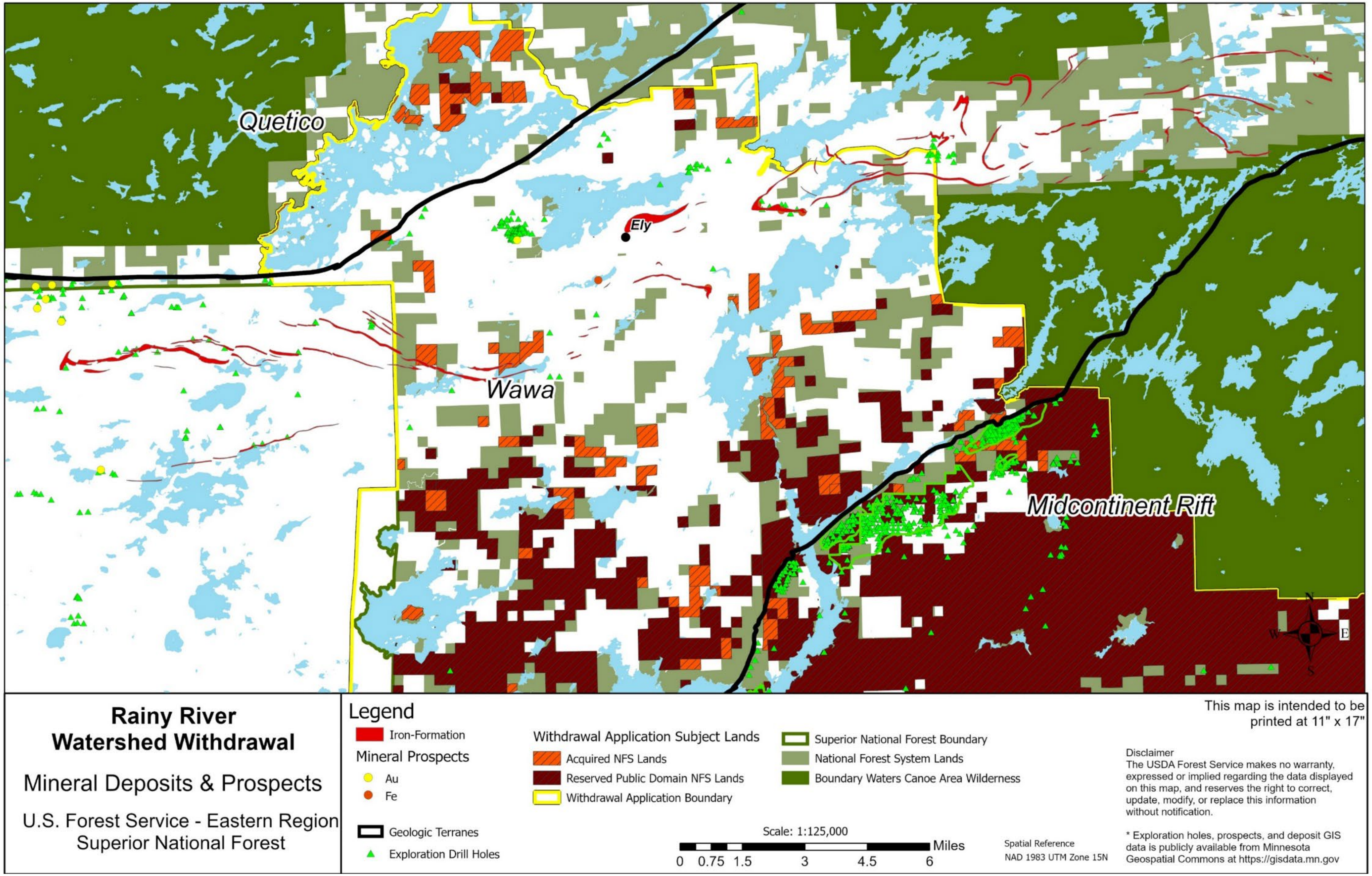
Map 4. Mineral deposits, prospects, exploration, and historic mineral related activity (labeled on map) within the withdrawal application area .



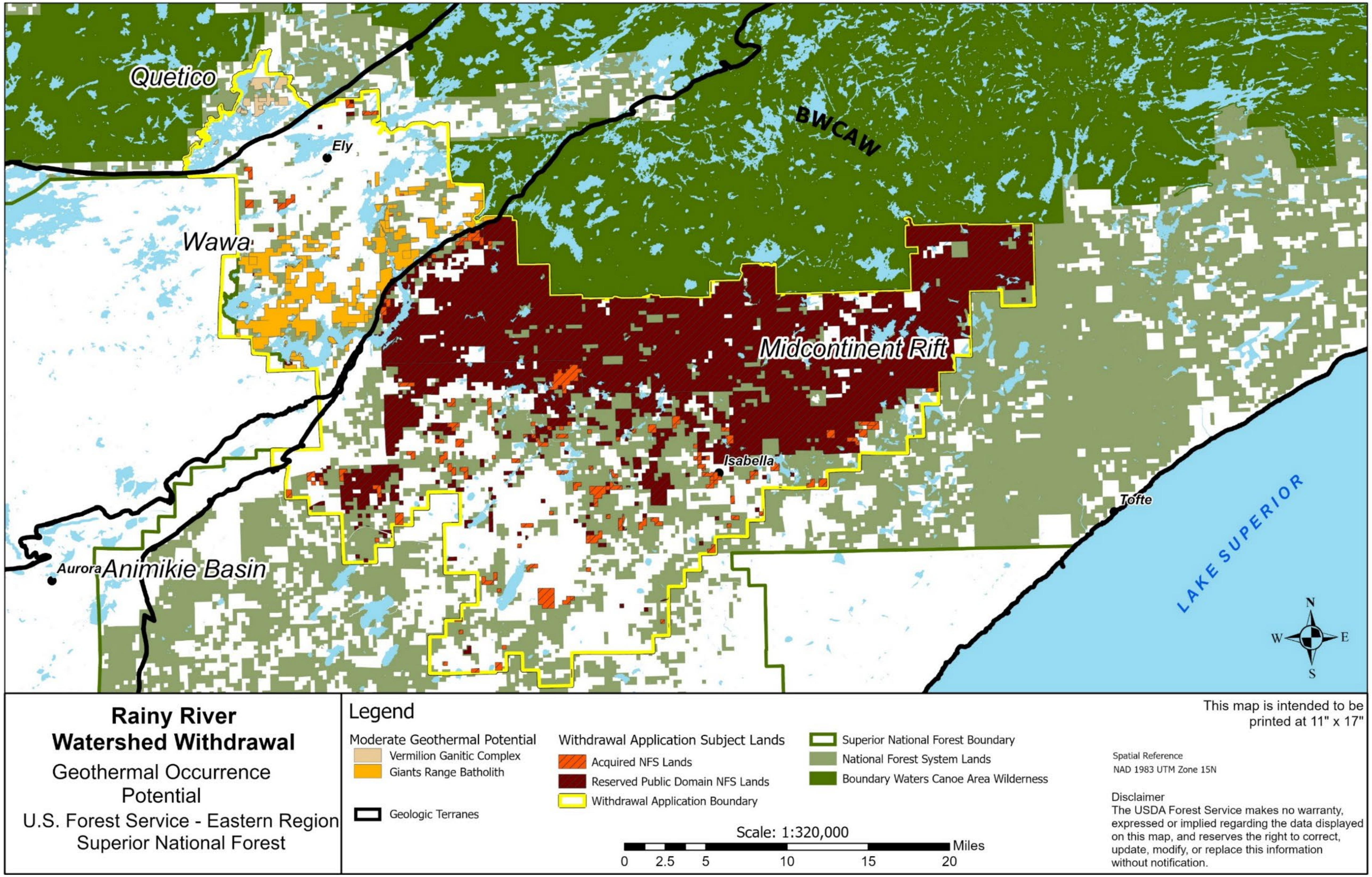
Map 5. Past and recent exploration activity within the Midcontinent Rift along with pending federal prospecting permits.



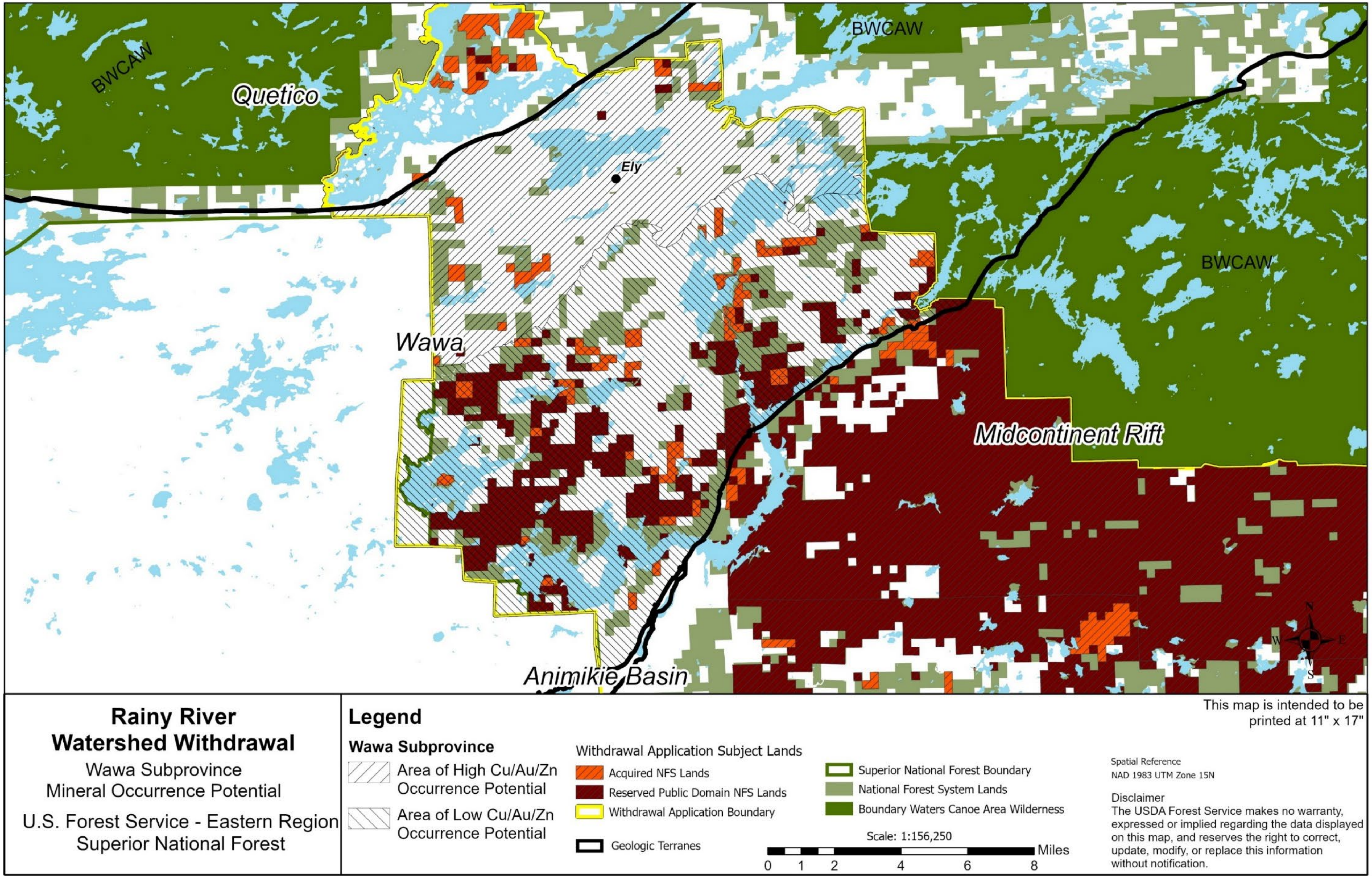
Map 6. Existing Superior National Forest salable sources and salable mineral occurrence potential. Note that areas outside of Vermilion and Highland moraines have low to moderate potential for aggregate mineral occurrence.



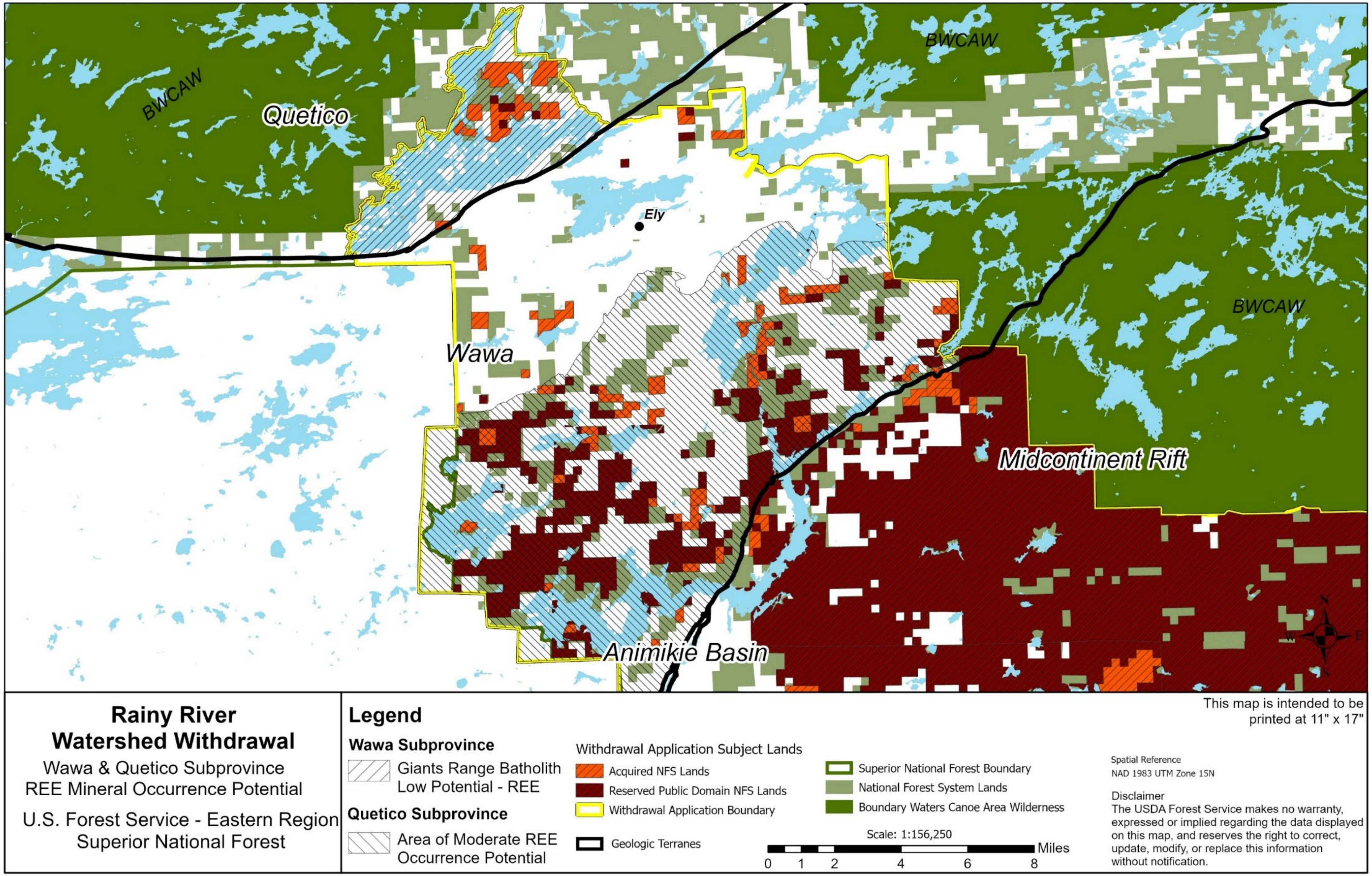
Map 7. Iron formation – iron ore. Note location of other mineral prospects (from map 4).



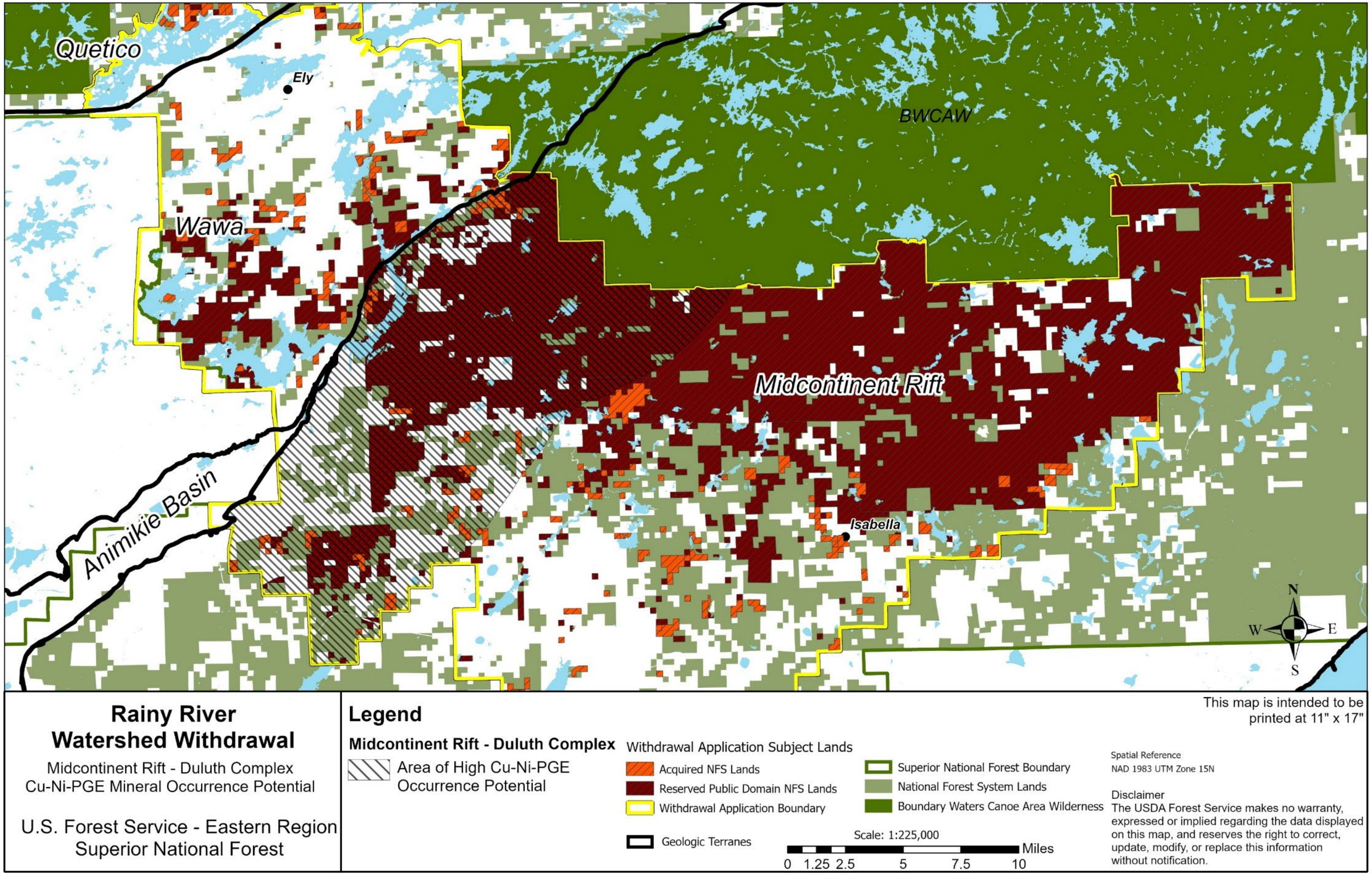
Map 8. Geothermal mineral occurrence potential.



Map 9. Wawa subprovince mineral occurrence potential.



Map 10. Rare earth element mineral occurrence potential.



Map 11. Midcontinent Rift – Duluth Complex Cu-Ni-platinum-group elements mineral occurrence potential.

Attachment 1 – Land List for the Rainy River Withdrawal

Fee title lands. Total acreage: 225,504.

Township 57 North, Range 10 West

Section	Subdivision
4	N1/2SE and SWSE exc. 3.12 acres and NESW exc. .09 acres.
6	Lots 5 and 6; W1/2SE
11	NWSW exc. 5.00 acres being the W1/2NWNWSW

Township 57 North, Range 11 West

Section	Subdivision
2	S1/2SE
4	SENE

Township 58 North, Range 10 West

Section	Subdivision
4	Greenwood Lake
4	Lots 8,9, and 10
5	Unsurveyed Island
7	Lots 1 and 2
13	NWSW
14	NESE; S1/2SE
18	NWNE
19	Greenwood Lake
31	NESE

Township 58 North, Range 11 West

Section	Subdivision
3	Lots 2 and 3
12	SENW; NESW; N1/2SE
25	E1/2W1/2
26	SESW; SWSE
27	NESE
35	Lots, 3, 5 and 6
35	N1/2NE

Township 58 North, Range 9 West

Section	Subdivision
6	Lot 7
12	NESE
21	NWNW
22	SWNE
26	NWNE

Township 59 North, Range 10 West

Section	Subdivision
1	McDougal Lake
1	Unsurveyed Island
2	Lot 7
2	Lots 8 and 9
2	Unsurveyed Island
4	SWSW
5	Lot 6
5	Lots 1 and 2
5	Stony Lake
5	SWSW; Lots 8 and 10
8	Lot 3
8	NESW
11	McDougal Lake
11	Unsurveyed Island
12	E1/2SW; NWSE
12	McDougal Lake
15	NESW
18	Lot 2
21	Unsurveyed Island
22	SENE
24	SESW
25	NENE
28	Greenwood River
28	Lot 3
28	N1/2NW; NWNE
29	NESE
32	SENE

Township 59 North, Range 11 West

Section	Subdivision
1	Lot 3; SENW
2	N1/2SW; SESW
3	W1/2SE; NESW; SENW
4	Lot 1
4	NESW
6	Lots 7,8,9,11-15 and 18
7	Lots 1, 10, 11, and 14
7	Lots 12 and 13
9	SWNE
10	SWNE; NESW; NWSE; SESE
11	NENW
11	NWNE; SWSW
12	Lot 3
13	Lots 2 and 6
13	Sand Lake
17	SWNE
17	Unsurveyed Island
18	Lots 2,3,4,5,and 7
19	Lots 5-8; 11 and 12
23	Lots 4 and 5
24	SENE; E1/2SE
24	Unsurveyed Island
25	E1/2NE
26	Lot 1

Township 59 North, Range 12 West

Section	Subdivision
1	Entire
2	S1/2NW; S1/2
3	S1/2NW; W1/2SW
3	SENE; E1/2SW; N1/2SE; SWSE
4	Lot 3; SWNW
4	S1/2NE; Lot 2; SENW
5	Lot 1 except that portion lying north and west of Erie Mining Co. R/W easement
5	N1/2SE; SWSE
5	NESW
5	NWSW except that portion lying N of Erie Mining Co. R/W easement
5	SENW except that portion lying north of Erie Mining Co. easement
5	SESE
5	SWNW except that portion lying north of Erie Mining Co. R/W easement

Section	Subdivision
5	SWSW
6	Lot 1
6	Parts of SENE; NWSE; Lots 7, 8, and 9; and all of SWNE; Lots 2 to 6
7	Lots 9 and 10
8	NENE
8	NENW
9	NWNW
10	E1/2NE; SWNW; W1/2E1/2; E1/2W1/2; W1/2SW; SESE
11	N1/2; NESW; S1/2SW; N1/2SE; SWSE
12	N1/2SE; SENE
12	S1/2NW; E1/2SW
12	W1/2NE; NWSW; N1/2NW; SWSE
13	NWNE; E1/2NW; NWSW
14	W1/2NE; NW1/4; N1/2SW
15	NWNE; N1/2NW; SWNW; N1/2SW; SESW; NWSE
23	NWNE; NWNW; NWSW
24	NWNE
25	NWSW
34	NESE
35	SESW

Township 59 North, Range 7 West

Section	Subdivision
6	Lots 4 and 10.
6	Unsurveyed Island
7	Lot 1
8	SESE
9	SE1/4
9	W1/2SW

Township 59 North, Range 8 West

Section	Subdivision
1	Dumbell lake
1	Lots 1 and 4
1	W1/2SE; Lots 6 and 7
2	Delay Lake
2	Lot 4 and Lot 11
3	Lots 1-4; S1/2NW; W1/2SW
4	Lots 1-4; S1/2N1/2
5	Lot 2
5	Lot 3

Section	Subdivision
5	N1/2SW
5	NWNW (Lot 4)
5	SWNW
5	SESW (Part of)
6	Lot 1
7	NENW
8	NENE exc. the NWNW of the NENE and 1.34 acres conveyed to the School District #2; NWNE exc. NENENWNE; NENW
8	NESE; S1/2SE
8	SENE
9	NWNW
9	NWSW
9	S1/2NE; NWSE
9	SENW exc. 2.50 acres being the NENESENW; SWNW
11	NWNE; E1/2NW
11	NWSW
12	SWNW
15	W1/2SW
21	SWSW
22	S1/2SW
23	NESE
23	SWNE
28	SENE
30	Lot 3
32	NESE; S1/2SE
32	SWNW

Township 59 North, Range 9 West

Section	Subdivision
2	S1/2NW; SW1/4
3	Lots 3 and 4; S1/2NW; N1/2SW; SESE
4	SWNE; Lot 3; SENW
5	Lot 5
5	Stony River
6	NESW
8	Lots 1 and4; NENE
8	Lots 6,7, SWSE
8	NESW; Lot 5
8	SESW
8	Stony River
8	Unsurveyed Island

Section	Subdivision
9	Lot 3
9	Lot 6
9	Stony River
10	E1/2; NWNW; NESW
11	E1/2NE;SWNE;W1/2NW;S1/2
12	W1/2W1/2; SESW
14	Entire
15	SWSW
17	NENW
18	SESW
18	W1/2SE
19	Lot 3
20	NESW
21	Lots 6 and 7
21	Stony River
21	SWSW
22	NWSE
22	SWSE
23	S1/2SW
26	NENW; NWNE
27	E1/2NW; NWNE
28	Lot 2; SWNW
28	Lot 3
28	Stony River
30	Lot 3; NESW
30	Lot 4
31	SENE
32	SWNW

Township 60 North, Range 10 West

Section	Subdivision
1	Grass Lake
1	Lots 1-4 and 6; SENE; SWNW
1	SWNE; SENW; Lot 5; SW1/2; W1/2SE
2	Lots 1-4; N1/2SW; S1/2N1/2; SWSW; NESE
2	SESW; SESE; W1/2SE
3	Lots 1-3; SENW; S1/2NE; S1/2
4	Lots 1-3; S1/2NE; S1/2
5	Lots 1-4 and 6-8; S1/2N1/2; W1/2SW; NESE
6	Entire
7	Lot 1; NE1/4; N1/2SE

Section	Subdivision
8	Lots 1-6; S1/2NW; SWNE; NENE
9	Lots 1-6; SENE; N1/2N1/2; NESE; SWSE
10	Deep Lake
10	Lot 8
10	Lots 1,3,4,6 and 7; Lot 11; W1/2SW
10	Unsurveyed Island
11	Deep Lake
11	Lot 1; SWSW; NWSE
11	NE1/4; E1/2SE; NESW; Lots 2 and 3; E1/2NW
12	Lots 3 and 4; SE1/4; E1/2NE; SWNE; SENW
12	NWNE; N1/2NW; SWNW
13	Pike Lake
13	W1/2NW; Lots 2, 3, and 4
14	Lots 1-6; SW1/4; W1/2Se; E1/2NE; SWNE
15	Clover Lake
15	Lots 1-4; N1/2NE; E1/2Nw; SWNW; SW1/4; SWSE
17	E. Chub Lake
17	Lots 1 and 13
17	Part of Lot 3
19	Lot 1; NWSE
20	E. Chub Lake
20	Lot 5
21	NENE
21	SESE
22	NWNE; N1/2NW; E1/2SE
23	E1/2; NENW; SW1/4
24	Lot 2; SENE; N1/2SW
24	Pike Lake
24	SWSW
26	N1/2SE; NESW
26	NWNE
26	NWNW
27	Lots 1-3; SWSE; S1/2N1/2; NESE;NWSW
27	NENE
27	SWSW
28	Lots 1 and 5; SESE
28	Lot 2
28	NESE
29	SENW; N1/2SW
30	Lot 2
30	SWNE

Section	Subdivision
31	Lot 4
34	Lot 3; SESW
34	NWNE; NENW; E1/2NWNW
35	Lot 4
35	NWNE
36	Unsurveyed Island

Township 60 North, Range 11 West

Section	Subdivision
1	Entire
2	Lots 1-5; SWSW; S1/2NW; N1/2SW; SE1/4
3	Entire
4	Entire
5	Entire
6	Lots 1-8 and 12; Lots 13, 21and 22; S1/2NE; SE1/4
7	Lot 10; S1/2NE
7	Lots 2 and 20; SESE; N1/2NE
8	E1/2; NWNW; E1/2W1/2; NWSW
8	SWNW
9	E1/2NE; SWNE; SW1/4; W1/2SE
10	NWNE; N1/2NW; SWNW
11	N1/2NE; SWNE; N1/2SE
12	Lot 1; W1/2NE; N1/2NW
13	SENE; E1/2SE
14	SENE
15	SWNE; NESW; NWSE
15	SWNW
17	NWNE; N1/2NW; W1/2SW; SESW; SWSE
18	Lots 2-16; E1/2
19	Entire
20	W1/2NE; W1/2
21	SWNE; SESW; S1/2SE
22	S1/2SE; SESW
22	SWSW
24	NENE
26	SWSW
27	NWSW; NWNE
27	SESE
27	SWNE; NW1/4
28	N1/2N1/2; NWSE
28	S1/2SE

Section	Subdivision
29	SENE
30	Lots 1-15
31	Lots 3-7 and11 and 12
31	NESE
32	W1/2SW
33	SESE
34	NENE
34	W1/2SW
35	NWNW
35	NWSW

Township 60 North, Range 6 West

Section	Subdivision
2	Entire
3	Entire
4	Entire
5	Entire
6	Lots 1-5; S1/2NE; SE1/4; E1/2SW
7	Entire
8	E1/2; E1/2NW; SWNW; SW1/4
9	Entire
10	Entire
15	NENE
15	NWNE; NENW
17	SW1/4; Lots 1 and 3; N1/2
18	Entire
19	Lots 1,3-5; SENW
20	Harriet Lake
20	NWNW
21	NWNE
28	Lot 9
29	Lot 1
30	Lots 1 and 2
31	Wolf Lake

Township 60 North, Range 7 West

Section	Subdivision
1	Lots 1-7; S1/2NW; SWNE; N1/2SW; SESW; W1/2SE
2	Lots 1-4; SWSE; S1/2N1/2; N1/2S1/2
3	Lots 1-4; E1/2SW; N1/2SE; S1/2N1/2
4	Lots 1-5; SENW; SW1/4; S1/2NE; W1/2SE; SESE

Section	Subdivision
5	Lots 1,3,4, and 5; SW1/4; S1/2NW; W1/2SE; SESE
6	Lots 1-7; SENW; NESW; S1/2NE; N1/2SE; SESE
7	Lots 1-4; S1/2NE; E1/2W1/2; SE1/4
8	N1/2; SESW; N1/2S1/2
9	N1/2; SW1/4; NESE; W1/2SE
10	NWNE; NENW; S1/2N1/2; S1/2
11	E1/2; S1/2NW; NESW
12	Entire
13	Entire
14	E1/2; E1/2NW; SWNW; SW1/4
15	N1/2N1/2; S1/2
17	N1/2NE; SWNE; W1/2; SE1/4
18	Entire
19	Entire
20	Entire
21	Entire
22	Entire
23	Entire
24	Entire
25	Lot 1; NWNE; N1/2NW
25	Lot 2 SWNE
25	Lots 4 and 5; N1/2SW
26	W1/2E1/2; W1/2; NESE
27	N1/2; SE1/4
27	SW1/4
28	Entire
29	Entire
30	Entire
31	Entire
32	SENE; W1/2NE; NW1/4; N1/2S1/2
33	NE1/4; W1/2NW; SENW; NESW; N1/2SE; Lot 4
34	Entire
34	Scott Lake
35	NENW; NWNE; SENE; Lot 1
35	Scott Lake
35	SWNE; W1/2NW; NESW; SENW; Lots 2-6, N1/2SE
36	Unsurveyed Island

Township 60 North, Range 8 West

Section	Subdivision
1	Jack Lake
1	Lots 1-5; SE1/4; E 1/2 SW
2	S1/2
3	Entire
4	Entire
5	Lena Lake
5	Lots 1-5; SE1/4; E1/2SW
6	Lena Lake
6	Lots 1-8; SESW; SWSE
7	Lots 1-4; W1/2NE; SE1/4;SENE;E1/2W1/2
8	Entire
9	Entire
10	N1/2NE; SENE; E1/2NW; SWNW; N1/2SW; SWSW; NWSE
11	W1/2NE; SENE; NW1/4; N1/2SE
12	E1/2; SWNW;E1/2W1/2; NWSW
13	E1/2; NENW; S1/2SW
14	N1/2; S1/2SW; E1/2SE
15	NE1/4, E1/2NW; SW1/4; SWNW; N1/2SE; SWSE
17	SWNE; S1/2NW; N1/2SW; W1/2SE; SESE
18	Lots 1-4; W1/2NE; NESW; E1/2NW
19	Lots 1-3; SWNE; SENW; E1/2SW; SE1/4
20	W1/2NE; NENW
21	SENW; W1/2NW; SW1/4; SWNE; W1/2SE; SESE
22	NE1/4; E1/2NW; SW1/4; N1/2SE; SWSE
23	Entire
24	Entire
25	Entire
26	Entire
27	E1/2; NW1/4; N1/2SW; SESW
27	SWSW
28	Lot 3
28	NWNE; Lot 2
28	S1/2NE
29	N1/2NW; SW1/4; W1/2SE
30	N1/2NE; SWNE; SENW; NESW
31	SENE
32	NW1/4; N1/2S1/2
32	SWSW
33	Eighteen Lake
33	Lots 1 and 5

Section	Subdivision
33	Lots 2-4, and 6; SWNW; SW1/4; W1/2SE; SESE
34	N1/2NE; Lots 1-6; E1/2NW; NESW; S1/2S1/2
34	NWNW
34	Partridge Lake
35	Entire

Township 60 North, Range 9 West

Section	Subdivision
1	Entire
2	Entire
2	Inga Lake
3	Entire
4	Lots 1 and 2; S1/2; S1/2N1/2
5	Lot 4; S1/2; S1/2N1/2
6	Entire
7	Beetle Lake
7	Lots 1-9; E1/2NW; NENE; W1/2NE
8	Entire
8	Two Lakes
9	Entire
9	Ova Lake
10	Cat Lake
10	N1/2N1/2; SENE; Lots 1-3; SWNW; SESW; W1/2SW
11	Inga Lake
11	Lots 1-4 and 6; S1/2NE; E1/2W1/2; W1/2SE
12	Entire
13	E1/2NE; NWNE; E1/2NW; Lot 3; SESW
14	Lots Pt.3, 5, 8 and 9; E1/2NW; SW1/4
15	Grouse Lake
15	Lots 3-5; S1/2; W1/2NW
15	Unsurveyed Island
17	Goose Lake
17	Lots 1-4 and 6; NENE; W1/2SE; W1/2SW; SESW
18	Lots 3 and 4; E1/2SE
19	E1/2SW; W1/2SE; SESE
21	N1/2; N1/2SW; SESW; SE1/4
22	N1/2NE; SWNE; SWNW
23	Lots 1,2, and 4; E1/2NW; NWNW
24	E1/2NE; S1/2NW
24	SE1/4
25	NWNE

Section	Subdivision
25	S1/2NW; NWSE; N1/2SW; SWSW
25	SE1/4
26	NW1/4
26	S1/2NE; NESW; W1/2SE; SESE
27	Lot 5
28	Lots 1,3,5, and Pt. 7; NWNE; NENW; S1/2NW; NWSW
28	SWSW
28	Unsurveyed Island
29	N1/2NW
29	NESE
30	SENW
31	NENE
32	NWNE;N1/2NW
35	NE1/4; SENW; SW1/4; W1/2SE

Township 61 North, Range 10 West

Section	Subdivision
3	Entire
3	Norway Lake
4	Entire
5	Entire
6	Bogberry Lake
6	Entire
7	Entire
8	Entire
9	Entire
10	Entire
13	Entire
14	Entire
15	Entire
16	August Lake
16	Entire
17	Entire
18	Entire
19	Entire
20	Entire
21	Lots 1-7; SENE; SW1/4; N1/2SE; SWSE
21	Unsurveyed Island
22	E1/2; NW1/4; N1/2SW; SESW
23	E1/2; NW1/4; N1/2SW; SESW
24	N1/2S1/2; N1/2

Section	Subdivision
25	Entire
26	E1/2NE; SWNE; W1/2; SE1/4
27	NWNE; S1/2NE; W1/2; SE1/4
28	Lots 1 and 2; E1/2NE; NWNW; E1/2SW; SE1/4
29	Lots 1,2 and 3; NENE; NWNW; S1/2NW; SW1/4; NWSE
30	Entire
31	Entire
32	Entire
33	Entire
33	Shamrock Lake
34	Lots 1,2,3, and 4; NE1/4; E1/2NW; N1/2S1/2
35	Entire
36	Entire

Township 61 North, Range 11 West

Section	Subdivision
1	Entire
2	Lots 2 - 4; SENE; SE1/4
3	Lot 2; SWSW; S1/2SE
4	Lots 1 and 2; SE1/4
5	Lots 1, 3 - 5; SENE; E1/2SW; N1/2SE
6	Entire except lots 13, 24, 27-30
7	Lots 1 - 10 and 12; Lots 15 - 19
8	Lots 1,2,3 and 4; W1/2NE; NWSE
9	E1/2; W1/2SW; E1/2W1/2
10	Entire
11	Entire
12	Entire
13	Entire
14	Entire
15	N1/2N1/2; SWNE; S1/2NW; NWSW; SESW; SE1/4
17	Lots 3-10; SENE; SESE
17	Unsurveyed Island
18	Lots 15 - 18
18	Lots 2, 7, and 9 - 14; Lots 19 - 22
18	Lots 3 - 6 and 8
19	Lot 5
19	Lots 1 - 4 and 7 - 11; Lots 17 - 19; SESE
19	Unsurveyed Island
20	Entire
21	Entire

Section	Subdivision
22	Entire
23	Entire
24	Entire
25	Entire
26	Entire
27	E1/2; SENW; W1/2W1/2; NESW
28	N1/2N1/2; NESW; N1/2SE; S1/2S1/2
29	Entire
30	N1/2NE; S1/2SE; Lots 18-24; 26-44
30	Unsurveyed Island
31	Entire
32	Entire
33	Entire
34	Entire
35	NENE; NENW; S1/2N1/2; NESW; W1/2SW; SWSE

Township 61 North, Range 12 West

Section	Subdivision
1	SESE
2	W1/2SE
3	SWSW
4	Lot 2; S1/2NW; N1/2SW; SESE
5	SE1/4; Lot 1; S1/2NE
6	Lot 4
6	N1/2SE, SWSE, W1/2NESE, W1/2SENE, Lots 2, 3 and 5
7	N1/2SE; SWSE; Lots 1, 3.4; NE1/4
8	NWSW; W1/2SE; N1/2; E1/2SW
9	E1/2SW; NWSW; E1/2; S1/2NW
10	NWNW; SWSE
10	SESE
10	SWNW
11	Lot 1
11	Lot 3; NESW
11	W1/2NE; E1/2NW
12	N1/2SW; NWSE; NENE; SWNE; SENW
13	NWSW; SESW; SENW
13	SWSW
14	N1/2NW
14	NENE; S1/2NE; S1/2S1/2; Lot 1, NESE
15	SENW; S1/2; NENE; S1/2NE
17	NENW; W1/2NW

Section	Subdivision
18	Perch Lake
18	SENW; NESW; Lots 1, 2, 4-6; S1/2NE
18	Unsurveyed Island
19	E1/2E1/2; Lots 1-3; SWNE
20	NW1/4; N1/2SW; E1/2
20	Unsurveyed Island
21	(2) Unsurveyed Island
22	Birch Lake
22	E1/2NE; NWNW; Lots 1, 2 and 5
22	Unsurveyed Island
23	N1/2N1/2; Lot 1
23	S1/2NW
24	NWNW
25	Lots 1 and 2
25	Unsurveyed Island
26	Lot 4
27	Birch Lake
27	Lot 1
27	Lot 6; SESE
27	Unsurveyed Island
28	Lots 1,2, and 6
28	Unsurveyed Island
29	Birch Lake
29	NWNE
29	Unsurveyed Island
30	Lots 3-6
30	Unsurveyed Island
31	Lot 2
31	SESW; SWSE; Lots 1,3,4 and 6, 8, 9, 11
31	Unsurveyed Island
32	Lots 2-6
32	Unsurveyed Island
33	Unsurveyed Island
34	S1/2Nw
34	W1/2 SW

Township 61 North, Range 13 West

Section	Subdivision
1	Lot 4; S1/2NW; NESW
2	Lots 1-4 and 7
2	Unsurveyed Island
4	Unsurveyed Island
10	Lot 5
10	Unsurveyed Island- 3
11	Unsurveyed Island
12	Bear Island Lake
12	S1/2SE
13	NWNE; S1/2; S1/2N1/2
14	Lots 2 and 5; NENE; NESE; S1/2SE
15	Lot 2
15	Lots 3,5, and 10
15	Unsurveyed Island
16	Unsurveyed Island
22	Lots 1-3; SWSW; S1/2N1/2
23	N1/2; SE1/4; N1/2SW
24	Lot 1
24	Lot 2; N1/2; SW1/4; NWSE
24	Unsurveyed Island
25	Lot 2
26	N1/2; N1/2SW; NWSE

Township 61 North, Range 5 West

Section	Subdivision
3	Entire
4	Entire
5	Entire
6	Entire
7	Entire
8	Lots 1-5; SWNE; W1/2; SWSE; N1/2SE
9	Lots 1-11; NWSW; SESW; S1/2SE
10	Lots 1-4; SWSW; NE1/4; NESE; E1/2W1/2
15	NESW

Township 61 North, Range 6 West

Section	Subdivision
1	Entire
2	Entire
3	Entire
4	E1/2
9	E1/2
10	Coffee Lake
10	Entire
10	Unsurveyed Island
11	E1/2; N1/2NW; SENW; NESW; S1/2SW
12	Entire
13	Bone Lake
13	Entire
14	Bone Lake
14	Entire
15	Entire
17	E1/2; E1/2W1/2; W1/2NW; NWSW
18	SW1/4; S1/2NW; Lot 1; E1/2
19	S1/2N1/2; N1/2S1/2; SWSE; SESW; Lots 1 and 2
20	Entire
21	Lots 1 - 7; SENE; NWNE; N1/2NW; SWNW; NWSW: E1/2SE
22	Entire
23	Entire
24	Entire
24	Two Lakes
25	Lots 2-8; SENW; W1/2W1/2
26	Entire
27	Entire
28	Entire
28	Tee Lake
29	Entire
29	Silver Island Lake
29	Unsurveyed Island
30	Entire
30	Unsurveyed Island
31	Lot 4
31	Lots 1, 2, 5 - 11
31	Silver Island Lake
31	Unsurveyed Island
32	Entire
32	Silver Island Lake

Section	Subdivision
32	Unsurveyed Island
33	N1/2; Lots 1 and 2; N1/2S1/2
34	Entire
34	Windy Lake
35	Entire

Township 61 North, Range 7 West

Section	Subdivision
13	NWNE; NENW; SWSW
14	Lot 3; SWNW; SW1/4; W1/2SE; SESE
15	Entire
17	Lots 1 and 2; W1/2; Lots 3 - 5
18	Lots 1 - 6; NENE; S1/2NE; NESW; N1/2SE
19	Entire
20	Lots 1 and 2; NWNE; S1/2NE; NW1/4; SWSW; N1/2S1/2
21	Entire
22	E1/2; E1/2W1/2; W1/2NW; NWSW
23	NWNE; NENW; SENE; W1/2SW; SESW
24	NE1/4; S1/2NW; S1/2
25	Lots 1 -4; SWNE; W1/2W1/2; W1/2SE
26	Entire
27	NWNW; SWSE
28	W1/2NE; NW1/4; N1/2SW; SWSE
29	Lots 1 - 10; S1/2SW; SE1/4
30	Entire
31	Entire
32	NW1/4; N1/2SW
33	Entire
34	Lots 2 - 4; NE1/4; S1/2NW; NESW; N1/2SE
35	Lots 1 and 2; SWNW; N1/2SW

Township 61 North, Range 8 West

Section	Subdivision
1	Section One (1), except that part lying within the Boundary Waters Canoe Area Wilderness as described August 1979 in accordance with Public Law 95-495 dated October 21, 1978.
2	Lots 1 - 5; S1/2N1/2; E1/2SW; SE1/4
3	That part of Section Three (3) lying east of the Boundary Waters Canoe Area Wilderness as described August 1979 in accordance with Public Law 95-495 dated October 21, 1978.
9	E1/2; SENW; NESW; S1/2SW
10	Entire

Section	Subdivision
11	Lots 1, 3 - 9; E1/2; SENW
12	Entire
13	Entire
14	Lots 1 -4, 7 - 11; NWNE; NWSW; SWSW; E1/2SW; SE1/4
15	Entire
16	Entire
17	E1/2; W1/2NW; SW1/4
18	Entire
19	Entire
20	Entire
21	NWNE; S1/2NE; W1/2; SE1/4
22	E1/2; NENW; S1/2NW; SW1/4
23	N1/2NE; SWNE; W1/2; NWSE
24	Entire
25	Entire
26	Entire
27	N1/2; E1/2SW; SE1/4
28	N1/2; SW1/4; NWSE; S1/2SE
29	Entire
30	Entire
31	Lots 1 - 6; NE1/4; E1/2NW; NESW; N1/2SE
32	Lots 1, 2, and 4; SWNE; N1/2NE; NW1/4; N1/2SW; NWSE
33	Entire
34	Entire
34	Helen Lake
35	Lots 1 - 4; NE1/4; S1/2NW; NESW; N1/2SE
36	Entire
36	Jack Lake

Township 61 North, Range 9 West

Section	Subdivision
8	In Section Eight (8); that part of the Southeast of the Southeast Quarter (SE1/4 SE1/4) lying southeasterly of the Boundary Waters Canoe Area Wilderness as described August 1979 in accordance with Public Law 95-495 dated October 21, 1978.
9	In Section Nine (9); that part of the South Half (S1/2) lying southwesterly of the Boundary Waters Canoe Area Wilderness as described August 1979 in accordance with Public Law 95-495 dated October 21, 1978.
11	In Section Eleven (11); that part of the South Half of the Southeast Quarter (S1/2 SE1/4) and the Southeast Quarter of the Southwest Quarter (SE1/4 SW1/4) lying southerly and westerly of the Boundary Waters Canoe Area Wilderness as described August 1979 in accordance with Public Law 95-495 dated October 21, 1978.
13	Entire

Section	Subdivision
14	E1/2; S1/2NW; SW1/4
15	N1/2; SW1/4; N1/2SE
16	Entire
17	E1/2E1/2; SWNE; NWNW; SW1/4
18	Lots 1 and 4; E1/2; E1/2W1/2
19	Entire
20	Entire
21	Entire
22	N1/2; NESW; N1/2SE; SESE
23	S1/2
24	S1/2N1/2; NWNW; S1/2
25	W1/2NE; SENE; W1/2; SE1/4
26	Entire
26	Little Bear Lake
27	N1/2; SW1/4; N1/2SE; SESE
28	Entire
28	Sphagum Lake
29	Entire
30	Lots 1, 2 and 3; NE1/4; E1/2NW; NESW; N1/2SE
31	Lots 1, 2, 4, 5, 6, and 7; NE1/4; SENW; NESW; N1/2SE
32	Lot 1; N1/2; NWSW
33	Lots 3 and 4; N1/2; N1/2SE
34	Lots 1 and 2; SWNE; N1/2S1/2; NW1/4
35	Little Bear Lake
35	Lots 1 - 6; E1/2NE; SWNE; SENW; N1/2S1/2
36	Entire

Township 62 North, Range 10 West

Section	Subdivision
19	Section Nineteen (19), except that part lying within the Boundary Waters Canoe Area Wilderness as described August 1979 in accordance with Public Law 95-495 dated October 21, 1978.
20	Section Twenty (20), except the Northeast Quarter of the Northeast Quarter (NE1/4 NE1/4).
29	E1/2; NW1/4; NESW; S1/2SW
30	Lots 1, 2, 3, and 7; NE1/4; E1.2NW
30	NESW
31	Bogberry Lake
31	Entire
32	Entire

Township 62 North, Range 11 West

Section	Subdivision
3	SESE
4	SWSE
4	N1/2SE
5	Unsurveyed Island
6	Unsurveyed Islands (2)
7	E1/2NE
7	Lots 7 and 8
7	White Iron Lake
8	N1/2NE
8	S1/2NE
8	S1/2NW
9	N1/2NW
9	SESW; S1/2SE
10	NENE
10	SWSE
10	E1/2SE
11	NWNW
12	SE1/4
12	SESW
13	NE1/4 NE1/4, NW1/4 SE1/4, Government Lots 1,2,3,4, and SW1/4 SW1/4, except that part lying within the Boundary Waters Canoe Area Wilderness as described August 1979 in accordance with Public Law 95-495 dated October 21, 1978.
13	Lot 5
14	SESE
15	NWNE; NWSE
18	Lot 2
18	Lots 1, 3, and 4; NESW
18	NWNE; NESE
18	Unsurveyed Islands (4)
18	White Iron Lake
19	Lots 1 and 6; NESW; NESE; N1/2SE
20	W1/2SW
21	E1/2; N1/2NW
22	Lot 2; NWSE; SENE; NWSW
23	Lot 6
23	Lots 7 and 8
23	Unsurveyed Island
24	Entire except the NW1/4 NW1/4, Government Lot 9, and that part lying within the Boundary Waters Canoe Area Wilderness as described August 1979 in accordance with Public Law 95-495 dated October 21, 1978.
25	NENE; E1/2SW; NWSE; S1/2SE

Section	Subdivision
25	NWNE; SWNW; N1/2NW
25	S1/2NE; SENW; NESE
26	S1/2NE; NWSE; NESW
26	SESW; SWSE
27	NWNW; SESW
28	NENE; NWNE
29	S1/2NE; SW1/4
30	Lots 2, 3, 6, 7, and 8; N1/2NE; E1/2SE
30	S. Kawishiwi River
30	Unsurveyed Islands (4)
31	Lot 7
31	Lots 1 and 6; E1/2; NENW
32	Lots 1 - 3; NENE; NESW; SWSW; W1/2NE; NWSW
32	N1/2SW; SWNW
32	Unsurveyed Island
33	Lots 2, 6, and 7; NESE; SWSE
33	SENE
34	S1/2NE; N1/2SW; W1/2SE
35	N1/2NE; NESE; N1/2NW; NWSW; SWSE

Township 62 North, Range 12 West

Section	Subdivision
1	Lot 7
1	Lots 1 and 9; SENE
1	White Iron Lake
7	Lots 3 and 4, NWSE; SWNE
7	Mitchell Lake
12	Unsurveyed Island
13	Lot 1
13	Unsurveyed Island
18	Lot 3
18	Unsurveyed Island
19	Lot 4; NWSE
20	SESW
20	SWSE
22	SW1/4
24	Unsurveyed Island
25	E1/2E1/2; W1/2NW; NWNE: SENW
27	N1/2SW; SWSW
28	N1/2SW; SENW; SWNE
28	NWNW

Section	Subdivision
29	N1/2NE
29	NESW; N1/2SE; SENW
30	Johnson Lake
30	Lots 2, 3, 5, and 6
31	Johnson Lake
31	Lots 1, 4 - 8; SESE
31	Unsurveyed Island
32	Lot 6
32	Lots 3, 4, and 5
32	NESW
32	NWNE; W1/2SW
32	Unsurveyed Island
33	Lots 1, 2, and 5
33	Unsurveyed Island
34	Lots 1 and 2.
34	One Pine Lake
35	SWSW; E1/2SE

Township 62 North, Range 13 West

Section	Subdivision
3	Lot 1
3	S1/2S1/2
10	SE1/4
10	W1/2
11	SW1/4
12	NESW
12	S1/2SE
13	Lot 1
14	NWNW; Lot 3
14	Unsurveyed Island
15	Lot 8
24	NWNW
24	S1/2SE
24	SWNW
25	N1/2SE; SWSE; S1/2SW; SENE; NWSW
26	NESE; S1/2S1/2
27	NENE
27	SESE
27	SWNW
34	E1/2NE
34	S1/2NW; SE1/4; W1/2NE; NENW

Section	Subdivision
35	E1/2; E1/2NW; N1/2SW
35	W1/2NW

Township 62 North, Range 5 West

Section	Subdivision
27	NE1/4; NENW; Lots 2-4; SESW; W1/2SE; SESE
28	W1/2NE; W1/2; Lots 1-3; NWSE
29	Entire
30	Entire
31	Entire
32	Entire
33	Lot 3; SENW; S1/2
34	SENE; W1/2NE; W1/2; SE1/4

Township 62 North, Range 6 West

Section	Subdivision
21	That part of Section Twenty-one (21) lying outside of the Boundary Waters Canoe Area Wilderness as described August 1979 in accordance with Public Law 95-495 dated October 21, 1978
25	Cook Lake
25	Entire
25	Unsurveyed Island
26	Entire
27	Entire
28	In Section Twenty-eight (28); the East Half (E1/2), and the East Half of the West Half (E1/2 W1/2)
33	In Section Thirty-three (33); the North Half of the Northeast Quarter (N1/2 NE1/4), the Northeast Quarter of the Northwest Quarter (NE1/4 NW1/4), and the South Half of the Southeast Quarter (S1/2 SE1/4).
34	Bill Lake
34	Lots 1, 2, and 6; NWNE; NENW; SWSE; W1/2W1/2
35	S1/2NE; NENW; S1/2SW; SE1/4

Township 63 North, Range 11 West

Section	Subdivision
20	Unsurveyed Island
27	N1/2SE; SWNE; SENW
28	Unsurveyed Island
29	Lot 8
29	Unsurveyed Island
32	Lot 9
34	Unsurveyed Island

Township 63 North, Range 12 West

Section	Subdivision
6	Lots 3 and 4
7	Lots 2 and 3
11	NESW
13	Cedar Lake
13	N1/2SW
13	SENE exc. 3.2 ac.; Lots 3 and 4; SWNW
14	S1/2NW
17	Unsurveyed Island
20	Lot 7
20	Unsurveyed Island
21	NENW
21	Unsurveyed Island
22	Unsurveyed Island
28	Unsurveyed Island
29	Lot 1
29	Unsurveyed Island
30	Lot 1
30	Lot 9
30	Unsurveyed Island
33	Shagawa Plat *

Township 63 North, Range 13 West

Section	Subdivision
1	Lots 1, 3, 4, 8; SENE; NESE
2	Lots 1 - 7; SENW
2	NESW
2	Twin Lakes
2	Unsurveyed Island
3	Unsurveyed Island
10	Lots 6, 7, 9 and 10; SENE; NESE
11	Lot 1; E1/2SW; SENW; NWSE
11	NENW; SWSE; S1/2NE
12	Lot 1; SENE; SENW; W1/2NW; NESE
12	NWSE
13	Unsurveyed Island
14	Lots 1 and 2; NENW
15	Burntside Lake
15	Lot 10
15	Lots 1 and 2
15	Unsurveyed Island

Section	Subdivision
16	Unsurveyed Island
20	Lots 26, 29, and 30
28	S1/2SE
29	Unsurveyed Island
30	Unsurveyed Island
31	Unsurveyed Island
33	N1/2NE
34	E1/2SE; NWSE
34	SWNE; SENW; N1/2NW