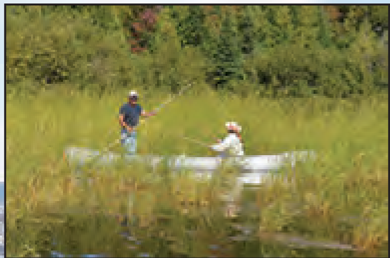
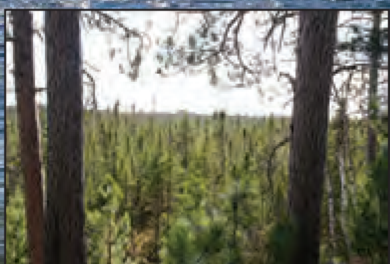
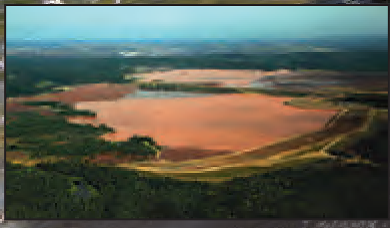
Metallic Mineral Mining: The Process & the Price







Great Lakes Indian Fish & Wildlife Commission

Metallic Mineral Mining: The Process & the Price

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Introduction

Point Abbaye, Michigan on Lake Superior's south shore.

The development of a major mine entails a substantial and long-term alteration of the landscape and the natural environment. Mining, particularly metallic mining, also presents certain unavoidable ecological risks. According to the US Environmental Protection Agency (EPA), the metal mining industry is the largest source of chemicals to the environment in the United States, and history is replete with examples of mine-related pollution. The EPA's Abandoned Mine Lands program currently lists 130 mine sites as having known or threatened releases of hazardous pollutants or contaminants. Mining disasters are not limited to distant history; since 2014, catastrophic collapses of metallic mine tailings ponds have occurred in British Columbia and in Brazil, sending contaminated effluent into waterways and, in the case of Brazil, costing many human lives.

Not all mines will cause the severe harm that some past mines have, and some of the ecological threats can be mitigated. Nevertheless, the decision to allow a metallic mineral mine reflects an acceptance of some degree of ecological harm, the extent of which can never be absolutely known or predicted with precision. The true price that will be paid for a mine's anticipated benefits becomes clear only if or when the theoretical risks manifest in environmental degradation.

For Indian and Aboriginal people and communities in the Upper Great Lakes region, the price of metallic mining can be particularly devastating. Tribes rely on natural resources like fish, wildlife, and wild plants for subsistence and to support them spiritually, culturally, medicinally, and economically. When mining affects the health and availability of resources that native people depend on for these purposes, their ways of life and their ability to sustain healthy communities is also affected.

Metallic Mineral Mining: The Process and the Price provides an overview of metallic mining by describing its stages and their associated environmental risks and illustrating those risks through real-life examples. It provides a brief overview of the laws and regulations related to mine permitting and environmental review, including US federal law and the laws of Minnesota, Wisconsin, Michigan, and the Canadian province of Ontario. It also describes how tribal treaty-reserved rights and an Anishinaabe worldview can intersect those laws. Most importantly, this document explains why the risks associated with mining pose special threats to Indian people who rely on the natural world to sustain their communities and whose culture and lifeways depend on access to clean and healthy natural resources.

Finally, it must be noted that this document has been produced by the Great Lakes Indian Fish and Wildlife Commission (GLIFWC), a natural resource agency representing 11 Ojibwe tribes in Michigan, Minnesota, and Wisconsin as they implement their off-reservation, treaty-reserved hunting, fishing and gathering rights. *Metallic Mineral Mining: The Process and the Price* is informed by that perspective. While this document uses a variety of terms in reference to Indian people (including tribe, tribal, Indian, Anishinaabe), it is intended only to reflect the beliefs and views that GLIFWC has come to understand in the course of serving its member tribes. In addition, this document refers to Ojibwe tribes in several ways. Ojibwe/Ojibwa tribes have come to be known as Chippewa in English; in Canada, the Ojibwe/Ojibwa are known as First Nations rather than tribes. Anishinaabe or its plural, Anishinaabeg, are the Ojibwe words for Indian(s), or original person (people), which are their names for themselves.

Despite the limits described herein, for other tribes that may be similarly situated or share a skepticism about the potential price they may pay for mineral development in areas they use to exercise their lifeways and sustain their communities, we hope this document may be helpful.

An Introduction to Metallic Mineral Mining and Tribal Land Interests in the Upper Great Lakes Region

Mining is the process by which target materials are extracted from the earth. Metallic mining refers to the extraction of both ferrous metals (typically iron) and nonferrous metals (including gold, silver, copper, nickel, lead, and zinc). Many of these metals are common elements in the earth's crust but usually exist only as components of other minerals and in minute quantities. Iron, for example, is the most plentiful of these elements but accounts for only about 5% of the world's crust by weight. Copper accounts for only 0.0058%, and lead and zinc account for even less. Because of the rare geological occurrence of these metals, they must be found in relatively high concentrations in order for mining to be economical.

When prices and demand for metal is high, lower-grade deposits become more economically feasible to extract.

Comparison of a disseminated copper ore (left) and a piece of native copper (right). Disseminated ore bodies have a small amount of metallic mineral by volume.

Understanding the Definition of Ore

Ore is defined by economics: a geologic formation is considered an ore body if it contains minerals in sufficient quantity to profitably mine. The definition of ore changes depending on the target mineral. High-grade iron ore has an iron concentration of 60%, while lower-grade taconite ore mined in the upper Great Lakes region has a concentration of 25% to 30%. For copper, a metal more valuable than iron, the definition of ore is different. At the closed Flambeau mine near Ladysmith, Wisconsin, for example, the ore averaged about 9.5% copper, a concentration that was more than sufficient to profitably extract. Sometimes an ore body contains more than one target mineral, and the combination alters the economic equation. While the massive portion of the ore body of the Back Forty site near Stephenson, Michigan contains only 0.44% copper, the ore body also contains an 8% concentration of zinc, increasing the overall economic viability of the deposit.

When prices and demand are high, lower-grade deposits become more economically feasible to extract. The proposed NorthMet mine in Minnesota, for example, has a disseminated ore body containing 0.28% copper, 0.08% nickel, and trace amounts of other precious metals. Despite the relatively low grade of this deposit, the mine operator, PolyMet, has applied for permits to mine at this site.

Metallic mineral mining refers to the extraction of both ferrous and nonferrous metals. *Sulfide mining* is a term often used to describe the mining of nonferrous metals, including copper, lead, zinc, and others, because these metals frequently are bonded to sulfur, forming sulfide compounds. But it is misleading to place only these types of metal mining under the sulfide description because various forms of sulfide also are found in ferrous (iron) mining. In the upper Great Lakes region, for example, iron deposits often exist within and adjacent to geologic formations that contain sulfur and sulfides. Ferrous mining can result in disturbance of the adjacent rock and thus mobilize sulfur. Minnesota's Iron Range is a prominent example of this effect: as the target iron ore is mined, the tailings basins and pit lakes left behind produce sulfur compounds that impact surface and groundwater throughout the Iron Range.

Native and European Metallic Mining in the Upper Great Lakes Region

Metallic mining in the Great Lakes region is not a new phenomenon. As far back as 4,000 B.C., indigenous people throughout the area used copper for jewelry and other articles. Much of this copper was easily accessed from formations found at the surface and along the shore of Lake Superior. Native people heated the copper and shaped it into jewelry and tools such as knives and spear points; the copper required no further processing because it was pure and not bound to other elements. As with silver and gold found in other areas of the western hemisphere, the copper used in the Great Lakes region by Indian peoples was primarily ceremonial and aesthetic. Great Lakes copper was also traded throughout North America.

The ability of tribes to exercise their treaty-reserved rights, both on and off their reservation land, can be profoundly impacted by mining activities.

Intensive commercial exploitation of native copper and high-grade iron ores began with the arrival of European miners in the second half of the nineteenth century. By the middle of the twentieth century, the high-grade ores of the Great Lakes region had been depleted. Today, the only potential sources of copper and other metals in the area are lower quality ores.

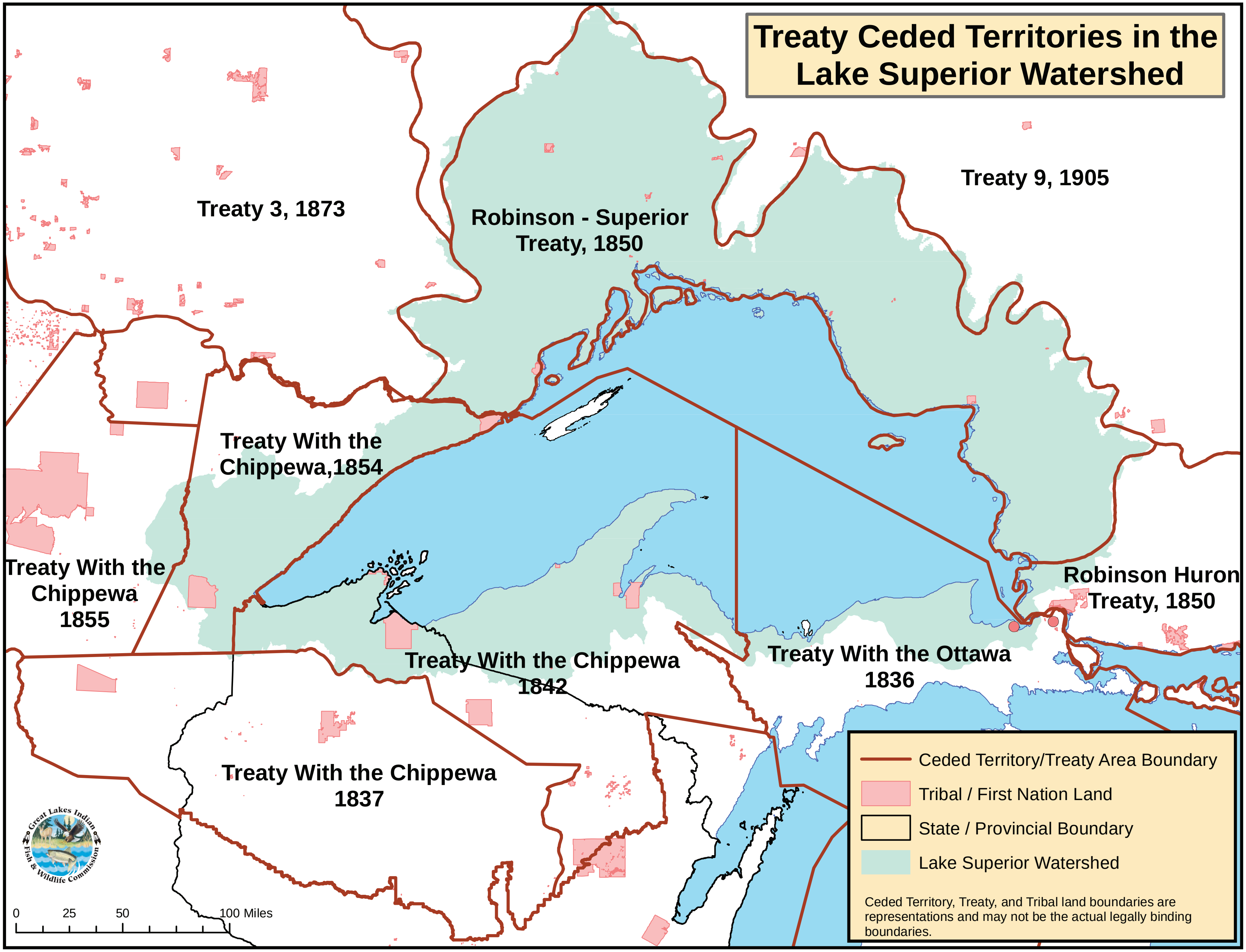
Mining remains an important issue to tribes in the region, some of whom retain legal rights to use the land. The ability of tribes to exercise their treaty-reserved rights, both on and off their reservation land, can be profoundly impacted by mining activities.

Understanding the Rights of Tribes and Aboriginal People in the Upper Great Lakes to Use the Land

Prior to contact with European settlers and foreign governments, tribes exercised their sovereignty both internally, by establishing their own governing systems, and externally, by forming alliances with other tribal nations. Anishinaabe tribes in the upper Great Lakes entered into their first treaty with the Spirit of the Universe. This Great Law of Nature holds that the land is a gift from the Creator and the Anishinaabeg are to live in harmony with and take care of that land through ceremonies, teachings, language, and the way they live their lives, or their lifeway.

The United States and Canadian governments, upon their arrival in North America, recognized the sovereignty of the Anishinaabe tribes and dealt with them on a government-to-government basis. In the early and mid-nineteenth century, various treaties were signed between the US and Canadian governments and Anishinaabe tribes in northern Wisconsin, northeastern Minnesota, and northern Michigan as well as in the Canadian province of Ontario.

Courts have ruled that in the treaties, the Ojibwe sold or ceded a considerable amount of land to the federal government



Areas ceded by tribes in the western Great Lakes region.

Land use decisions that put mining interests before native interests may violate legal guarantees and undermine the tribes' abilities to sustain their communities in ways that are consistent with their teachings and worldview.

but did not give up all rights of usage. These lands often are referred to as ceded territory. (See map on page 5.) Within the ceded territories, the signatory tribes reserved the right to continue to hunt, fish, and gather on the land. Modern state and federal court decisions have affirmed these rights as valid and continuing. The Ojibwe rights to hunt, fish, and gather on ceded territory lands are called treaty rights, usufructuary rights, or reserved rights.

Tribes also have reservations within the ceded territory. Tribes have more extensive rights to control activities on their reservation land than in ceded territory, but the establishment of reservations did not limit or curtail their reserved rights to hunt, fish, and gather *off* the reservation on lands within the ceded territory.

Similarly, Canadian Ojibwe First Nations in the Lake Superior region signed treaties with the government of Canada in which they ceded land but retained the right to hunt and fish in the territory ceded. The treaties that created the ceded territory in the Ontario portion of the Lake Superior basin also provided for reserves (or reservations) for individual First Nations.

For tribes and First Nations in both the US and Canada, their status as sovereigns, recognized in treaties and upheld by courts, provides the basis for their right to maintain themselves as distinct cultural and self-governing entities. Their sovereignty and authority over their reservations and exercise of treaty-reserved rights carries particular responsibilities, including the proper management of those resources.

In carrying out these management responsibilities, tribes work to assure the continued quantity and quality of natural resources. Tribes also coordinate the exercise of sovereignty and management with other governments exercising concurrent authority in the ceded territories. Land use decisions that put mining interests before native interests may violate these legal guarantees and undermine the tribes' abilities to

Extensive landscape alteration at the Hull-Rust mine in Minnesota.

sustain their communities in ways that are consistent with their teachings and worldview. (Chapter 5 provides a more detailed look at Anishinaabe lifeways.)

Mining's Potential to Alter the Life Sustaining Resources of the Anishinaabeg

The ability to practice their lifeways on reservation land and in ceded territories is fundamental to Anishinaabeg survival as distinct cultural and political entities. Healthy natural resources sustain the lifeways of Indian people who depend on them for spiritual, cultural, medicinal, subsistence, and economic purposes. Mining puts the land and these natural resources at risk.

All mining activity will affect air, water, soil, and living organisms. Some mining impacts are less severe than others, and some can be prevented or mitigated. But any mining project necessarily involves a degree of environmental disturbance that can never be exactly predicted. And while any type of mining alters the natural landscape and produces mining waste, metallic mining poses environmental risks that are especially acute due to the tremendous scale of some metallic mines and the geochemical characteristics of the target minerals, ore body, and surrounding rock.

Undersized sedimentation basin along a mine haul road. The sediment will need to be removed for the basin to work as intended.

Given these inevitable impacts, state and federal regulators in ceded territories must determine what levels of pollution are acceptable or allowable under various permits. Tribes generally do not set regulatory standards in ceded territories; thus, they may be concerned that other governments will not adequately consider their worldview or reliance on natural resources when setting applicable standards.

Mine operators often attempt to reduce the environmental impact of their projects through mitigation measures including air and water capture and treatment systems, sedimentation basins, and wetland mitigation activities. When mitigation measures are insufficient or fail, however, the resulting destruction of natural resources can profoundly affect the native people who rely on them. For Anishinaabe people, harvesting natural resources is

Anishinaabe people are very cautious when making decisions that may affect the health or availability of natural resources; their worldview holds that decisions must ensure the protection of the resources for the next seven generations. Negative consequences that occur within 250 years would fail this cultural standard.

Access portal for the Eagle mine is drilled into the base of Eagle Rock, a sacred site to tribal people. (photo courtesy of Chauncey Moran)

more than just a means to provide food. Hunting and gathering are cultural and spiritual activities that renew both the person and the harvested resource. Anishinaabe people are very cautious when making decisions that may affect the health or availability of these resources; their worldview holds that decisions must ensure the protection of the resources for the next seven generations. Negative consequences that occur within 250 years would fail this cultural standard.

For tribal communities, reservation lands and land in ceded territories provide the environment needed to practice their culture, traditions, and sustain their ways of life. On these lands, mining can affect fundamental aspects of tribal life and culture in a number of ways. Tribal members may lose opportunities to use and harvest resources due to the destruction of fish, wildlife, and plant habitats, the disruption of wildlife migration patterns, the closure of public lands, or the contamination of water, air, or soil. In addition, the economic value of resources harvested by tribal members may be lost.

The impact of mining on tribes goes far beyond the ability of tribal members to find appropriate fish and wildlife to serve as meals or ceremonial feasts. Tribal culture itself suffers when natural resource usage patterns are altered, disrupted, or destroyed. Mining can threaten traditional Anishinaabe ways of life and tribes' existence as a culturally distinct people. This perspective was expressed by Susan J. LaFernier of the Keweenaw Bay Indian Community to help explain the deep concern or opposition many tribal members have toward mining:

> ...[metallic mining] gains are far outweighed by the potential for permanent and severe damage to the

environment in and around the Tribe's territory along with the human health risks associated from certain mining related contamination for our generation and generations to come. The preservation of our land, our culture, and our way of life require that we act now as guardians for the next seven generations and mining will be the single greatest threat to our water and lands in our lifetime along with all of the other challenges. As Ojibwa (Nature's) people, we are a part of Lake Superior and the land, and our survival depends on both. We all need to share the responsibility and privilege to care for our Earth and not make any more environmental 'mistakes.'

Mining can pose significantly different risks to tribes than to other natural resources users because of tribes' dependence on healthy natural resources. But despite being uniquely affected by mine permitting decisions, tribes are not often the decision makers. In determining where and to what extent mining is allowed in any geographical area, state and federal decision makers bear a special responsibility to ensure tribal lifeways are respected and protected.

Rivers, lakes, and wetlands interconnected by shallow groundwater systems are common in the Great Lakes region. (photo courtesy of Chauncey Moran)

Challenges of Mine Waste in a Complex Hydrologic Setting

Predicting a mine's environmental impacts involves an extensive process of site-specific research and complex data gathering and analysis. For regulators to reach a decision about whether to allow a mining project, the potential environmental consequences of a proposed project must be accurately described and fully understood. Impacts such as the project's effects on water quality can be difficult (although not impossible) to predict; historically, a majority of mine projects have failed to accurately predict the water quality issues that ultimately occurred. Many of these failures were caused by a lack of sufficient baseline data and incomplete understanding of local hydrological processes.

Understanding how and why past mining operations failed to protect water quality is particularly important in the Lake Superior basin because of its complex hydrology. Numerous lakes, wetlands, and rivers are interconnected by complex groundwater systems. These groundwater systems in turn connect through different layers of glacial materials in the shallow aquifer, as well as in fractures and faults in the bedrock.

The abundance of interconnected water systems in the Lake Superior basin significantly increases the risks associated with metallic mining. Multiple interacting water systems lead to uncertainty in predicting how pollutants will behave within them and the adequacy of pollution control measures. An abundance of water also makes it more likely that pollutants will contaminate the water and less likely that pollution controls will be completely effective. Finally, the Lake Superior region is one of climate extremes. A mine's tailings basins, caps and liners, and stockpiles must be designed to withstand a number of challenges, including temperature changes, heavy rain and snow, freezing and thawing soils, as well as future climate change effects that are not yet fully understood.

To prevent pollution of ecosystems near mining sites, mining wastes must often be permanently isolated from the environment. This isolation is extremely difficult and efforts to do so have failed at many mines. Two reasons can be cited for these failures. Current technology for managing mine waste is constantly evolving and no method has been in use long enough to completely prove itself. Research on how to prevent or mitigate acid mine drainage and pollutant leaching is ongoing; new metallic mining operations in the western Lake Superior region would only be the testing grounds for these technologies. Second, the effectiveness of any mine's pollution control technology depends on a number of factors, including the unique characteristics of its operation, the characteristics of the ore, and the environmental characteristics of the site. Every mine is unique, and every mine's pollution control plan must be specifically designed for those characteristics. (Chapter 3 and Chapter 4 discuss many of the potential impacts of metallic mineral mining.)

Wild rice winnowing.

Wild rice harvest.

Evaluating a Mine's Potential Social, Economic, and Environmental Impacts

Generally, before mining begins, decision makers must conduct a comprehensive analysis of environmental and other effects of the proposal. Sound public policy can only be made by recognizing the nature of the environmental threats and by understanding that science and technology cannot always predict or repair all of mining's impacts.

Additionally, there are treaties, legislation, and judicial decisions that guarantee tribal rights. Any mine permitting process must give full weight to how the mine would affect Indian tribes. For those impacts to be fully understood, decision makers should explore the traditional ecological knowledge (TEK) held by tribal members. Traditional ecological knowledge stems from centuries of living in close connection to the land. It provides critical information not just about tribes and their relationship to natural resources but about the resources themselves and their appropriate management. Any permitting process must afford tribes the opportunity to fully participate; only in this way can potential impacts be properly understood and evaluated from a tribal perspective.

The process of predicting, describing, and evaluating potential impacts in the US generally requires the development of an Environmental Assessment (EA) or the more comprehensive Environmental Impact Statement (EIS). In Canada, this type of review is required in some but not all cases. The environmental review process in the US involves an analysis of the direct, indirect, and cumulative environmental consequences of the proposed action as well as a discussion

When a project affects treaty or trust resources, whether on or off reservation, tribes' concerns must be considered during the environmental review process.

of any alternatives to the action. The EA and EIS processes also examine a mine's potential socioeconomic impacts on the human environment. (Chapter 4 describes issues related to mining's socioeconomic impacts; see Chapter 6 for a fuller description of the environmental review and permitting processes.)

When a project affects treaty or trust resources, whether on or off reservation, tribes' concerns must be considered during the environmental review process. The review process may also trigger various pieces of federal legislation, depending on the project's expected impacts. Some of the federal acts include the National Historic Preservation Act, the American Indian Religious Freedom Act, and the Native American Graves Protection and Repatriation Act of 1990.

Predicting a mine's impacts on the surrounding environment is a complex undertaking. If data is incomplete or insufficient, the environmental review process and the resulting EA or EIS can underestimate or mischaracterize environmental impacts. Accurately estimating the environmental price of mining is essential to meeting environmental review requirements and making informed decisions.

Ensuring a Mine Can Clean Up the Damage

When a decision is made to move forward with mining activities, a mine operator must provide some form of *financial assurance* to ensure the mine site is reclaimed properly when the mine stops operating. The amount of financial assurance differs for each project and is based on estimated closure and reclamation costs; the primary goal is to ensure taxpayers are not left to pay for them. Unfortunately, financial assurance amounts often are based on *predicted* impacts, meaning they can fail to cover the costs of fixing or remediating those problems that were not predicted.

Because closure and reclamation costs are based on a prediction of the mine's impacts, an accurate cost estimate requires a detailed closure and reclamation plan. High-quality predictions of impacts are critical: if impacts are missed, or their severity is underestimated, the amount of financial assurance will be insufficient to cover the costs.

Several forms of financial assurance can be used for mining projects. The most secure is cash or an equivalent financial instrument that will provide funds even if the mining company declares bankruptcy. Less desirable financial assurance instruments include surety bonds and insurance. Mining companies might also propose a self-guarantee for financial assurance. If a mining company goes bankrupt, however, a self-guarantee holds little promise because the money can be distributed to other creditors instead of paying for clean-up activities.

Because closure and reclamation costs are based on a prediction of the mine's impacts, an accurate cost estimate requires a detailed closure and reclamation plan. High-quality predictions of impacts are critical: if impacts are missed, or their severity is underestimated, the amount of financial assurance will be insufficient to cover the costs. Underestimating a mine's impact on water quality, for example, may mean the financial assurance is insufficient to pay for a water treatment facility after the mine closes. All of these uncertainties combine to make financial assurance a vital topic in planning for mining.

2. From Raw Earth to Refined Metals: The Stages of the Metallic Mining Process and Their Effects on Surrounding Ecosystems

From inception through closure, a mine goes through several stages of development, each with its own impacts on the environment and local ecosystems. The various stages affect ecosystems, habitats, and the quality and quantity of natural resources that live there.

Exploration: The Challenge of Exploring Under the Surface

A mine operator typically explores a potential site to determine whether it wants to move forward with a mining operation. A key question during exploration is whether the deposit contains minerals in a high enough concentration to make it economically viable to extract them. A mine operator weighs many criteria, not only how much target mineral the deposit contains but also the mineral's quality (grade) and the cost of removing it in a manner that safeguards the surrounding ecosystem.

Taconite pellets.

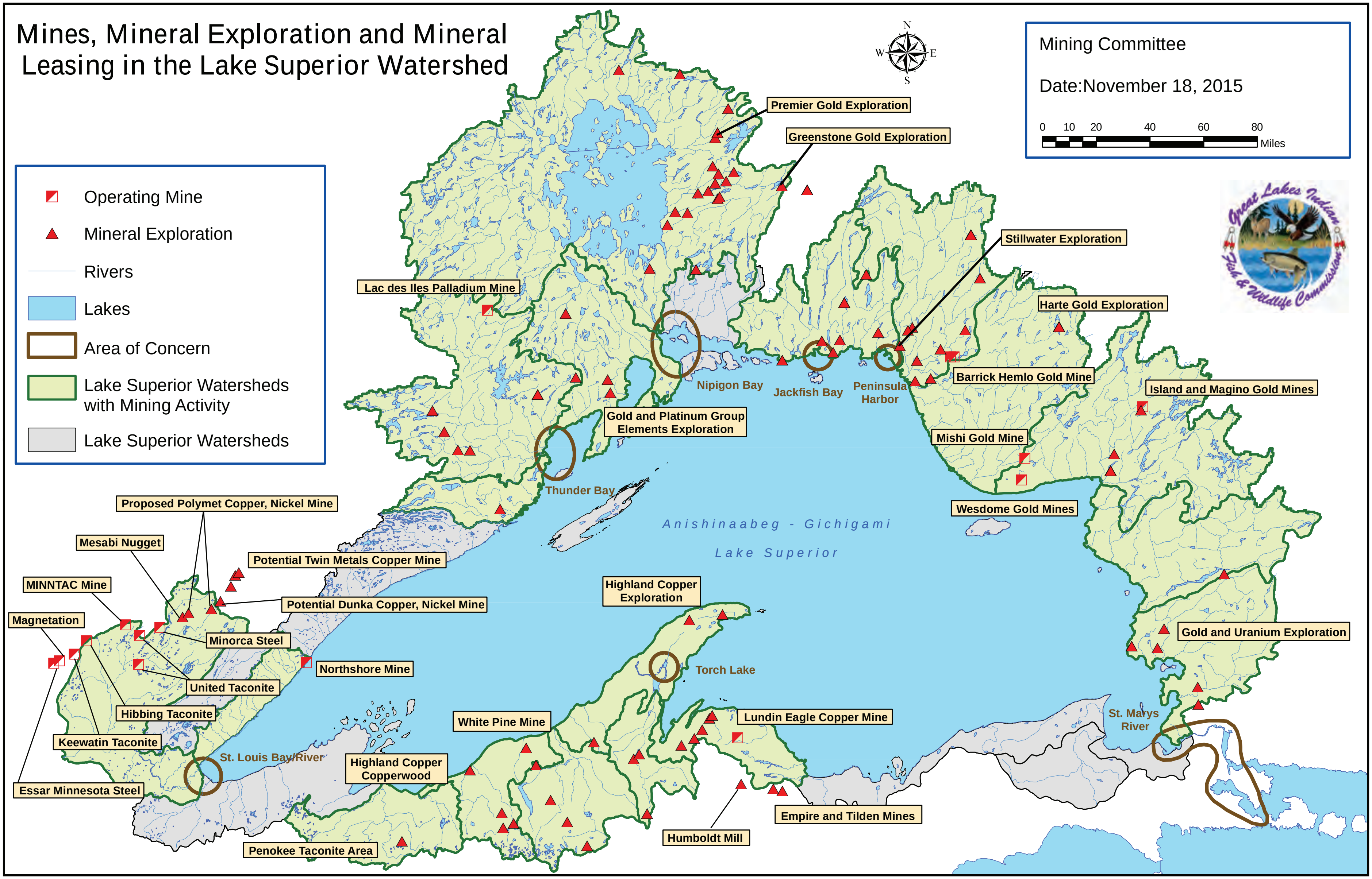
The mine operator also has to consider the costs of returning the mine site to a pre-mine condition after the deposit is exhausted and mining ends.

The map on the next page shows areas of historic and current mineral exploration throughout the Lake Superior basin. The map also depicts areas that have been identified as having potential for mineral development. While it is unlikely that many of these deposits will become operating mines, the fact that exploration is occurring indicates that those areas have the potential to be developed.

Exploratory drilling penetrates different geologic layers and may cause water from different aquifers to mix, thereby changing the water's chemistry. It can also cause water elevations within an aquifer to change, causing wells to go dry.

In the exploration phase a mining company conducts field explorations, core drilling, metallurgical bulk sampling and testing, and other studies. In addition to determining the economic viability of the deposit, one of the goals of the exploration phase is to establish the geometry of the ore body and whether it is amenable to processing. The information also helps determine the economic potential of the ore body and whether it is suitable for underground or open pit mining.

The standards by which an ore body is judged suitable for mining can vary over time. When high-grade iron ore was plentiful, taconite (a low-grade iron ore) was not mined because it was considered a waste rock. But as the supply of high-grade



Locations of operating mines and areas of recent mineral exploration in and around the Lake Superior basin.

Dril rig operator at the PolyMet potential mine site in Minnesota displaying a piece of core.

Drilling operation at the Bend deposit in Wisconsin.

A mining haul road constructed after the Eagle mine was permitted in Michigan.

iron ore decreased, the mining industry began to view taconite as a potential resource. This changing attitude is important in the Lake Superior region because taconite is found extensively in the iron ranges of Michigan, Minnesota, and Wisconsin. Once taconite ore is removed from the ground, the mining company concentrates it into pellets slightly smaller than a marble. The pellets (also called taconite) are a concentrated iron product, more economical to transport and process into finished goods.

A mine operator also must consider the potential threats exploration activities pose to the surrounding ecosystem. Exploratory drilling penetrates different geologic layers and may cause water from different aquifers to mix, thereby changing the water's chemistry. It can also cause water elevations within an aquifer to change, causing wells to go dry.

Another potential threat in the exploration phase is drilling sludge, the material brought to the surface during drilling. Drilling sludge, also known as drill cuttings, can contain sulfide ore, heavy metals, and other contaminants, and it can contaminate surface waters when not disposed of properly.

The exploration phase also causes land to be disturbed by road and drill pad building and by heavy equipment use. These activities can introduce invasive

(At far left)
Waste rock stockpile at the Humboldt Mill in Michigan.

(Near left)
Satellite image of the U.S. Steel MiNNTAC tailings basin. This facility is approximately 16 square miles in size.

species and compact soils, resulting in greater surface run-off.

Development: Ecological Impacts of Constructing a Mine

When a proposed mine has cleared all permitting hurdles, the mining company can begin development and start turning the land into a working mine. Mines are either developed underground or, more commonly, as an open pit, but their purpose is the same: to bring to the surface what was formerly underground.

Developing an open pit or underground metallic mine generates large amounts of waste rock and ore processing byproducts. Waste rock is made up of the soil, rock, and non-target materials a mining company must remove to reach and excavate the ore that lies under the surface. The amount of waste rock a mine generates depends on the location and depth of the ore body. Often a mine can use some of the waste rock in other parts of the mine operation, but rarely can a mine utilize all of it. Thus, when a mine closes, it typically leaves behind large stockpiles of waste rock.

Tailings are the byproducts of processing left over after a mine removes and refines the target minerals. For all mine and ore types, the lower the ore grade, the more tailings are produced.

Tailings are the byproducts of processing left over after a mine removes and refines the target minerals. A typical mining operation generates an extraordinary volume of tailings compared to the amount of usable mineral it extracts, because even ore considered high mineral content has a mineral concentration that is quite low. A taconite facility that mines

24 million tons of ore in a year will typically generate 16 million tons of tailings for every 8 million tons of pellets. In a typical copper mine, the ratio of tailings to usable mineral is far higher: each ton of ore yields only about eight to ten pounds of copper, meaning a copper mine produces about 1,990 pounds of tailings for every 10 pounds of copper it produces. For all mine and ore types, the lower the ore grade, the more tailings are produced.

Mine development affects local ecosystems in a myriad of ways:

Erosion and Sedimentation

Developing a mine necessarily involves a dramatic reshaping of the land, exposing it to erosion by disturbing its natural contours and form. Steep slopes often formed by mining operations may erode when rain washes the soil downhill. When the rain carries those soil fragments into nearby waterways, sedimentation occurs. Sedimentation presents a multitude of ecological risks. In lakes and streams, sedimentation can cover and kill vegetation and invertebrates; it can cover fish spawning grounds as well as introduce contaminants into the environment. When sediments from mine development are acidic or contain heavy metals, they pose threats similar to those caused by acid mine drainage (AMD) and heavy metal contamination. (Chapter 3 provides a more detailed discussion of acid mine drainage and its effects on ecosystems.)

Taconite mine pit and pit lake in the Mesabi Range of Minnesota.

Hydrologic Changes

Because any pit or shaft constructed below the water table accumulates groundwater, a mine developer must pump the water out of a mine before it can remove ore. Whether the mine is open pit or underground, it acts as a giant well by pulling in water from the surrounding area. In a process called *dewatering,* water is pumped out continuously until mining is finished and the mine closes. A consequence of continuously removing this groundwater is that it can lower water levels in the surrounding area, causing what is known as a *cone of depression.* If the groundwater is linked to rivers or lakes, removing it from the mine pit will not only lower water levels in nearby wells

High-quality wetland complex in the ceded territory.

but can also lower surface water levels. The extent of the cone of depression and the extent of its impact on surface water depends greatly on the area's hydrology and geology.

The location of a metallic mine dictates the nature and severity of its hydrologic threats. If an ore body is mined near interconnected lakes, streams, and wetlands, the water itself can transport pollutants throughout the system. The proposed NorthMet mine in Minnesota provides a good illustration of the ripple effect mining development can have in wetland areas. The NorthMet mine would be located within the Hundred Mile Swamp, an area of high-quality wetlands with excellent biodiversity. The project would fill approximately 1,000 acres in this wetland complex. Thousands more acres could be indirectly impacted by a combination of mine-related effects including hydrology changes, aerial deposition of reactive dust, and the fragmentation of animal habitats. The removal of these wetlands to construct mine pits would reduce the habitat of a number of species, including moose who use them in summer as a refuge from hot temperatures. Finally, the surrounding surface waters and groundwater aquifers likely would be affected due to the interconnection between aquifers, surface waters, and the holes that mine pits create in the landscape.

Contaminant Leaching

To get to the subsurface ore, a mine operator must dig open or underground pits. When mining operations end, these large pits are sometimes backfilled to add stability and prevent the remaining rock from being exposed to air and water. When not carried out properly, however, backfilling can cause negative impacts. Backfill often consists of waste rock and tailings made from the ground rock and process effluents used in the concentrating process. If the backfill contacts water and escapes from the mine's underground workings or pits, surface and groundwater can be contaminated.

Some mine projects, however, opt to leave behind a lake that is formed when groundwater re-floods the mine pit. The operators of the NorthMet mine in

Tailings ponds of the Empire Iron mine in Michigan. Lake Superior is visible in the background. (photo courtesy of Chauncey Moran)

Acid rock srainage from the Buck and Dover Iron Mines in Michigan.

Minnesota propose to leave behind such a pit lake. The danger of these lakes is that the water can be contaminated and dangerous to wildlife. Compounding the risk of a contaminated lake is the danger that the water will overflow at the surface or seep into the groundwater, thereby spreading the contaminated water beyond the mine site.

Sulfur-bearing waste rock and tailings that are disposed of above ground present another type of ecological threat. If they are exposed to air and water, both have the potential to generate acid mine drainage and release metals into the surrounding environment. Tailings can contain heavy metals, chemicals, and acid-generating sulfur compounds, all of which are toxic to the environment in varying degrees, and waste rock may contain radioactive materials. (Chapter 3 provides a more complete discussion of issues surrounding waste rock and tailings.)

Air Quality Impacts

Mine development can also impact air quality. When rock is excavated, crushed, and transported to the surface, it can release contaminants into the air. Dust generated by mining contains particulates that may affect human and animal health if inhaled and contain pollutants which can contaminate soil, water, and vegetation. Gaseous air pollutants may contain sulfur dioxide which irritates the lungs and can damage or kill plants, especially evergreens. Metallic mining operations in the Lake Superior region have disturbed geologic layers containing asbestos-form fibers which, if released into the air, can pose serious health risks.

Dust generated by mining contains particulates that may affect human and animal health if inhaled and contain pollutants which can contaminate soil, water, and vegetation.

Carbon Footprint

Developing and operating a mine requires enormous amounts of electricity to run machinery, process ore, and maintain climate control in the underground tunnels. This energy demand leads to significant releases of greenhouse gases which contribute to global climate change. For example, the Bureau of Mines reported that electric power requirements at most taconite operations ranged between 100 and 150-kilowatt hours per ton of pellets produced, meaning a mine that produces 8 million tons of taconite pellets per year uses the amount of electrical energy equal to approximately 110,000 households.

Ore truck headed to the Eagle mine in Michigan.

Transportation Effects

During mine development, ore is removed and transported for processing. Blasting materials, heavy equipment, and large ore trucks used to remove and transport the ore can introduce a number of harmful chemicals into nearby waterways. Because a great percentage of the mined ore will be waste, generally the ore cannot be economically transported very far off-site. If the ore is particularly high grade, however, it can be cost-effective to transport it off-site for further processing. At the Flambeau mine in Wisconsin, for example, the high grade of the ore made it economically feasible to ship it to facilities in Canada for further concentration and smelting.

When new transportation corridors and improvements are constructed to transport ore, they can have significant impacts on the environment through deposition of ore dust that escapes from trucks and rail cars. At the Eagle Mine, for example, the mining company proposed construction of a new road to link the mine to Humboldt Mill, an ore beneficiation plant in rural upper Michigan. The proposed road would have transected a remote area, filled approximately 26 acres of wetlands, and crossed 22 streams. The potential damage was not limited to the road's construction: ore dust from trucks would have impacted the area during mine operation and would have had lasting consequences on water quality along the corridor. In the end, the mining company abandoned that road proposal after the EPA objected based on water quality concerns.

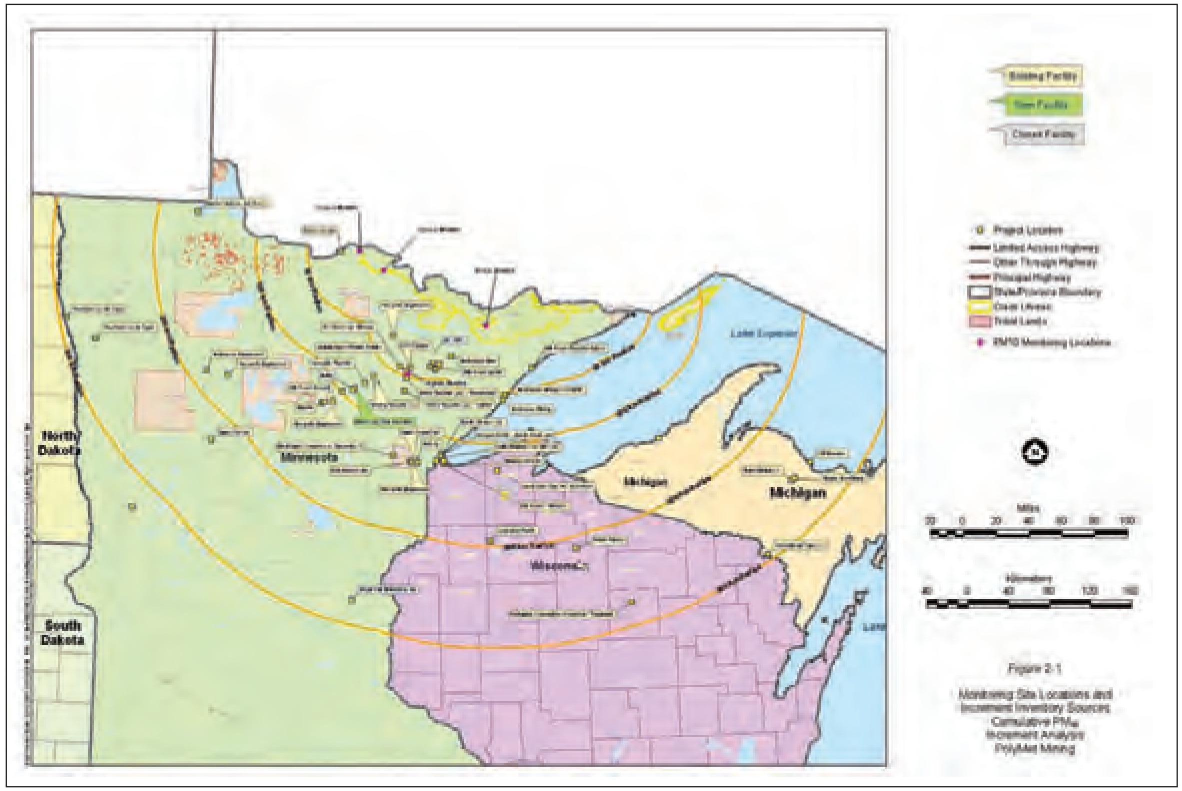
Milling: Reducing Boulders to Sand

After the ore is removed, milling is generally the next step toward producing a usable metallic mineral product. Milling involves crushing large pieces of ore removed from the mine. Crushing and grinding reduce the ore pieces to a size suitable for mineral extraction, down to fine sand or even a fine powder.

Fugitive dust can potentially contaminate soil, surface water, and groundwater because it can carry toxic elements including heavy metals. It also can be deposited on surrounding soils and surface water and taken up in plant tissues.

A primary ecosystem threat from milling comes in the form of fugitive dust that escapes during that process. Fugitive dust can potentially contaminate soil, surface water, and groundwater because it can carry toxic elements including heavy metals. It also can be deposited on surrounding soils and surface water and taken up in plant tissues. This particulate dust also can affect regional haze, another type of air pollution.

Techniques for controlling dust are not completely effective. In open pit operations, the sheer size of the exposed area makes dust suppression difficult. In Minnesota, for example, hundreds of miles of perimeter roads around the Minntac facility have been constructed from coarse tailings. For dust control, tanker trucks constantly spray water throughout the facility. Despite these efforts, the mine has not been able to fully control its dust. In 2008, mine owner U.S. Steel agreed to pay a $120,000 fine for air quality violations related to excessive dust emissions at Minntac. Other taconite facilities along the Iron Range in Minnesota have also been cited for failures in dust control.



Map of area of potential effect for regional haze prepared for the Polymet DEIS.

Truck spraying water for dust suppression at the Minntac tailings basin.

Beneficiation: Transforming the Milled Ore to Usable Metals

In the Lake Superior region as well as most of the world, high grade ores of iron, copper, gold, silver, and other metals have been mined out. Metal-bearing ores are rarely found in high-grade form but are mixed with gangue, or waste material, and generally as compounds of several elements. This means that even after the milling process has reduced the ore to a powder, a mine operator must further concentrate the target metal to make shipping economical.

Mines use various processes collectively known as beneficiation to accomplish this further separation and concentration of the target metal. The beneficiation method a mine uses depends on the target metal, ore grade, and specific chemical characteristics of the ore. Every mine develops a unique combination of physical and chemical processing techniques in order to maximize recovery of the target mineral.

Concentrating

Generally all types of ore must be concentrated through separation. The most common separation methods are gravity, froth flotation, and magnetic.

Gravity separation, used in nonferrous processing, separates the minerals according to their different densities by suspending them in a fluid. Their different settling rates allow the desired mineral to be collected from the bottom of a tank.

Froth flotation is the most widely used method of beneficiating nonferrous ores. The froth flotation method begins by adding chemicals to the milled ore so that the surface of one or more minerals in the slurry will repel water and attract air bubbles. The air bubbles rise to the surface of the slurry and the resulting froth, containing the minerals, is then skimmed and collected. Froth flotation is the beneficiation method that was proposed by the Crandon Mining Company in Wisconsin and at the NorthMet project in Minnesota.

Magnetic separation is used in some ferrous mine operations. The magnetic separation process mixes the crushed ore with water and grinds it to a fine powder with a rotating mill. Magnets separate the magnetic iron from the gangue, and the resulting iron powder is then mixed with limestone and baked into marble-sized taconite pellets.

The final product of the concentrating process is often called a concentrate.

Metallurgical Beneficiation

Once concentrates are isolated through gravity, chemical, or magnetic processes, metallurgical beneficiation processes can be applied to extract target metals that other methods were unable to recover. Hydrometallurgy uses water-based solutions to extract metals from ores, a process known as leaching. Pyrometallurgy uses high temperature processes to force a chemical reaction to convert the ore to a more extractable form. Electrometallurgy involves the use of electrical current to extract metals from ore. Smelting (a form of pyrometallurgy) is the most common type of metallurgical beneficiation, and involves heating the metal concentrate beyond its melting point to separate out impurities.

Beneficiation Byproducts and Environmental Impacts

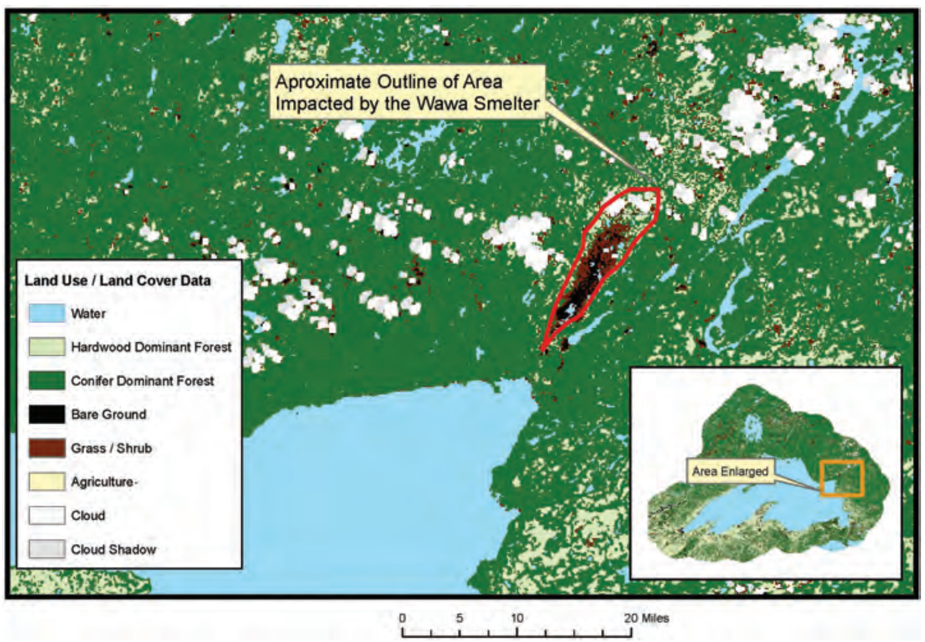
The different methods of concentration and beneficiation use a large variety

Beneficiation equipment: autoclave for hydrometallurgy.

and volume of chemicals. Some of these chemicals are relatively benign but others, like sulfuric acid and cyanide, are highly toxic. They must be transported to and stored at the mine site until used and can harm ecosystems if they leak or spill. Many process chemicals persist in the tailings, where they can contact ground or surface water and be carried away from the mine site.

The smelting process releases large amounts of sulfur dioxide, affecting and sometimes killing trees by acidifying soil and damaging leaves and flowers. The released sulfur dioxide can also react with oxygen and water to form sulfuric acid, a component of acid rain. Acid rain lowers the pH of water and may increase its sulfate level and the production of hydrogen sulfide, both of which can be toxic to aquatic and terrestrial ecosystems.

The environmental impacts of sulfur dioxide releases can be seen at the iron beneficiation plant that operated in Wawa, Ontario from 1939 to 1998. The plant's sulfur dioxide emissions caused severe damage to the boreal forest throughout a 20-mile kill zone downwind of the plant. Impacts included tree and shrub deaths and a marked decline in species diversity. In addition to these impacts, surface waters downwind of the smelter showed a marked increase in sulfate and acidity when compared to other waters



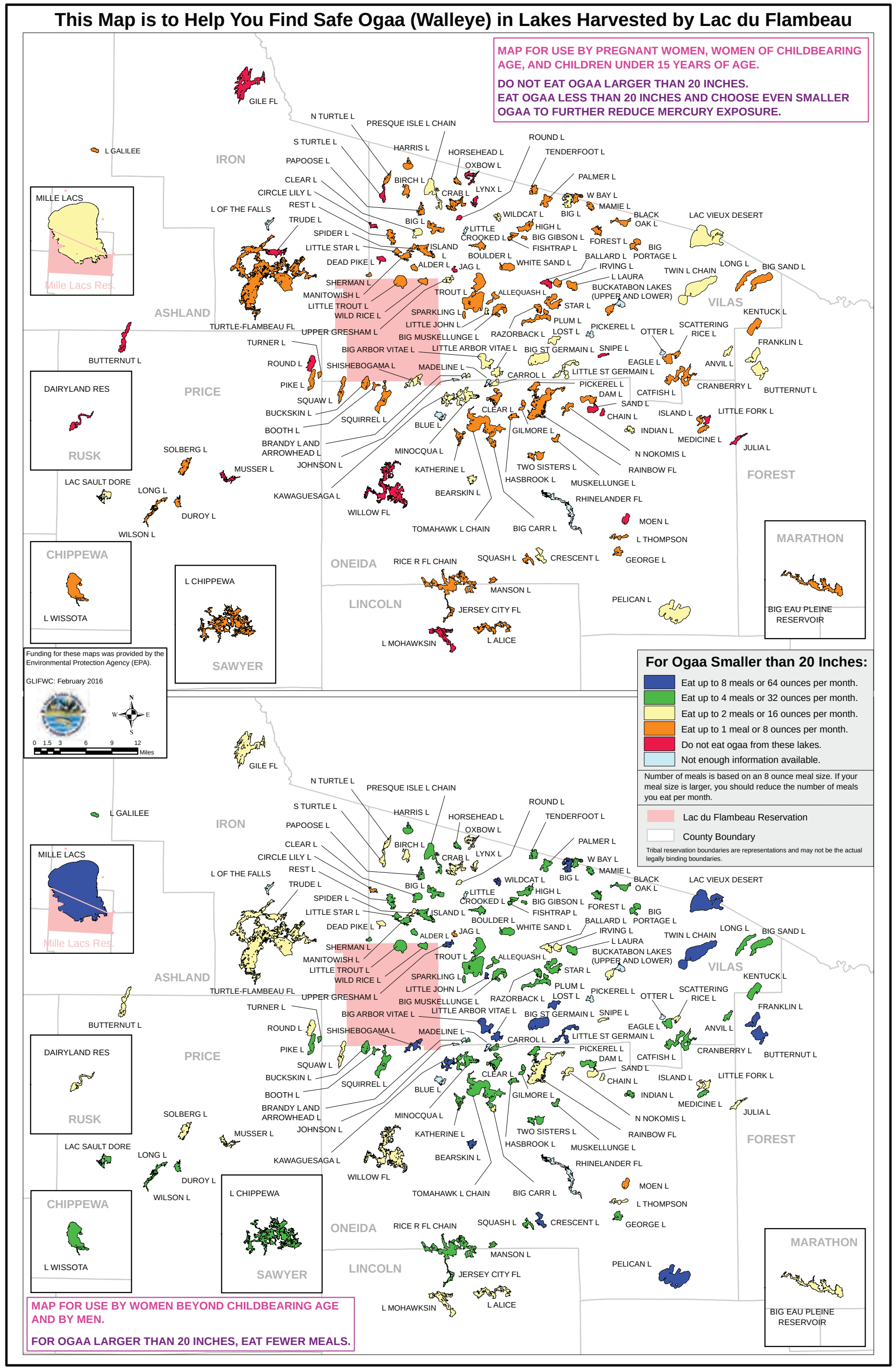
Satellite image of the zone of dead vegetation downwind of the smelter at Wawa.

REAGENT	THREAT TO THE ENVIRONMENT
Potassium	Toxic at very high levels, causes salt imbalance
Sodium xanthates	Unknown
Thiocarbonates	Unknown
Kerosene, fuel oil, wood tar, coal-tar oil, pine oil	Toxic, impairs flavor of tissue, decreased dissolved oxygen in water
Aliphatic alcohols	Toxic
Polypropylene glycol methyl ether	Unknown
Methyl isobutyl carnbinol	Unknown
Crysylic acid	Toxic, used in disinfectants
Copper sulfate	Highly toxic to aquatic life
Sodium sulfide	May increase hydrogen sulfide
Sulfur dioxide	May decrease pH
Sodium cyanide	Highly toxic to aquatic life
Zinc sulfate	Highly toxic to aquatic life
Starch	Breakdown products can deplete oxygen in water
Sodium dichromate	Highly toxic to aquatic life
Sodium fluoride	Used as insecticide, toxic
Sodium hydroxide	Increases pH
Lime	May increase pH and hardness
Soda ash	Increases pH
Sulfuric acid	Decreases pH
Sodium carbonate	May increase pH
Sodium silicate	May increase pH
Tannin	May decrease pH, reduces metal toxicity
Complex phosphates	May decrease pH, causes excessive aquatic plant growth

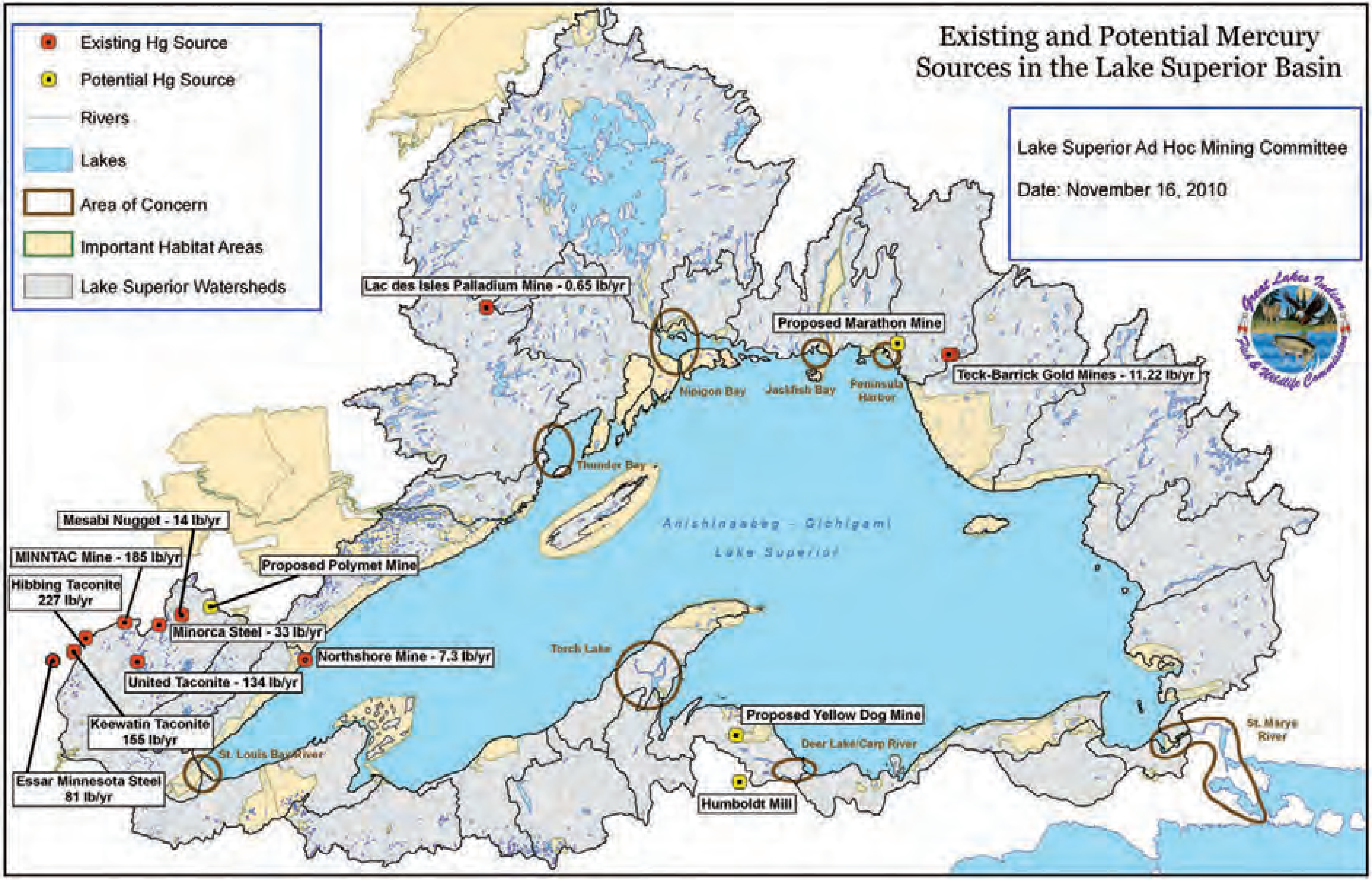
Mercury is another byproduct of beneficiation that is of particular concern in the Lake Superior basin; the negative effects of mercury to human health are well documented.

in the region. Soil samples in this area also contained elevated levels of soluble sulfate and arsenic. Scars from this contamination were evident in satellite imagery taken in 2010 even though the plant had been closed for 12 years.

Mercury is another byproduct of beneficiation that is of particular concern in the Lake Superior basin; the negative effects of mercury to human health are well documented. In most cases mercury is a low concentration component of the ore and is released when the ore is processed with heat, such as during taconite pellet formation and pyrometallurgy. The mercury enters the air and is deposited on the landscape by dry and wet deposition. Fish living in contaminated waterways absorb and concentrate mercury in their bodies. When humans eat the contaminated fish, mercury acts as a neurotoxin, interfering with the brain and nervous system.



Walleye consumption advisory for Mercury for the Lac du Flambeau band.



Major sources of mercury in the Lake Superior basin.

Tributary of Lake Superior that could be impacted by subsidence at the proposed Copperwood mine site.

Reclamation: Deconstructing Mine Workings and Reclaiming the Mine Site

When the target mineral is depleted or the mining operation is no longer profitable, production ends and the mine project enters the closure and reclamation phase. The process of permanently shutting down mining operations and returning the site to its natural condition is a long-term, expensive, and time-intensive procedure. In most cases, the goal is to return the mine site as closely as possible to its pre-mining conditions.

One risk that can occur both during and after mining is subsidence, the surface collapse of underground mine workings. Catastrophic collapse of underground mines during mining can be a serious hazard to workers and surrounding communities. Even when subsidence is not associated with a disaster or accident, planned subsidence can alter drainage patterns and disrupt the natural surface hydrology. The operator of the underground Copperwood mine in Michigan is planning to allow surface subsidence of several feet after mining ends.

For contaminated sediment within stream banks or lake beds, remediation can be very complicated.

Closing a mine operation involves demolishing mine buildings and facilities, removing pipelines, roads, rail lines, and power lines, re-vegetating disturbed areas, and beginning post-mining water treatment and monitoring. During the closure phase, additional monitoring of surface and groundwater, customized to post-mining conditions, should begin. Monitoring is essential at waste rock stockpiles and tailings basins to ensure contaminated water is not seeping into surrounding surface and groundwater. Monitoring should continue until the monitoring data indicates that mine seepage, mixed with naturally occurring rain and groundwater, has reached equilibrium and meets applicable water quality standards.

Forested wetland at the Lynne Copper deposit in Wisconsin. Once lost, this type of wetland is difficult to restore.

Post-closure refers to the time that it takes, after surface reclamation, for a mine site to be returned to its pre-mine condition. Post-closure reclamation will be influenced by the climate, physical characteristics of the mine site, applicable law, and the technical and economic feasibility of the reclamation project. The amount of time needed to achieve a pre-mine condition depends on which resources are contaminated and the extent of contamination.

If the site needs remediation to reach its pre-mine condition, the time required will depend on the extent of contamination and the resources committed to cleaning up that contamination. For contaminated sediment within stream banks or lake beds, remediation can be very complicated. At the closed Flambeau mine in northern Wisconsin, for example, drainage from a parking lot entered a stream, and efforts to remediate the copper-contaminated stream have been ongoing for over a decade beyond mine closure.

Sediment detention ponds at the closed Flambeau mine in Wisconsin.

3. Mining and Its Effects on Water

Mining operations impact the environment in a myriad of ways, with varying degrees of consequences and reparability. Metallic mining's most dangerous risk, however, is to water. Metals contamination, chemical pollution, the possibility of acid mine drainage, and other threats to surface and groundwater are risks that must be taken into consideration in both permitting decisions and when operating a mine. Mines and associated facilities must be carefully designed and engineered to contain the wastes produced; the failure to do so has had devastating effects on ecosystems. In 2015, for example, two tailings dams containing iron mining waste collapsed at the Samarco iron ore mine in Brazil. The tailings escaping from the dam mostly destroyed a nearby town and contaminated the water supply to more than 200 other area towns.

Satellite image of the town of Bento Rodrigues in Minas Gerais Brazil before the structural failure of the Samarco tailings dam.

Satellite image of the town of Bento Rodrigues after the structural failure of the Samarco tailings dam.

Hydrologic Changes: Acid Mine Drainage, Metals, Chemical Pollution, and Water Quantity

Acid Mine Drainage (AMD)

Among the many environmental risks posed by metallic mineral mining, acid mine drainage (AMD) stands out for its potential to permanently and irreparably damage the surrounding ecosystem. AMD originates when minerals containing sulfur interact with oxygen and water. The chemical reaction that follows generates the acids and oxides commonly referred to as AMD. Mining can significantly accelerate the acidification process because mining raises the sulfide minerals to the surface and crushes them, thereby exposing more surface area to water and oxygen. While nonferrous minerals are often bound with sulfur, creating a significant potential for the generation of

Uncontrolled acid generation from AMD results in an ecosystem with high levels of metals, dissolved solids, sulfates and acidity. A mine draining acid water can devastate rivers, streams, and aquatic life for many years.

AMD, ferrous ores that contain pyrite can also generate AMD.

A mine can generate AMD for hundreds or even thousands of years, until all of the sulfur in its tailings, waste rock stockpiles, and exposed mine pits has been consumed in the acid generation process. AMD can kill fish and other aquatic life and severely contaminate surface and groundwater. Not all mines will have an AMD problem, but it is critically important that the possibility of AMD generation be fully investigated at every mine. Although it can sometimes occur under natural conditions, AMD comes primarily from active and abandoned mines.

In addition to acidifying ground and surface water, AMD accelerates the dissolution of metals such as copper, lead, and mercury into ground or surface water. Uncontrolled acid generation from AMD results in an ecosystem with high levels of metals, dissolved solids, sulfates and acidity. A mine draining acid water can devastate rivers, streams, and aquatic life for many years.

Acid rock drainage at the Buck and Dover mine in Michigan. The water flows into the Iron River.

The waste rock stockpiles at the now-closed Dunka Mine in Minnesota demonstrate how a mine can continue to generate and release AMD. In addition to generating acid, the waste rock still releases sulfate and metals such as copper, nickel, and cobalt at levels that exceed state and federal water quality standards. Efforts to mitigate this contamination by installing caps on the stockpiles to limit infiltration and by using constructed wetlands to treat the discharged effluent have had limited success. The pH levels in the affected creeks have improved, but the concentrations of some metals, like nickel, have not decreased. The source of acid and metals at the Dunka Pit is the Virginia Formation, a sedimentary layer on top

Safety warnings in the Iron River downstream of the Buck and Dover mines.

of the Biwabik Iron Range in Minnesota. New mine proposals along the east end of the Mesabi Range, including the proposed NorthMet mine, would intersect this same mineral formation and could create similar AMD issues.

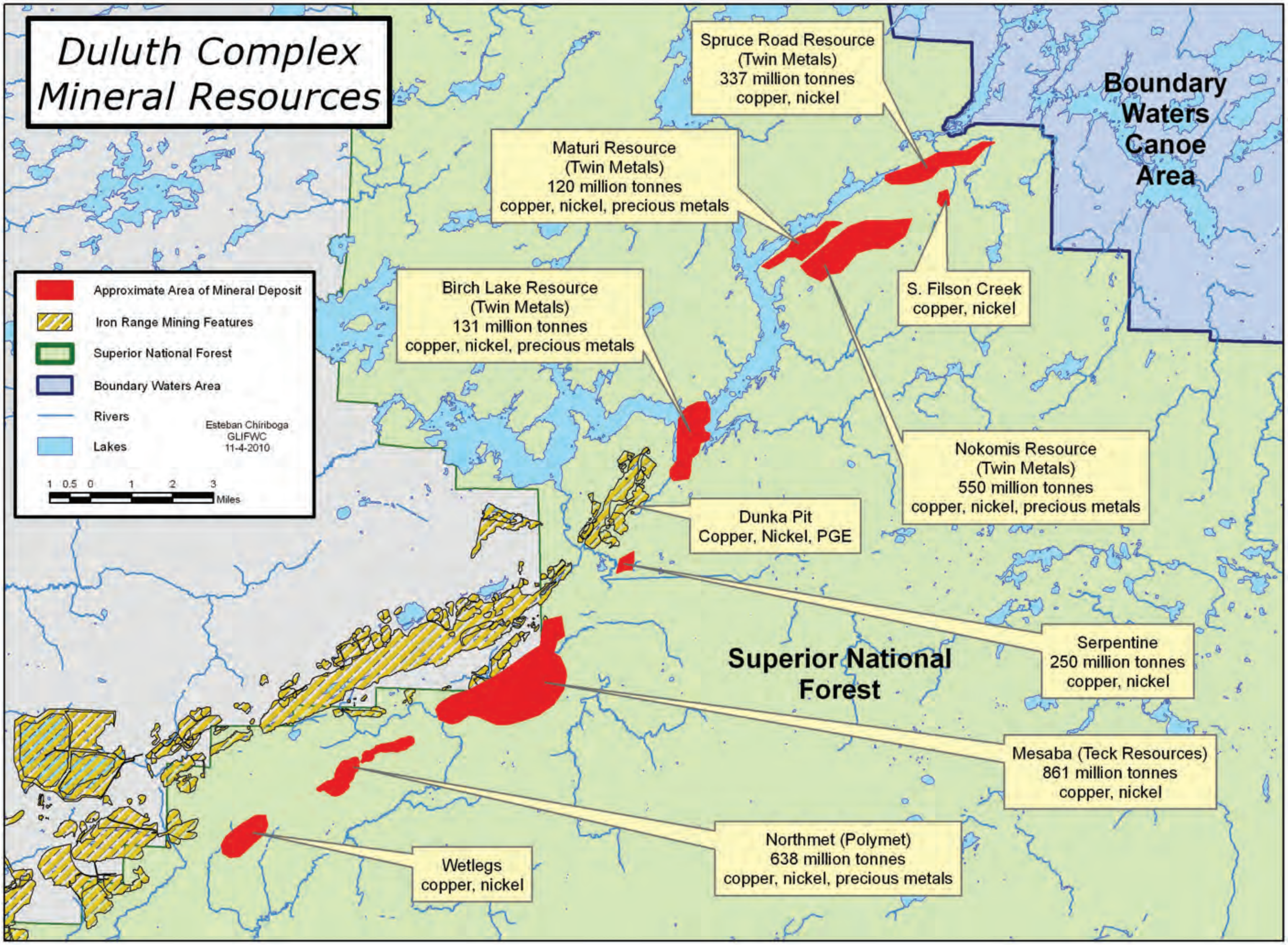
Metals Contamination

Mining extracts the minerals and metals found in the ore body. These metals—lead, arsenic, antimony, cadmium, cobalt, copper, zinc, mercury, manganese, molybdenum, and many more—may be essential to life but in large quantities cause metal toxicity. Some of these metals form relatively insoluble compounds in water that will sink and be buried in the sediments. Others, however, are more soluble and will become available to interact with organisms. Although many metals become more soluble in acidic water, including copper, cobalt, cadmium, and nickel, some metals are more soluble at neutral or higher pH. These include selenium, fluoride, aluminum, uranium, and arsenic. In addition, some processing chemicals like cyanide are most soluble at neutral to alkaline conditions.

Chemical, Sulfur, and Thermal Pollution

Metals are not the only chemicals released at metallic mine sites. Other forms of chemical pollution can result from spills of ore, concentrate, process chemicals, and other materials used at the mine. Contaminated water seeping out of tailings basins, waste rock stockpiles, and underground mine workings are common causes of chemical pollution.

For example, in 2008, the Michigan Department of Environmental Quality (MDEQ) became concerned about elevated selenium concentrations in effluents from the Empire and Tilden taconite mines. Selenium levels in area waterways exceeded water quality standards considered protective of fish and



Potential copper nickel mines along the east end of the Biwabik Iron Range.

Fish are an important subsistence food for tribal members.

Empire-Tilden mining district in Michigan. Waste rock piles, mine pits, and tailings from over 50 years of mining.

aquatic life, in some cases by more than tenfold. GLIFWC found that:

> [f]ish collected from the Escanaba River, Goose Lake and surrounding streams, including brook trout, northern pike, and white suckers, all exceeded the EPA's suggested threshold values above which there may be impacts on fish reproduction. Selenium levels in these fish were approximately 20 times the national average. The results confirmed that selenium is accumulating in fish at levels that may have adverse impacts on these species.

Because excess selenium exposure can be harmful to humans, these findings led the MDEQ to issue fish consumption advisories for lakes and streams down gradient of the mine effluent. Efforts to reduce selenium discharges are underway but data collected by GLIFWC in 2015 indicates that the levels still exceed standards.

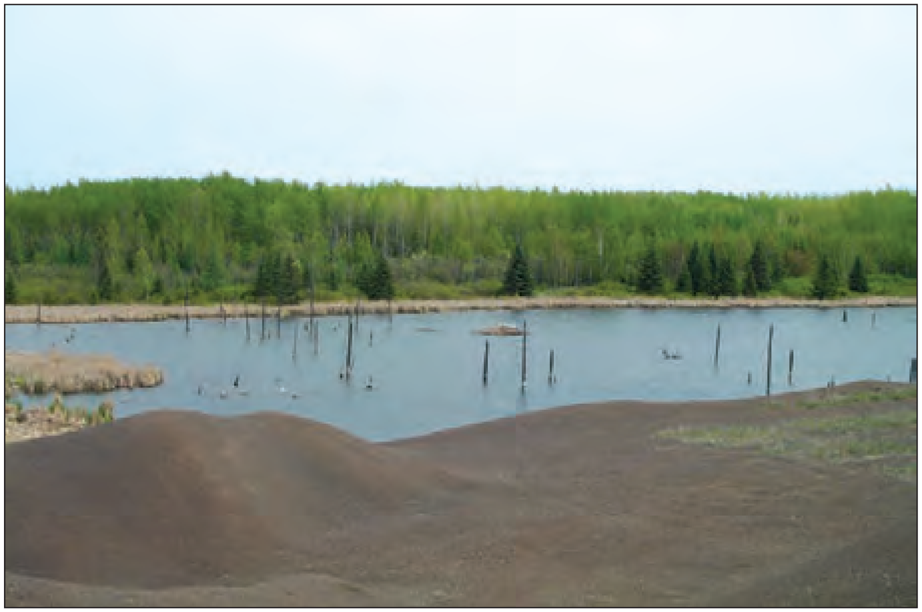
Another mine-related chemical of concern is sulfate. Sulfur occurs naturally as the pure element and in compounds. When sulfur (in the form of sulfate) is present with mercury, the combination has the potential to have extensive environmental impacts. In the presence of sulfate, mercury can be transformed into methylmercury, a neurotoxin. Methylmercury becomes increasingly concentrated as it moves up food chains, resulting in greater exposure to humans and wildlife. Because fish is a primary source of mercury in humans, the mercury in fish tissue stemming from mining releases of sulfate is a great concern for tribes.

Sulfate can also suppress the growth of wild rice. Minnesota has limits on the discharge of sulfate into rice waters, although those standards have rarely been enforced. The effects of sulfates on manoomin (or wild rice) are of great concern to the Anishinaabe because of their deep cultural connection with manoomin. In the 1940s, Minnesota Department of Natural Resource scientist Dr. John Moyle conducted extensive field research on the distribution of wild rice in Minnesota. Moyle's data showed that waters with sulfate levels over 10 parts per million (ppm) did not support healthy stands of wild rice. His work is one of the reasons Minnesota limits sulfate levels to 10 parts per million for water used in wild rice production. The amount of sulfate in mine water can be tens or hundreds of times greater than the amounts naturally found in nature. Recent research has indicated that sulfate released by mines is converted to sulfide in the sediment of a river or lake and it is this sulfide that is highly toxic to wild rice. Controls to limit the discharge of sulfate into waterways could help limit the generation of toxic sulfide.

The effects of sulfate releases on wild rice beds can be seen in the Sandy River and connecting lakes in Minnesota. While these waterways historically provided abundant manoomin, almost none exists there now. The primary reason for the decline is the high concentrations of sulfate seeping out of the Minntac tailings basin immediately upstream.

Wild rice on the Mondeaux Flowage. This area could be impacted by mining in the Chequamegon-Nicolet National Forest.

Water seeping out of the Minntac tailings basin and moving toward the Sandy Lakes in Minnesota.



Flooded wetlands downgradient of the Minntac tailings basin. Dead spruce trees indicate a change in hydrology.

Flooded Minnesota county road CT308, downstream of an iron mine tailings basin.

State regulators have recognized that sulfate emissions in the hundreds of parts per million coupled with increased water levels (see discussion below) are a probable cause of the near disappearance of wild rice in the area.

Another water issue in mine development arises when the discharged wastewater is a different temperature than the receiving water. Warmer water is lethal to some fish, and elevated temperatures can reduce fish egg viability.

Recent research has indicated that sulfate released by mines is converted to sulfide in the sediment of a river or lake and it is this sulfide that is highly toxic to wild rice. Controls to limit the discharge of sulfate into waterways could help limit the generation of toxic sulfide.

Water Quantity

By its nature, mining consumes and diverts surface and groundwater and can seriously affect its quantity, flow speed, and flow direction in the area around the project. The management of water is an important consideration in both evaluating environmental impacts and in planning mine operations.

The need to manage water begins with the workings used to access the ore body. If nearby lakes and streams are connected to the water table, their levels will drop as well. Wetlands that depend on groundwater for a portion of their water may experience a change in species composition; wetlands that are dependent on groundwater may dry out completely.

For fish, lowering the water table can expose spawning grounds, making them unusable. To mitigate the impacts of a lowered water level, mine operators sometimes pump water directly into lakes and streams. But this approach bypasses the natural system and may not adequately replicate the water's flow, temperature, oxygen, and chemistry.

Water pumped out of the mine must be stored or used. Some of the water is used in ore processing and much of it is used to transport tailings to the disposal facilities. From there, the water can re-enter the environment as seepage.

Most modern mines treat wastewater to comply with water quality standards but often dispose of the treated wastewater through drain fields that flow into existing bodies of surface water or shallow groundwater. Introducing this treated water can alter existing hydrology and create excess water in the system. In streams, the additional water can lead to flooding and increased scouring of streambed and banks. Wetlands that are inundated with excess water can change type, and the ecology of those wetlands can become permanently altered. Although wastewater itself may meet water quality standards, the chemistry of the wastewater can leach metals from the surrounding geology, causing increases in groundwater concentrations of toxic constituents.

Because mine tailings can be a source of AMD, the goal for sulfur containing tailings is to engineer a facility that isolates tailings from either oxygen or water.

Finally, water level changes caused by pumping water out of mine pits and releasing water through tailings basins can damage wild rice. Wild rice grows in shallow water, and increases in depth may flood wild rice beds. In addition, if a large quantity of water is released all at once, it can uproot and kill the growing plant.

The Challenge of Containing Mine Waste

Mine facilities, especially the tailings management areas and waste rock storage areas, must be carefully designed, operated, and maintained. Only with a high level of care, not only during the life of the mine but often for many years beyond, can a mine avoid the negative impacts described above.

Tailings

Tailings are the main byproduct of the beneficiation process. More specifically, tailings are composed of minerals which could not be recovered or have no commercial value, along with the water and chemicals used in beneficiation processes. Tailings are a combination of solid waste and water, typically in slurry or paste form because the milling process creates very small particles. They must be stored in a reservoir made specifically for tailings storage, often a pond or basin. Because mine tailings can be a source of AMD, the goal for sulfur containing tailings is to engineer a facility that isolates tailings from either oxygen or water. This isolation prevents the acidification reactions from occurring, but, as described below, it can be difficult.

The environmental challenges at tailings facilities are many. Tailings ponds and basins typically are very large in size and become permanent features of the landscape. Because tailings contain sulfide compounds, heavy metals, and unrecovered beneficiation chemicals, storage facilities that contain them are a source of contaminants to surrounding waters for centuries or longer. Environmental contamination occurs when tailings escape from management areas or from backfilled mine workings; almost any type of facility for storing these mine wastes eventually will leak contaminants into water.

A very serious risk associated with tailings storage is the long-term structural stability of the storage facilities. Catastrophic failures have occurred throughout time at tailings dams, causing environmental contamination and the deaths of local residents.

How a mining company designs a tailings facility depends on the site's specific environment, the conditions, and the type of mineral processing it will utilize. The difficulty is that tailings are not easily kept isolated from the surrounding environment. All liners and cap systems used to isolate tailings and tailings water from the surrounding environment leak, due to imperfections in their installation and general wear over time. In addition, no containment system or engineering

A tailings basin at the Minntac mine complex with trunks of trees uprooted.

control will last forever, and the perpetual maintenance and care of these facilities has become an important factor in the assessment of mining impacts. Illustrating this principle is the Grouse Creek mine in Idaho, located adjacent to the largest wilderness complex in the contiguous United States. The Grouse Creek Mine was heralded as a state of the art mine when it opened in 1994. Three years later, the mine closed. Soon thereafter, a tailings impoundment began leaking cyanide into surrounding water. In 2003, the U.S. Forest Service declared the mine site an "imminent and substantial endangerment" to human health; cleanup activities are ongoing.

A very serious risk associated with tailings storage is the long-term structural stability of the storage facilities. Catastrophic failures have occurred throughout time at tailings dams, causing environmental contamination and the deaths of local residents. For example, in 2014, a tailings pond catastrophically collapsed at the Mount Polley gold and copper mine in British Colombia, Canada. The breach sent over 30 million cubic feet of contaminated effluent into waterways, and the formerly pristine Quesnel Lake. About one million sockeye salmon spawn annually in the Quesnel Lake watershed. As mentioned above, the failure of two tailing ponds at the Samarco mine in Brazil killed 17 people and contaminated the water supply for many more.

Specular hematite ore left behind on a waste rock stockpile in Michigan.

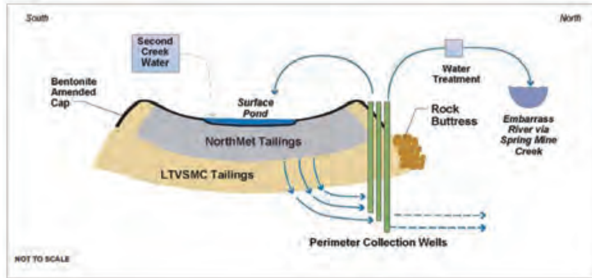
Tailings from hydrometallurgical processes are more hazardous than tailings produced during the concentration process discussed in Chapter 2. They contain high levels of metals and chemicals used in the hydrometallurgical beneficiation process and so must be separated from the environment in capped and often double lined facilities for hundreds or thousands of years. Tailings generated by other types of concentration processes, such as froth flotation and gravity separation, can be stored in pits, tailings dams, impoundments, or other types of tailings management areas. Ideally these facilities are lined with impermeable materials, such as clay or synthetic liners, but this is not always the case.

Waste Rock

Rock that is not targeted by the mining operation is called waste rock. Waste rock, like tailings, is a physical byproduct of the mining process that presents an environmental challenge and reclamation responsibility. A mine generates waste rock in the process of stripping the overburden (the rock and soil on the surface) to reach the ore body and access the target mineral. Waste rock may contain some target mineral but it is in amounts insufficient for a mine to economically process.

Waste rock does, however, still contain metals and minerals. These metals may include lead, zinc, arsenic, antimony, silver, cadmium, cobalt, copper, mercury, manganese, aluminum, molybdenum, and nickel. Waste rock also can contain sulfide compounds, and to prevent AMD it should not be exposed to air or water. These substances can escape into the environment through runoff or fugitive dust, and groundwater containing metals can contaminate surface waters.

Waste rock is sometimes stored in lined facilities with leachate collection systems to collect water that escapes, thereby reducing impacts to surface and groundwater. Another common waste rock mitigation measure is the sub-aqueous (under water) disposal of rock if it has a high sulfur or metal content. This disposal method involves placing waste rock



Cross section of a version of the Polymet tailings basin with seepage capture and geotechnical stability features.

underwater, thereby reducing the exposure of sulfur and metals to oxygen to decrease acidification and oxidation. Sub-aqueous disposal generally is an effective mitigation method; however, not all mines have an open pit that can be used as a disposal site, and using natural lakes destroys the existing ecosystem of the lake.

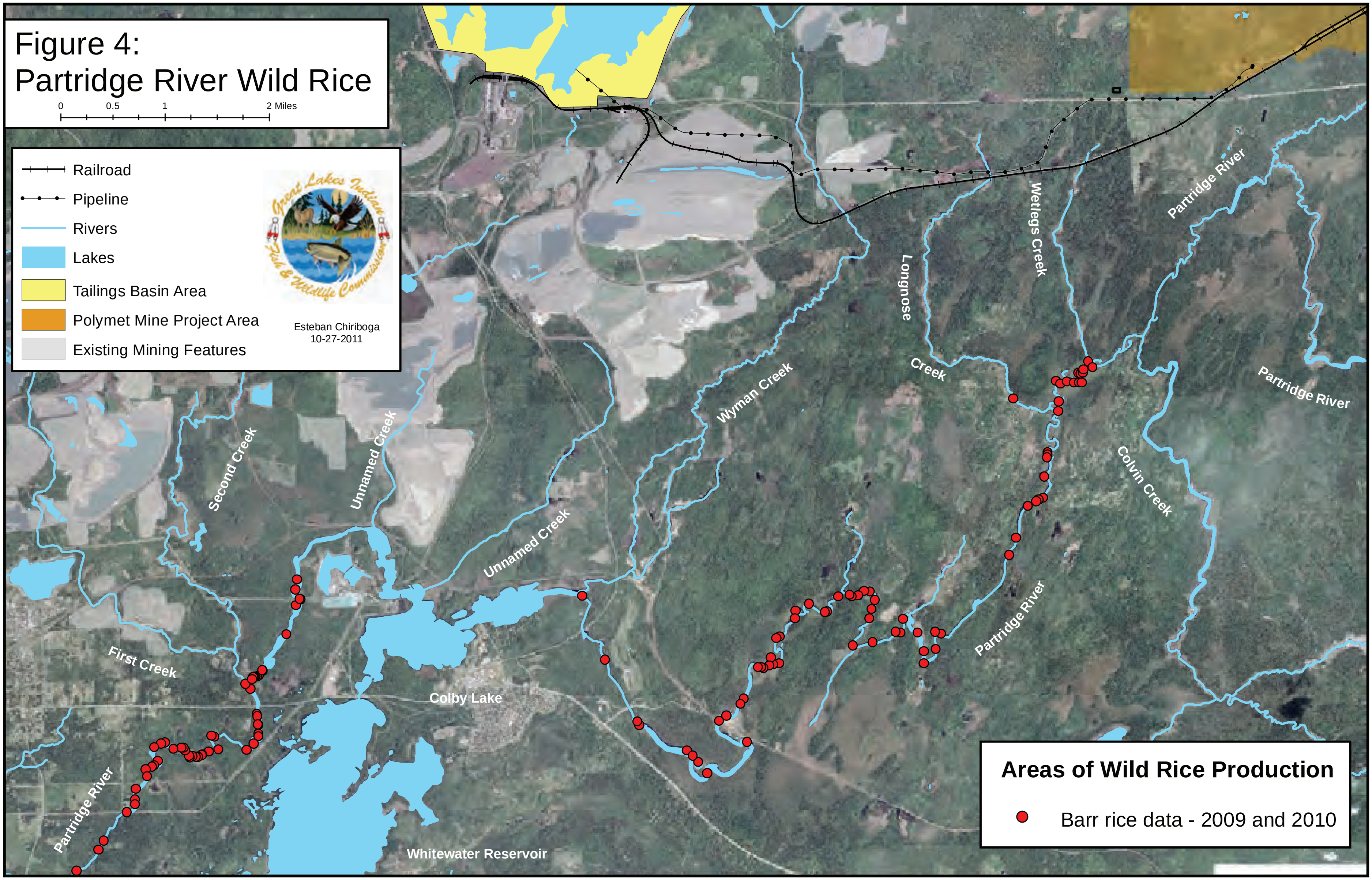
Restoring Hydrology

Water quality and quantity issues can persist after mining ends. The very existence of surface and underground mine features can permanently alter local hydrology by changing water levels in streams and lakes, filling wetlands, and creating backfilled pits and underground workings that alter local groundwater quality and flow. Water treatment is also often needed during and after mining to ensure that discharges meet water quality standards.

Mines sometime send wastewater and leachate (liquids collected from tailings areas and waste rock stockpiles) to a water treatment plant. After treatment, water and useful chemicals may be recycled for use in mine operations such as ore processing, but wastes must be stored in the tailings facilities. Even after a metallic mine closes, water treatment plants may need to operate, sometimes for many years, to prevent contamination of surrounding waters. If well-planned and implemented, a water treatment system can be an effective mitigation tool at operating and closed mines but must be maintained at significant expense.

Some types of wetlands may take decades to restore and may never again become self-sustaining ecosystems or provide the ecosystem benefits that they provided before being altered. The difficulty of the restoration and the time required depend on the type of wetland and the quality of the mitigation work.

Seepage to groundwater from some facilities, such as temporary waste rock stockpiles of non-reactive waste rock, might need water treatment and water quality monitoring for a short time. Other facilities like tailings basins may need groundwater capture and treatment and water quality monitoring for centuries after a mine has closed. The



Map of wild rice locations in the Partridge River downstream of the proposed Polymet mine pits. The project must meet the wild rice sulfate standard at these locations.

Wetland restoration projects are complex and don't usually replace all functions of an intact wetland.

hydrometallurgical tailings basin proposed at the NorthMet mine in Minnesota, for example, would contain hazardous materials that in a water-rich environment could eventually leak to groundwater. The NorthMet basin would be a potential source of contamination in perpetuity. That facility would be constructed in a wetland and over a buried stream that eventually enters the Embarrass River, so long-term containment is essential.

A particularly challenging aspect of groundwater protection is the difficulty of monitoring. Because groundwater moves down gradient much more slowly than surface water, it may take centuries for contamination to be detected at monitoring points. The long-term nature of this threat means that groundwater monitoring must also be long-term, particularly in wet areas like the Great Lakes region.

Wetland restoration is an important part of mine closure, and wetlands can play an important role in the restoration of both water quality and quantity. But the restoration of wetlands is not a straightforward task. Some types of wetlands may take decades to restore and may never again become self-sustaining ecosystems or provide the ecosystem benefits they provided before being altered. The difficulty of the restoration and the time required depend on the type of wetland and the quality of the mitigation work. Many wetland restoration projects also require long-term monitoring and periodic maintenance.

Constructed wetlands are sometimes used to improve water quality. Treatment wetlands use biological processes to remove metals from the water. While they can be successful in removing some metals, each wetland must be individually designed for the specific type of waste stream it will treat. Treatment wetlands, similar to other mining water treatment systems, require long-term maintenance to ensure the proper functioning of the biological processes that remove contaminants from the water.

Given the significant impacts that mining has on water quality and quantity and the potential long-term nature of some of those impacts, careful management is essential.

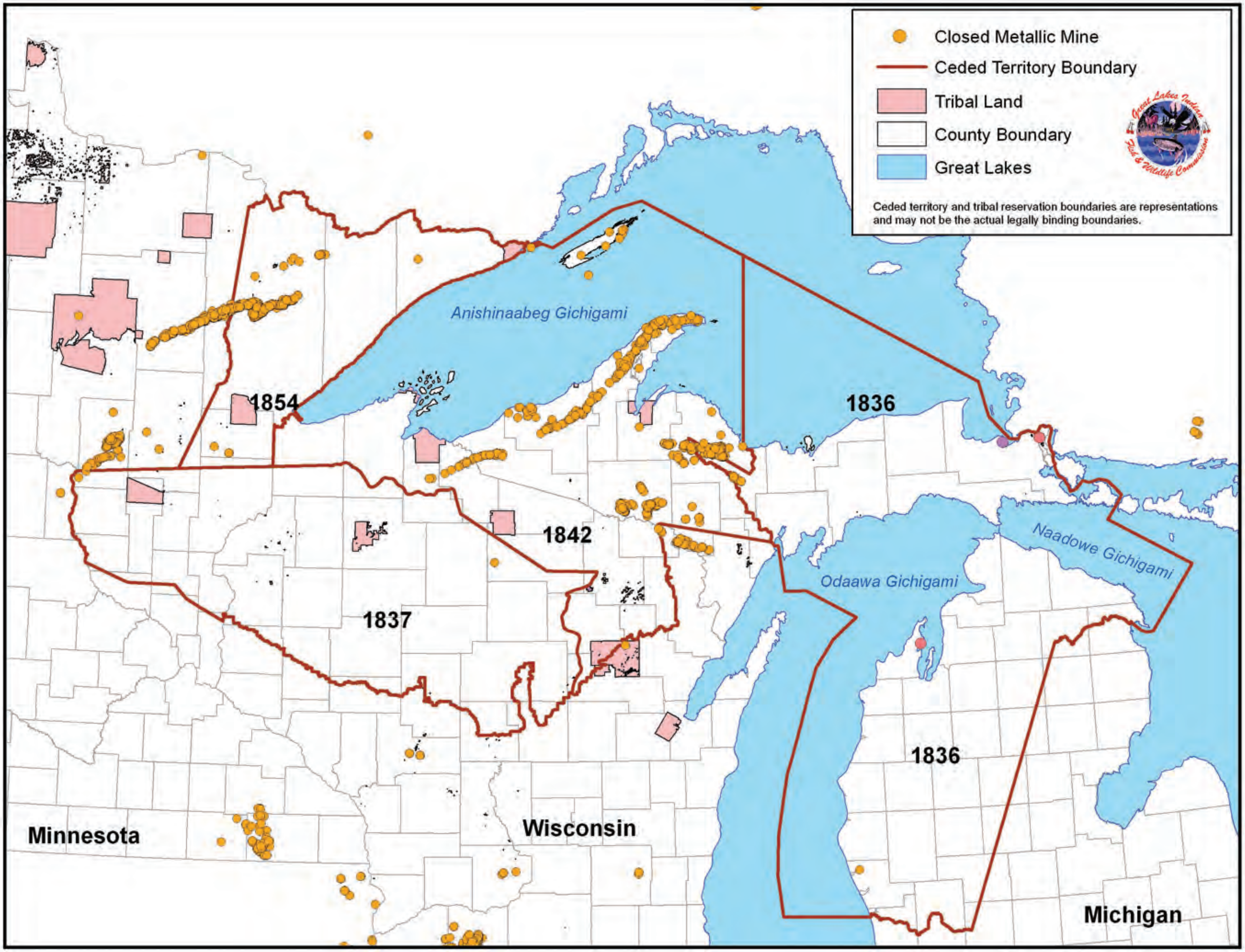
Cumulative Impacts of Metallic Mining— Time, Geography, and Community

Headframe at the Northshore mine in Silver Bay, which has been operating since 1956.

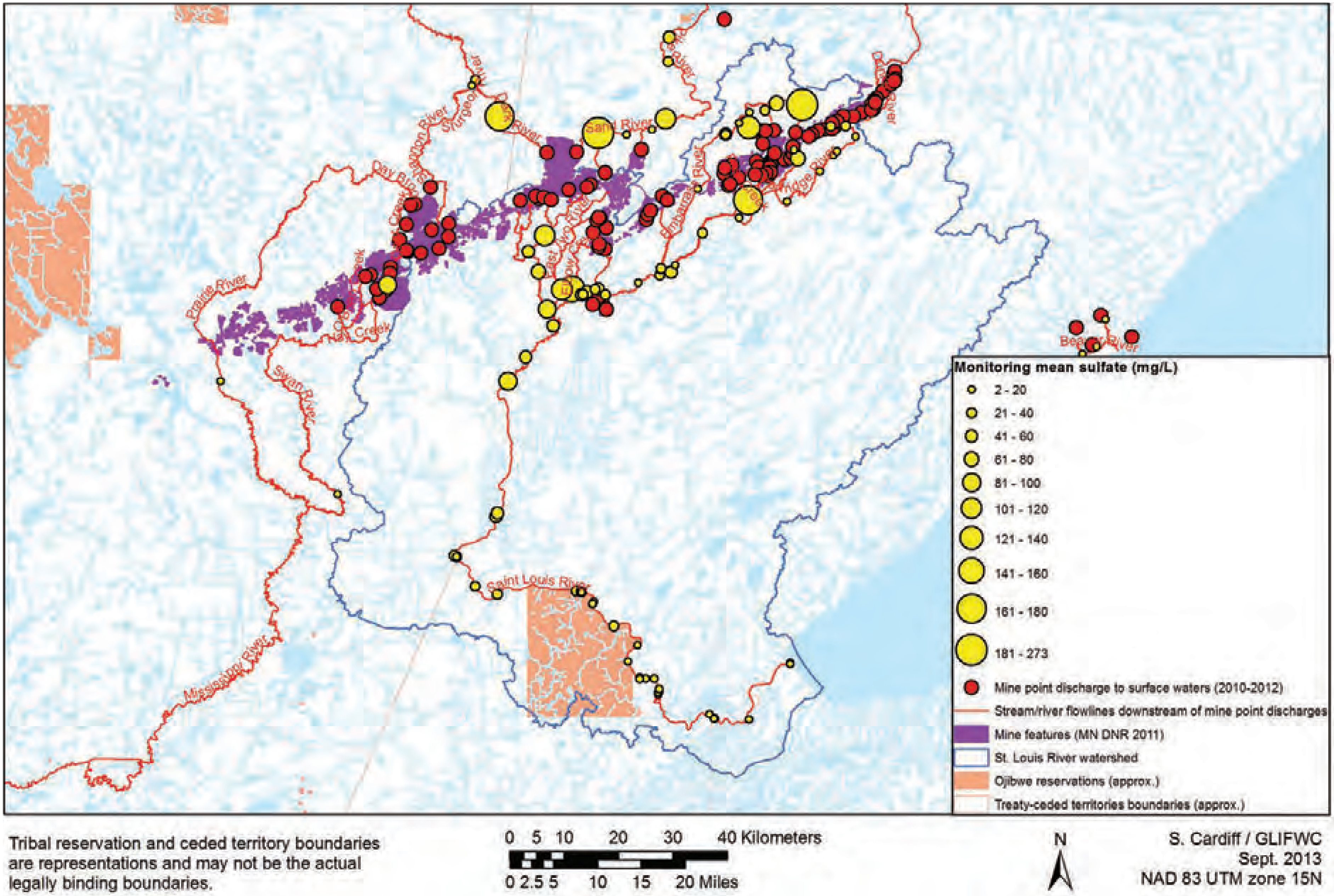
To develop an accurate and complete understanding of mining's impacts, regulatory agencies need to take a big-picture view, taking into account not only the cumulative effects of an area's past and current metallic mines but also mining's potential economic effects over generations.

Environmental Effects of More than One Mine

The Great Lakes region provides a good example of how historical mining operations complicate the monitoring and safety of new mining ventures. Mining has occurred throughout the Great Lakes region for more than 150 years; historical metallic mining operations dot the landscape throughout the 1836, 1837, 1842, and 1854 ceded territories. (See map on page 42.) Because some historical mines operated with little environmental protections, water contaminated with acid and metals often drained away from the



Closed metallic mines in the ceded territory.



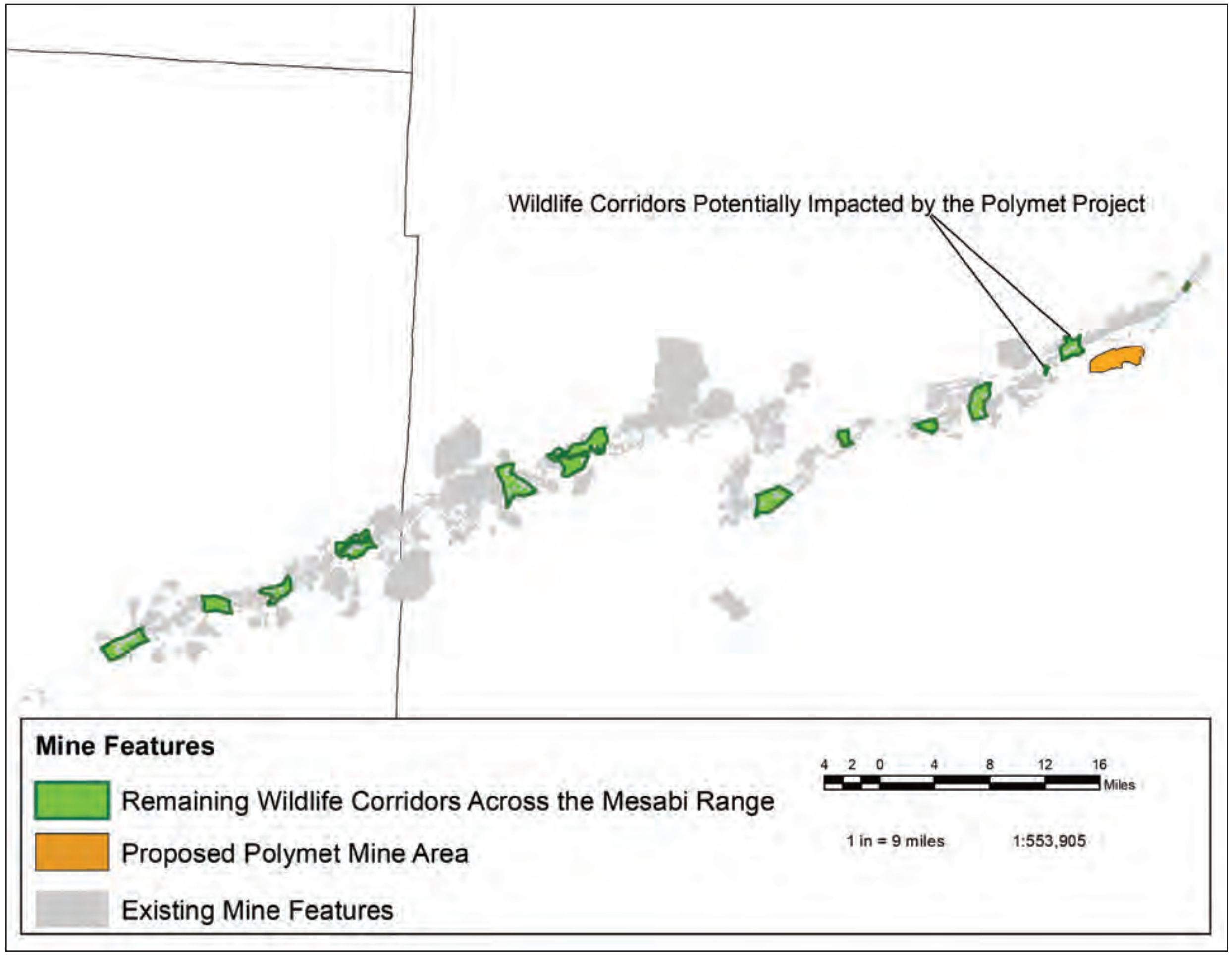
Cumulative effects of mine discharges have increased sulfate concentrations in the St. Louis River.

mines and into streams. Some mines were closed without remediation or monitoring activities. The cumulative environmental impact of closed and abandoned mines is relatively unknown; nevertheless, environmental review of a new project should consider these historical facilities and their possible impacts when a new mine project is proposed for the same area.

Multiple mining operations in the same area can cause simultaneous impacts to the environment.

Mining effects can also accumulate and compound where ore bodies of different grades or different minerals overlap in one geographic area. Multiple mining operations in the same area can cause simultaneous impacts to the environment. For example, water with high concentrations of sulfate seeping out of several different tailings basins in Minnesota flow through different tributaries to the St. Louis River. (See map on page 43.) In that case, the cumulative effect of sulfate on the St. Louis River is greater than the effect of any one mine project.

Regional impacts of multiple mine projects are of particular concern for the Ojibwe tribes whose treaty rights extend throughout much of the Lake Superior basin. For example, if ore from a mine in Wisconsin were smelted in Michigan, environmental impacts on treaty resources at both locations would have to be addressed. In response to this concern, the US Environmental Protection Agency worked closely with tribes and tribal agencies to develop a protocol for assessing cumulative impacts on tribal lands.



Few wildlife corridors remain on the Iron Range of Minnesota due to mining impacts.

Cumulative effects from numerous mine developments can impact species' habitats. And while land use changes accumulated over time can affect a variety of species, they are a particular concern for endangered or threatened species already in decline. Habitats can be fragmented by the large surface areas that mines typically

The US Environmental Protection Agency worked closely with tribes and tribal agencies to develop a protocol for assessing cumulative impacts on tribal lands.

disturb. The combination of new mining activity coupled with existing stressors such as climate change creates concerns for the long-term health of populations of these animals. An analysis of wildlife migration corridors prepared for the proposed NorthMet mine provides an apt demonstration of cumulative impacts. (See map on page 44.) The report concluded that only limited migration corridors remain in the Iron Range of Minnesota, highlighting the fact that the disruption of any one corridor would have a significant impact.

Recreational value of land, such as camping and trail use, must be accounted for in socioeconomic analysis.

Socioeconomic Issues and Impacts

While the economic evaluation of a potential mine typically focuses on jobs and revenue, a true and accurate picture must also factor in the financial aspects of the environmental degradation. For example, many mine projects may require water treatment activities for decades or centuries. Ideally the costs of water treatment, cleanup, and remediation activities will be paid by the mining company through financial assurance bonds. Historically, however, many mining companies have gone bankrupt and been unable to pay the cost of cleanup. An estimation of a mine's cost to the community must therefore factor in the possibility that mine closure and remediation costs will be left to local residents or taxpayers.

Just as the negative costs of mining have to be considered, so must a community weigh the tangible benefits that a healthy environment provides to the public. Wetlands, so often placed at risk by mining operations, have been called "the kidneys of the world" because they naturally filter and clean the water that

If a wetland is filled, its function as a no-cost, natural water treatment is destroyed, and it might need to be replaced by a costly artificial water treatment system.

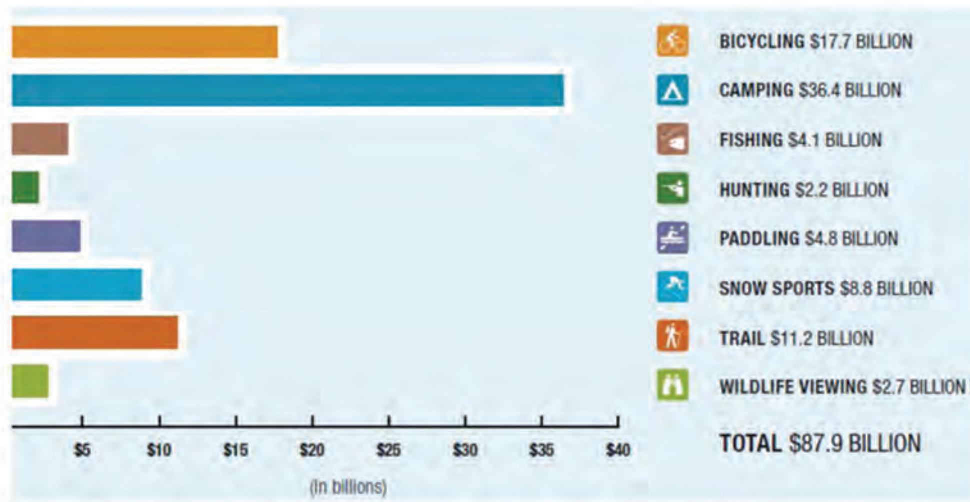
flows through them. If a wetland is filled, its function as a no-cost, natural water treatment is destroyed, and it might need to be replaced by a costly artificial water treatment system.

Other factors complicate the understanding of mining socioeconomics, including the job losses that can result in other sectors of a rural economy. Tourism and outdoor recreation activities like camping and fishing are not always compatible with a large industrial project like mining. If tourists choose other destinations for outdoor recreation, jobs in those sectors of the economy can suffer. Also complicating an understanding of mining socioeconomics are the impacts of rapid population growth which may overextend schools and social services.

While some mines may provide an overall positive economic outcome in a

Areas of the US having the highest levels of long-term poverty tend to be the very places that were the site of thriving extractive industries.

community, economic research indicates that mines do not necessarily result in long-term economic prosperity for the local area. Understanding what a potential mine will and will not do for a community is critical to accurately evaluating its effect on that community.



Federal and state tax revenues generated by recreational activity
Outdoor Industry Foundation 2003

Because most new mines are proposed in rural areas where economic development is challenging, local communities often view a mine as an economic engine that will allow their town to thrive. Yet the reality is that areas of the US having the highest levels of long-term poverty tend to be the very places that were the site of thriving extractive industries like mining. And while many look at mining as a long-term economic panacea, the social and economic impacts are far more complex. Researchers and economists have found a correlation between mining activity in rural communities and negative economic outcomes, as well as a connection between geographic areas with concentrated levels of mining and high levels of chronic poverty.

When researchers at the University of Wisconsin-Madison compiled socioeconomic information on incomes, unemployment rates, and poverty rates for 301 mine sites located in rural areas, their findings showed that:

> [C]ontrary to the long-established assumptions, but consistent with more recent critiques, roughly half of all published findings indicate negative economic outcomes in mining communities, with the remaining

findings being split roughly evenly between favorable and neutral/indeterminate ones.

The researchers found little scientific basis for the popular assumption that mining always leads to economic improvement.

Mining projects do create a number of high paying jobs, yet past and present mining communities often see high levels of poverty. The reasons underlying this paradox are complex, and a true understanding of mining's impacts on a community can only be reached through consideration of the full range of its economic costs and benefits. One factor is that modern mines employ fewer workers than in the past because much of the work is now mechanized and automated. Research by Dr. Thomas Power, an economics professor at the University of Montana, shows that employment trends in mining operations of the Iron Range in Minnesota reflect an 83% reduction in the number of mining jobs between 1979 and 2005, with increased mechanization being one of the main reasons for this decline. Many mining jobs that remain require a level of education, specialization, and technical expertise not typically found in a rural workforce. The result is that many of the high paying mining jobs go to nonlocal workers who possess the needed qualifications. New mining jobs may be produced, but local workers may not be able to take advantage of them.

Many of the high paying mining jobs go to nonlocal workers who possess the needed qualifications. New mining jobs may be produced, but local workers may not be able to take advantage of them.

The boom and bust cycle typical of the mining industry is another factor that can negatively impact a rural community. Metal prices fluctuate drastically on the global market; typically, when prices are high, mines expand and new mines are built. When prices decline, however, mines reduce their output or temporarily close. This ebb and flow in ore prices is particularly relevant in the upper Great Lakes region, where many of the proposed mines have relatively low ore grades. Generally, the lower the grade, the lower the profit margin for a mine. The effects of this sensitivity to price has been seen more recently in the iron mines of Northern Minnesota, where, starting in 2015, a market glut of foreign steel caused taconite prices to drop. The resulting lower prices caused the shutdown of half of the region's big iron-ore operations, at least temporarily, and the loss of 1,500 area jobs in the "notoriously cyclical" iron mining industry.

Community support for mining typically depends upon an assumption that mining will bring high paying jobs to local citizens and general economic prosperity for the community. But mining's legacy of environmental damage may be too easily overlooked when a mine project is proposed in a rural community hungry for jobs and lost prosperity. As socioeconomic studies have shown, this view of mining as an economic savior has little basis in long-term economic reality. And for the communities that come to depend on them, mines and mining jobs will always have a limited lifetime. Even if the price of the ore is stable, the resource is finite and the projects will come to an end when the resource is gone.

Mining's Effects on Anishinaabe Culture

In Anishinaabe culture, environmental decisions are based upon how they will impact the land for seven generations to come.

A mine brings many changes to the surrounding land and to the people who live there. These consequences can feel especially acute to native people whose culture is inextricably tied to that land. In order to appreciate what these changes mean for the Ojibwe tribes in this region, it is important to understand their worldview and orientation toward the natural world.

Ojibwe Spiritual Beliefs and the Moral Dimensions of Land Stewardship

To the Anishinaabe, any environmental destruction has consequences, whether or not it is associated with mining. When hunting, fishing, or gathering, Anishinaabe see their role as part of both the natural and spiritual order. Anishinaabe spiritual beliefs mandate the use of certain plants, animals, and fish in ceremonies attendant to hunting, fishing, and gathering

(At far left) Frances Van Zile, a Sokaogon Chippewa tribal member gives a ceremonial staff to a visitor.

(At left) Sokaogon Chippewa tribal member using a drum during a ceremony.

(Above) Evaporating the ziinzibaakwadwaaboo (maple sap) at a sugarbush.

Makwa (black bear) is a culturally important species to the Anishinaabe. A large percentage of Ojibwe people belong to makwa doodem (bear clan) who traditionally held the role of patrolling village outskirts. Makwa is also viewed as a keeper of medicinal plant knowledge.

Waawaashkeshi (deer) or ayaabe (buck) is a main staple of the traditional and modern diet of many tribal members. The waawaashkeshi will allow itself to be harvested for subsistence as long as Anishinaabeg pays the proper respect to ensure the continuation of the spirit of the waawaashkeshi.

Ma'iingan (wolf), also a clan animal, accompanied the Original Man on his journey to name all of creation. Although they parted ways once the journey was complete, the deep kinship that was formed exists to this day.

activities. These ceremonies ensure the perpetuation of the resources and the physical, mental, and spiritual well-being of the person.

Three aspects of an Anishinaabe view of nature inextricably link the perpetuation of humans to the perpetuation of the natural world. This belief system holds that the line between human and non-human beings is ambiguous:

- For the Anishinaabe, the difference between humans and non-humans when determining who constitutes a spiritual being is less clearly defined. A spiritual being may manifest as a human, animal, plant, or rock but may also reside in or be associated with certain places such as a mountain or body of water. As such, when an Anishinaabe is interacting with a part of their environment that may be deemed inanimate by some, there may still be spirits that need to be recognized and honored. All spiritual beings, whether human or non-human, have rights and warrant respect.
- Humans are not the masters of the world but rather weak and pitiable creatures, dependent upon all other non-human beings for survival. The proper attitude towards the natural world is one of care-taking, humility, and gratitude.

Aerial view of Terrace Bay in Ontario.

Many traditional teachings of the Anishinaabeg occur in landscapes such as the sandstone sea caves and the shores of Gichigami (Lake Superior).

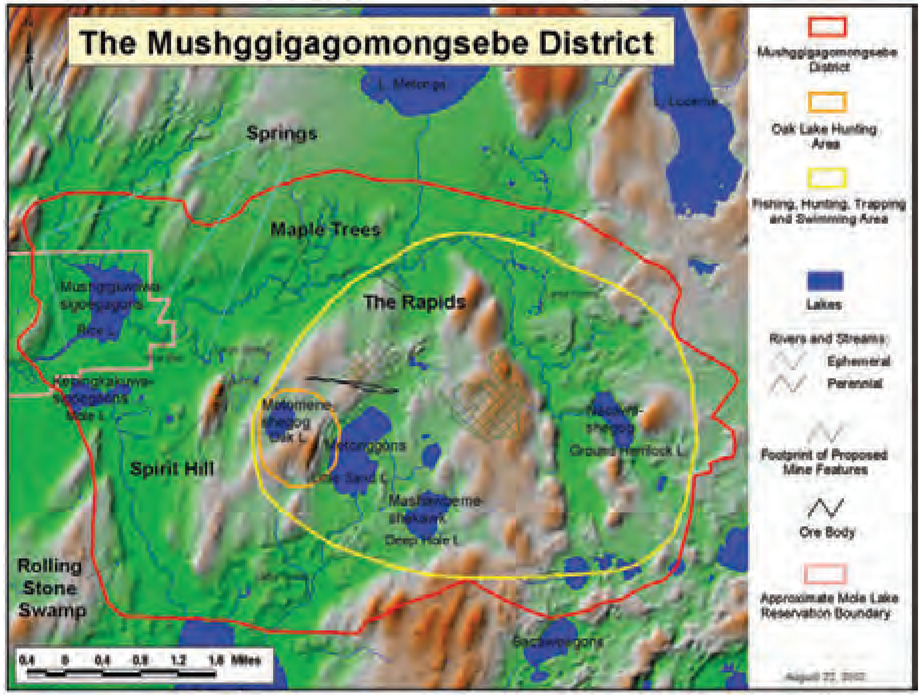
Anishinaabe spiritual beliefs mandate the use of certain plants, animals, and fish in ceremonies attendant to hunting, fishing, and gathering activities. These ceremonies ensure the perpetuation of the resources and the physical, mental, and spiritual well-being of the person.

- The relationship of humans to the rest of nature is one of reciprocity. Animals, for example, will offer themselves to a hunter as an act of pity for his or her weakness. If the hunter does not accept this gift with feelings of respect and gratitude, the natural world will withdraw cooperation.

Anishinaabe perpetuate this worldview and their attendant responsibilities to the natural world through stories, ceremonies, and language. These teachings instruct Anishinaabeg about how to care for, manage, and make decisions that affect the land.

Given this worldview, the alteration or destruction of plant and animal communities without proper respect given to the non-human beings involved invites disaster not only for the environments affected but also for humans. Harm to the rights of non-human beings is equivalent to environmental harm. In a reciprocal world, such a violation is understood to have dire consequences for humans who disregard this relationship. In addition, human beings have a responsibility to be a voice for non-human beings who cannot speak for themselves.

Illustrating this belief system are thoughts shared by the Sokaogon Chippewa Community, in a report prepared during the environmental impact analysis of a proposed mine. The report, titled *The Mushgigagamongsebe: A Traditional Cultural Landscape of the*



Map depicting the Traditional Cultural Property of the Sokaogon Chippewa. The proposed Crandon mine would have been located within this TCP.

Sokaogon Indian Community, described how environmental impacts of the mine would have been

> visited not only on the waters, wetlands, streams, and hills that make up what we here call the *Mushgigagamongsebe* District, but on the Tribe, other Ojibwe groups, and the living cultural environment for whose care Ojibwe people deem themselves to be responsible.

Mining and Its Effect on the Land: The Keweenaw Bay Indian Community and the Eagle Mine

An Anishinaabe view of land focuses on the importance of sustainability and integrity of natural resources and the habitats that support them. Place is particularly important to the general Anishinaabe thought, which is rooted more towards space than time. The importance of a particular geographic spot can no more be moved to a different location than a significant event in

American history be moved to a different time. This sense of specific geographic importance and integrity can be at odds with modern mining interests.

The importance of the land and the rights of non-human beings in Anishinaabe culture is at the heart of the Keweenaw Bay Indian Community's concerns about the Eagle mine, located in the 1842 ceded territory. The opening to the mine shaft is adjacent to the base of Migizi Asin (Eagle Rock), a place where the community has conducted fasting, prayer, and other ceremonies for generations. A portion of the mine will extend under the rock, and Migizi Asin could be damaged if the mine workings collapse. The rock is also subject to the industrial noise of mining operations, a significant impact considering the ceremonial use of the site relies on its quiet and remote location. Theoretically, Migizi Asin remains accessible, but visitors are required to obtain permission from the mining company and wear proper safety attire while at the rock.

The importance of a particular geographic spot can no more be moved to a different location than a significant event in American history be moved to a different time. This sense of specific geographic importance and integrity can be at odds with modern mining interests.

Since the mining company has conditioned access to Migizi Asin, practicing Ojibwe spirituality at the site has been affected and forced to undergo an inorganic change, at least for the lifetime of the mine. If Migizi Asin does not survive the mining activities, the loss of such a key site would impact the Anishinaabeg ability to practice their spirituality and culture and lead to a corresponding loss of Anishinaabe identity.

Migizi Asin, or Eagle Rock, at the Eagle mine site in Michigan, after the mining company restricted access to this sacred site.

Aerial view of the Eagle mine site.

Mining's Disruptive Effects on Resources and Practices Critical to Anishinaabe Culture

Manoomin (Wild Rice)

Manoomin is central to the Ojibwe migration story and tribes' subsequent settlement in the Great Lakes region: Ojibwe prophecy directed them to journey until they found the "food that grows upon the water." When they reached the shores of Lake Superior and found manoomin growing on the waters, the Anishinaabe understood their 500-year journey was over. Manoomin remains a unifying feature of Ojibwe society and culture. Not only is it an important food source, it is used in ceremonies as a way to honor the Ojibwe prophecy and to show continued respect for this invaluable resource. In fact, the distribution of Anishinaabe corresponds closely to the distribution of manoomin. Wild rice features in the lives of other tribes as well, including the Menominee Tribe of central Wisconsin, whose English name is derived from the Ojibwe word for "wild rice man."

Stories and histories of various Ojibwe bands throughout the Great Lakes region illustrate manoomin's distinct influence on and importance to the Ojibwe people. The manoomin found in the aptly named Rice

(Above) Tribal members seeding manoomin on Rice Bay on Lac Vieux Desert Lake.

(Right) Young tribal members enjoying manoomin.

Lake, on the Mole Lake Reservation in Wisconsin, is one of the main reasons the tribe settled in that area. The tribe waged wars with neighboring Dakota tribes to keep possession of the lake, and these wild rice beds continue to figure prominently in the tribe's cultural practices. In response to the proposed Crandon mine that would have been located less than two miles upstream, Frances Van Zile, a member of the Sokaogon (Mole Lake) Chippewa, explained the sense of loss that would accompany the destruction of this manoomin: "There is no substitute for wild rice. My whole way of being as an Indian would be destroyed. I can't imagine being without it. And there is no substitute for this lake's rice."

Manoomin remains a unifying feature of Ojibwe society and culture. Not only is it an important food source, it is used in ceremonies as a way to honor the Ojibwe prophecy and to show continued respect for this invaluable resource.

As described in Chapter 3, sulfates and water level changes pose threats to the manoomin resource. Given the integral role manoomin plays in Anishinaabe culture, regulators must give serious consideration to these impacts when considering a potential mine. To adequately understand the Anishinaabe view of manoomin generally and information about particular beds specifically, regulators should seek out tribal Traditional Ecological Knowledge (TEK). Such knowledge is derived from centuries of living alongside this resource and can shed light on how it may respond to environmental changes and how it should be managed.

Tribal members harvesting manoomin on Rice Bay on Lac Vieux Desert Lake.

Giigoonyag (Fish)

Mining can affect fish in many ways. (See Chapter 3 for a detailed discussion of mining's effects on water.) Impacts to the food chain in lakes and rivers are particularly damaging to Anishinaabe because of the nature of subsistence harvest of fish. Tribal members tend to consume fish in cycles, with peak consumption occurring in spring. When the fish are impacted to the point that tribal members must limit their fish intake or avoid it altogether, their ability to consume fish in ways required by their culture, such as in feasts, is significantly affected.

Mercury in fish tissue is the primary source of fish consumption limits in the Great Lakes region, and mines are the largest sources of mercury in the Lake Superior basin. The mercury from mines is emitted to the air via smokestacks. A portion of this mercury returns to the waters in the ceded territories where bacteria can convert it to methylmercury. These bacteria are eaten by bigger organisms, who are eaten by small fish, who in turn are eaten by bigger fish like walleye and northern pike. These fish are important components of the tribal diet and are used in multiple ceremonial feasts throughout the year. When people eat these fish, they also consume all the methylmercury that has been accumulated through the food chain.

Another mine related contributor to this food chain problem is that the sulfate coming from mining increases the rate at which the bacteria converts mercury to the toxic form that allows it to enter the food web. The combination of mercury and sulfate emissions increase the necessity of fish consumption advisories and may ultimately affect the health of individuals who consume those fish.

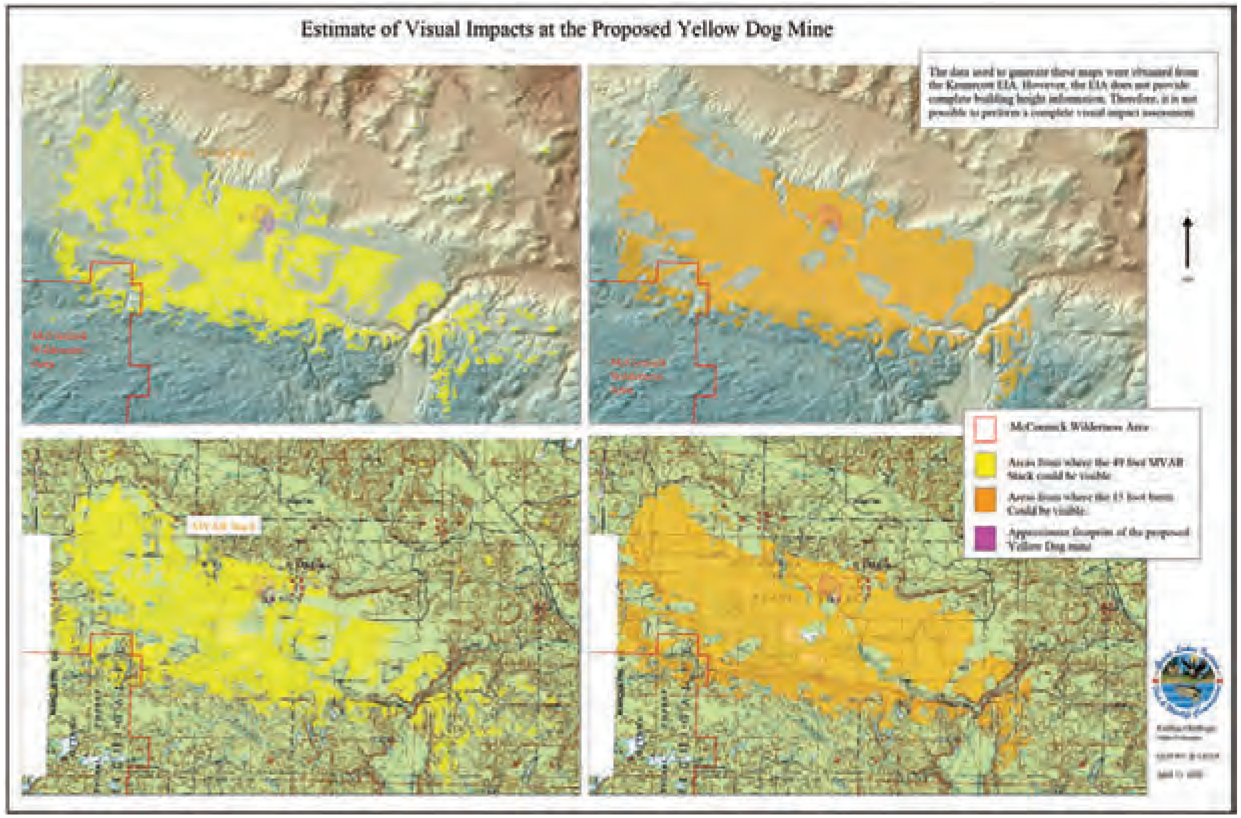
(Above) Subsistence harvest of ogaa (walleye) during the traditional spring spearing season.

(Left) Mercury in fish tissue can force tribal members to limit the fish they eat or avoid fish altogether. Mines are the largest source of mercury in the Lake Superior basin.

Mercury is not the only element that bioaccumulates in this manner. Like mercury, selenium in fish has created the need for fish consumption advisories intended to protect human health.

Disruption to Sense of Place

For an Anishinaabe, a mine project can drastically alter a region by changing its aesthetic. Tribal people are particularly sensitive to the visual and acoustic impacts of mining because, as described above, their perspective is focused more on space than time. Geographic locations are not interchangeable, so the loss of a cultural or natural resource in one location cannot simply be replaced with a similar resource in another location. Noise and vibration from blasting and other mining activities can carry for miles and produce decibel levels hazardous to human and animal health. Smokestacks, processing plants, and mine head frames are large structures that can extend well above the tree line and are visible from long distances. Such features, when constructed in a remote area, can significantly change the local landscape and profoundly affect tribes who have important cultural stories relating to their landscape.



Map illustrating the viewshed of the Eagle mine headframe. This is the area where tribal members exercising treaty rights would be able to see the mine feature.

These are just a few examples of how mining affects the lands and rights of Anishinaabe people. When various activities, including mining, compromise or destroy natural resources, on reservation lands or in the ceded territory, the ability of native people to support their tribal ways of life is greatly diminished. These impacts in turn can translate into impacts on a tribe's ability to sustain healthy communities that function in harmony with the natural world and are consistent with Anishinaabe worldviews.

The Anishinaabeg prioritize protection of water and believe that without clean water there would not be life.

6. Legal Landscape: An Overview of Mining Law and Regulation

Mining in the United States is regulated under a combination of state, federal, and tribal authorities. No single mining agency holds control over all mining operations. Similarly, no one body of law provides a singular regulatory framework for all aspects of mining. Mining operations instead are governed by a patchwork system of interconnected and sometimes overlapping laws, rules, and regulations, some of which date back to the 1960s and 1970s. (While this document discusses the mining laws of Ontario, the national laws Canada as a whole are not examined.)

Which agencies and regulatory frameworks will govern a mining operation depends on the circumstances and geographic area of the individual mine. If a mine is located on or near reservation lands, tribal air and water quality standards can apply. The situation is similar in the Canadian province of Ontario, where various provincial and federal agencies and laws apply to mining proposals.

Various federal environmental laws and regulations apply to most mining projects.

In the US, the mine permit process generally is done through the state, but various federal permits and agencies also play a role. Two federal agencies in particular—the Environmental Protection Agency (EPA) and the US Army Corps of Engineers (Corps)—are involved in regulating activities that occur in conjunction with mining. The EPA and the Corps can play the role of primary decision maker for the federal permits required for a mine project. These agencies also set environmental standards a mining operation must comply with, often through a program delegated to a state.

The EPA has the ultimate oversight authority to administer laws and regulations formulated through federal legislation such as the Clean Air Act, the Clean Water Act, and the National Environmental Policy Act (NEPA). The Corps of Engineers regulates and issues permits for various types of development projects, including mining activities that impact wetlands and other "waters of the United States." Particularly under the

Clean Water Act (described more fully below), the Corps' regulatory authority is broadly defined. "Waters of the United States" are defined generally as waterways capable of supporting interstate commerce and including their tributaries and adjacent wetlands. Determining whether the Corps' authority extends to some isolated waters requires a detail-driven analysis. The EPA has oversight authority when the Corps issues permits under the Clean Water Act (described below).

Tribal sovereignty and treaty rights also have implications for mines proposed in treaty ceded territories. Treaties are the law of the land, and state and federal agencies cannot disregard treaty obligations when implementing laws that regulate mineral development. How those rights may affect permitting decisions or permit conditions is not always clear and will depend heavily on the specific facts of a particular proposal. Nevertheless, tribal interests must be taken into account when determining how a mine would impact a tribe, its treaty rights, and its community.

US Federal Laws and Regulations Related to Metallic Mining

The particular circumstances of a mine project dictate which federal environmental laws and regulations will apply. The Clean Air Act and the Clean Water Act are two of the primary legislative frameworks in the US that pertain to metallic mining.

The Clean Air Act requires the EPA to develop ambient air quality standards as well as standards for hazardous air pollutants. Relevant to mining operations, the Clean Air Act imposes strict standards on new or modified sources of air pollution and a stringent approval process for new sources of pollution.

Two federal agencies in particular—the Environmental Protection Agency (EPA) and the US Army Corps of Engineers (Corps)—are involved in regulating activities that occur in conjunction with mining. The EPA and the Corps can play the role of primary decision maker for the federal permits required for a mine project.

The objective of the Clean Water Act is to restore and maintain the chemical, physical, and biological integrity of the nation's waters through the control of both point and nonpoint sources of pollution. The Clean Water Act gives states the authority to set their own standards, but if a state chooses not to do so or sets standards the EPA deems inadequate, the EPA will take action and mandate the water quality standards for that state.

An example of how a metallic mining operation might trigger the Clean Water Act: Section 404 of the Act requires a mine operator to obtain a permit before it can discharge dredged or fill material into waters of the United States, something that might occur in the process of constructing a mine. The Corps of Engineers typically is the agency to issue these permits, but the EPA has the ultimate oversight of the Corps' section 404 permit decisions. The only time the Corps is not involved in a section 404 permit is when a state has been delegated that authority. In these cases, however, the EPA still retains the ultimate oversight. So far only two states, Michigan and New Jersey, have been delegated section 404 permit authority and assumed this permitting role.

A myriad of other federal acts can apply to metallic mining in the US, far more than can be described in this document. Examples include the Endangered Species Act (if the operation may impact plants or animals that are listed as threatened or endangered); the Toxic Substance Control Act (which requires regulation of chemicals that present risks to health or the environment); the Comprehensive Environmental Response Compensation and Liability Act (CERCLA) (requiring reporting of hazardous substance releases and inventory of chemicals handled); the Safe Drinking Water Act (which directs standards for quality of drinking water

Protestors concerned about the Eagle mine project's effect on water quality demonstrate at the state courthouse in Marquette, Michigan.

supplied to the public, for which states are primary authorities); the Migratory Bird Treaty Act (protecting nearly all bird species); and the Solid Waste Disposal Act (which regulates generation, storage and disposal of hazardous waste and manages solid, non-hazardous waste).

Another federal law, the National Environmental Policy Act (NEPA), is triggered by any major federal action that has the potential to significantly impact the quality of the human environment, including permitting decisions. NEPA requires the federal agencies involved in the permitting processes to take a hard look at the environmental impacts of each proposed project, thereby ensuring that the environmental costs and benefits are considered in each decision.

NEPA first requires the lead agency to prepare an Environmental Assessment (EA) to get a preliminary feel for whether the proposed project will have a significant impact. If the agency finds that the project may have a significant impact on the environment, it must then prepare an Environmental Impact Statement (EIS). The EIS must provide not only an in-depth analysis of the environmental impacts of the project as proposed, but it must also describe the impacts of alternative project plans.

The EIS process includes public hearings to allow citizen comments about the proposed action. Federal regulations and guidance require agencies to contact Indian tribes and provide them with opportunities to participate at various stages in the preparation of an EA or EIS.

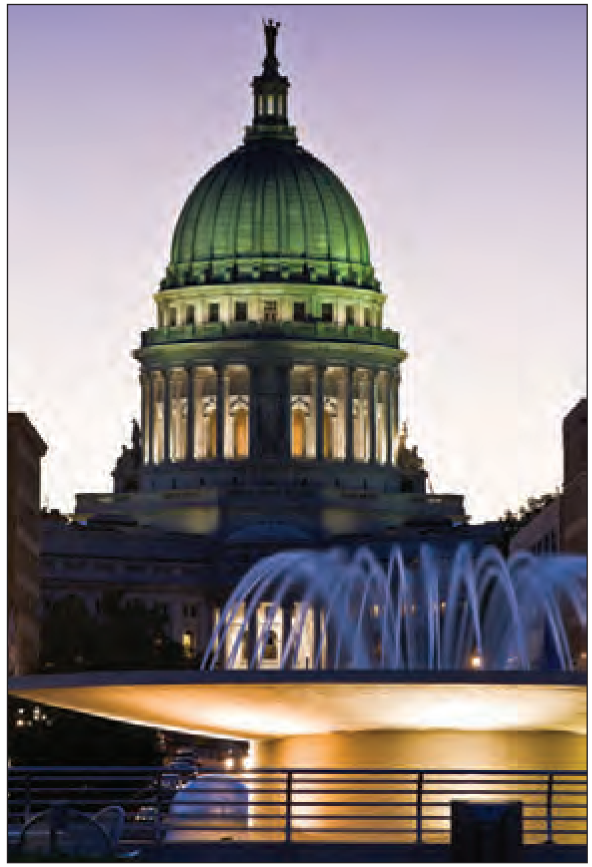
Another important act that may be considered in the issuance of the mining permit is the Native American Grave Protection and Repatriation Act. If the mine site is on federal or tribal lands and Native American graves or artifacts are found, then the construction may be halted. Similarly, if the mine site is designated as a Traditional Cultural Property (one with significant architecture, history, archeology, engineering, or culture) under the National Historic Preservation Act, and eligible to be listed on the National Register of Historic Places, the federal government must consult with tribes in order to avoid, minimize, or mitigate adverse impacts.

A Brief Overview of Mining Laws and Policies of Minnesota, Wisconsin, Michigan, and Ontario

Whether or not federal environmental laws are triggered, individual states have their own laws, policies, and regulations that apply to mining operations. Minnesota, Michigan, and Wisconsin all require permits before mining operations commence, as does the Canadian province of Ontario.

Wisconsin law and policy

In 2013, the landscape of metallic mining law changed significantly in Wisconsin with the passage of Act 1, which established a separate statutory framework for ferrous (iron) mining. Prior to Act 1, Wisconsin regulated ferrous and nonferrous metallic mining in the same manner. Act 1 created a new statutory framework, setting ferrous mining apart from all other types of metallic mining and creating a separate, expedited process for ferrous permits and approvals. In addition, Act 1 changed state law to incorporate a presumption that significant adverse impacts to wetlands are necessary to accommodate ferrous mining activities.



In 2013, the Wisconsin legislature established a separate legal framework for the regulation of iron mining.

For conflicts that arise between other state laws and the new ferrous mining law, Act 1 declared that the ferrous mining statute controls the outcome (a change from previous law and from the current nonferrous metallic mining law).

Whether a ferrous or nonferrous mine is proposed, Wisconsin's Department of Natural Resources (DNR) is the agency primarily responsible for mine permitting. The fee for a nonferrous mining application is $10,000, but the applicant is responsible for the full amount of the Department's cost to review the application. For a ferrous mining application, however, Act 1 capped at $2 million the amount a mine applicant must reimburse the DNR for application related costs.

The DNR performs an environmental review of the project and advises the applicant on what additional mining-related permits the applicant should seek from the agency. The DNR makes the ultimate decision whether to issue a mining permit. Under Act 1, it must make a decision on a ferrous mining application within 420 days after the mining application is deemed complete. For nonferrous mines, the timelines are longer and depend on the outcomes of several steps built into the application process.

One unique feature of Wisconsin law as it pertains to nonferrous mining (sometimes referred to as sulfide mining) is the 1998 Mining Moratorium Law, also known as the 'Prove It First' law. This law requires an applicant for a nonferrous mining permit to show examples of mining operations in the US or Canada that have not polluted ground or surface water for at least 10 years during operations and after closure.

Michigan law and policy

Michigan also has seen changes in its mining laws. Until 2004, ferrous and nonferrous metallic mining were regulated under the same statutory framework, the Reclamation of Mining Lands law, and Michigan had no specific provisions for the mining of nonferrous metallic minerals. In 2004, however, due to increased interest in metallic mining in the State's Upper

Michigan does not prepare its own Environmental Impact Statement for a proposed metallic mining project but rather uses one prepared and submitted by the mine applicant.

Peninsula, Michigan passed Part 632 of the Natural Resources and Environmental Protection Act (NREPA). Part 632 provided new regulations for the mining of nonferrous metals and set up a permitting system to oversee it. Michigan recognizes in Part 632 that nonferrous mining may be an important contributor to Michigan's economic vitality but that it shall only occur under conditions that assure the environment, natural resources, and public health and welfare are protected. Michigan's earlier reclamation law, the Reclamation of Mining Lands, still governs ferrous mining under Part 631 of NREPA.

Michigan's Department of Environmental Quality (DEQ) is the agency primarily responsible for mine permitting. The permit fee for a nonferrous mine permit in Michigan is $5,000; there is no application fee for a ferrous mine permit. The timelines for permit decisions depend on the type of mining permit sought. For ferrous mining, the state has 60 days to approve or deny the permit once it deems the application accurate and complete; for nonferrous mining, the timeline prescribed by statute can range from four to six-and-a-half months depending on various aspects of the application process.

Michigan is unusual in that it is one of only two states to whom the Army Corps of Engineers has delegated authority to administer a section 404 permitting program for discharges of dredged or fill material into waters of the United States. Because of this delegation, a potential mine operation in Michigan is less likely to have active federal participation in its permitting process and may not be subject to the National Historic Preservation Act or the National Environmental Protection Act's requirement for an Environmental Impact Statement.

Minnesota law and policy

In Minnesota, ferrous and nonferrous mining laws are a part of the Minnesota Environmental Policy Act of 1973, although additional laws relating to nonferrous metallic mining were adopted in 1992. Minnesota's newer laws emphasize financial

In Minnesota, the primary agencies responsible for mine permitting are the Department of Natural Resources and the Pollution Control Agency.

assurances, waste characterization, and a thorough environmental review and permitting process. The state's policy regarding reclamation focuses on both environmental protection and the economic value of mining to the state. As declared by statute, Minnesota recognizes the effects of mining on the environment but aims to provide for the reclamation of mined lands, control possible adverse environmental effects of mining, preserve natural resources, and encourage planning for the future of the land. At the same time, the state aims to further "the orderly development of mining, the encouragement of good mining practices, and the recognition and identification of the beneficial aspects of mining."

A Minnesota statute enacted in 2011 imposes a goal upon the Minnesota Department of Natural Resources (DNR) and the Minnesota Pollution Control Agency (MPCA) to approve or deny environmental and resource management permits within 150 days of receiving an application. These two agencies oversee most mining activities in Minnesota and are primarily responsible for approving the various permits necessary to mine. A third agency, the Minnesota Environmental Quality Board (EQB), is not as involved in the permitting process but plays a role in overseeing the environmental review process. A mine permit in Minnesota is required for both ferrous and nonferrous metallic mining, although the permitting fee differs: $25,000 for a ferrous mining operation; and $50,000 for a nonferrous mine.

Ontario law and policy

Ontario's laws governing mining remained relatively unchanged throughout much of its history but in 2009, the government promulgated the Mining Act. The Act's purpose, according to the Ontario Ministry of Northern Development and Mines (MNDM), is to "encourage prospecting, staking and exploration for the development of mineral resources" in a manner consistent with the recognition and affirmation of existing Aboriginal and treaty rights, including the duty to consult, and to minimize the impact of these activities on public health, safety, and the environment. To implement these requirements, the Mining Act mandates consultations with First Nations at various stages of the process of reviewing a proposal. The duty to consult lies with the government considering the decision or action that may impact Aboriginal and treaty rights, although Ontario encourages mining companies to establish communications and relationships early on to facilitate the consultation process.

Ontario's Mining Act mandates consultations with First Nations at various stages of the process of reviewing a mine proposal.

Ontario's Mining Act outlines the rules and regulations that apply to mining in the province. The MNDM is the government agency that oversees mining, but other agencies also have regulatory roles related to the legislation they administer. For example, the Ministry of the Environment and Climate Change issues permits and approvals for activities such as the use of water and disposal of waste.

Before a mining project can proceed, the MNDM requires a closure plan prepared by the applicant in which the applicant must certify its compliance with all legislative requirements.

The Role of Tribes and Aboriginal Communities

Tribes have extensive regulatory authority over their reservations and may have regulations that could impact mine development on reservation lands. In addition, US tribes that have *treatment as a state* status under the Clean Water Act or Clean Air Act can enact water or air quality standards for the reservation. When discharges upstream or upwind of a reservation have the potential to exceed those standards, federal statutes prescribe procedures to ensure that the tribe's standards are not violated.

In the ceded territory, states must take into account tribes' treaty-reserved rights. States do not have the unfettered discretion to exercise authority over natural resource management in ways that would be detrimental to tribal treaty rights or violate the court cases that reaffirmed those rights. States may not legislate away treaty rights nor may they defeat them through legislation that negatively

Native veterans' color guard at the Wisconsin Capitol prior to the State of Tribes address in 2011. In that address, Bad River tribal chairman Mike Wiggins Jr. explained how a proposed iron mine upstream from the Bad River reservation threatened the existence of Ojibwe people and the natural resources they rely on.

affects treaty resources through habitat destruction.

The US federal government and the states of Michigan, Minnesota, and Wisconsin have obligations to consult with tribes when they are considering actions that may impact the tribes and their treaty-reserved rights. For individual states, court cases often prescribe the form of that consultation, but each state, by Executive Order, has committed to consult with tribes whether or not a court has required it. The extent of these consultations depends on the specific statutes or regulations that prescribe when tribes must be notified or consulted, the willingness of the parties to substantively engage, and the extent of the potential impacts of the proposed action. It is often the case, however, that tribes feel their concerns are not sufficiently addressed by state regulators. Thus, tribes often also pursue consultation with the federal government who, as a treaty signatory, has specific treaty obligations as well as a general trust responsibility to protect treaty rights.

Treaties are the law of the land, and state and federal agencies cannot disregard treaty obligations when implementing laws that regulate mineral development.

As described above, recent amendments to Ontario's Mining Act recognize and affirm the treaty rights of Aboriginal people, and emphasize consultation in order to minimize adverse impacts.

Select Commonalities and Differences in the Mining Laws and Policies of Minnesota, Wisconsin, Michigan, and Ontario

Environmental review

Minnesota, Wisconsin, and Michigan each requires an environmental review process to occur before a mine permit can be issued. Ontario requires an environmental review process in some but not all cases.

Each state process analyzes significant environmental impacts and alternatives to the proposed project. This review process also discusses mitigation techniques as well as the unavoidable economic and sociological effects on the surrounding communities. The names vary slightly between the states: Minnesota has an Environmental Analysis Worksheet (EAW) followed by an Environmental Impact Statement (EIS); Ontario (when required) has an Environmental Assessment (EA); Wisconsin requires an EIS that conforms to federal EIS requirements; and Michigan requires an Environmental Impact Assessment (EIA) for nonferrous mine proposals but does not require an explicit environmental analysis document for ferrous mining proposals. As noted earlier, environmental review neither approves nor denies a proposed project; rather, its purpose is to analyze and document possible impacts so decision makers have complete information before them when determining whether to permit a mine.

Wisconsin, Michigan, Minnesota, and the Canadian province of Ontario all regulate mining in slightly different ways.

In Minnesota and Wisconsin, the state Departments of Natural Resources perform the environmental review, conducting their own analyses and

producing their own EISs. However, these reviews depend heavily on information supplied by mine applicants. Michigan law differs: the DEQ does not prepare its own EIA for a proposed metallic mining project but rather uses an EIA prepared and submitted by the mine applicant. In Canada, the province of Ontario does not generally require a separate environmental assessment, but one may be required in some cases under the federal Canadian Environmental Assessment Act. In instances where environmental assessments are required under provincial and federal legislation, the governments have agreed to a harmonized process.

It should be noted that other activities related to mining—such as air or water discharges—can require permits which in turn trigger a separate environmental review process. The review process for that individual activity, however, may not be as comprehensive as one that considers the mining activity in its entirety.

The environmental review processes for mining permits in Minnesota and Wisconsin are structured to provide opportunities for public participation, and public hearings and informational meetings are required at certain points in the process. In Michigan, the DEQ may hold public hearings but is not required to. For mining projects in Ontario, the project proponent must give public notice of the availability of its closure plan.

Water quality

Under US federal laws such as the Clean Water Act, states may take over the responsibility of promulgating and enforcing regulations. States also have independent authority to regulate water quality and mining. As a result of these combined powers, states often are the primary regulators of water quality (and mining activity more generally) within their borders.

In the case of the Clean Water Act, all three states have assumed the authority to set water quality standards. How a water body is used dictates how it is regulated; for example, Minnesota has enacted a sulfate standard for "waters used in the production of wild rice." Neither Wisconsin nor Michigan has a comparable standard.

The states also differ in their regulation of groundwater. In Wisconsin, for example, groundwater standards for nonferrous mines apply at a predetermined boundary, which may be up to 1,200 feet from the location of the facilities. Monitoring is required within the compliance boundary, and if there is a reasonable probability that standards will be violated at the boundary, the DNR may order the mining operation to take action to remedy the problem. In Minnesota, the location at which groundwater standards apply is determined by the PCA; in general they apply only at the boundary of the mining company's property. In Michigan, groundwater compliance wells must be located within 150 feet of the mining activity being monitored.

Wetlands

Many states have both federal and state wetlands that can be regulated in different ways. The Army Corps of Engineers typically has authority if "waters of the United States" (which include many wetlands) will be dredged or filled. As noted earlier, however, Michigan issues permits for wetland activities with minimal involvement from the Corps because it is one of two states with

Laws and regulations protecting wetlands and their functions often differ between states, and policies sometimes depend on the type of mining at issue.

delegated permitting authority under the Clean Water Act. If a mine in Michigan is located in a wetland, the state's Wetland Protection Act applies, and a permit may be issued only if the mining activity is "primarily dependent upon being located in the wetland" and an alternative does not exist.

In Wisconsin and Minnesota, both state and federal regulators will determine whether to allow a mining project to impact wetlands, and if so, how those wetland functions should be replaced. Under federal regulations, a mining company must first avoid and next minimize impacts to wetlands before it can turn to compensatory mitigation (creation or restoration of wetlands). Similarly, Minnesota law requires a mining project to evaluate how to avoid or mitigate wetland impacts before the state will consider allowing it to use compensatory mitigation to replace wetland functions.

Wisconsin's wetland policies vary depending on the type of mining at issue. For nonferrous mining projects, the use of wetlands is presumed to be unnecessary unless particular showings are made. For ferrous mining operations, the Wisconsin legislature changed state policy in 2013 to direct that significant impacts to wetlands are "presumed to be necessary."

In Ontario, no legislation exists specific to wetlands, but wetlands are indirectly protected under a variety of provincial and federal laws that protect other resources like water, fish and birds.

Conclusion

Throughout the US, many communities are paying the price of unwise decisions related to metallic mineral mining: acid mine drainage, heavy metals contamination, and other forms of environmental damage. In the Great Lakes region, various projects have left environmental degradation in their wakes. Given its full cost, whether to allow metallic mineral mining must be a decision undertaken thoughtfully and using every available resource. At stake are solemn treaty promises to the Anishinaabe people guaranteeing their rights to use the land.

In light of mining's legacy of environmental damage, it is important that those who make mining laws, those who administer mining regulations, and those who evaluate metallic mineral development proposals employ every effort to fully understand the environmental and societal impacts of those proposals. To carry out their sovereignty as independent nations, tribes must be in a position to exercise their authority and have the capacity to engage in mining decisions. The Anishinaabeg would counsel that decisions must ensure the protection of natural resources for the next seven generations. When mining damages the ecosystems and environment of the limited land base remaining for tribes, there are lasting impacts for Anishinaabeg who cannot and would not leave their homeland.

Those who determine whether metallic mining can occur in the Great Lakes region inevitably balance a variety of trade-offs. While new mining technologies are being developed to mitigate or prevent environmental damage, these methods necessarily use the natural environment as their testing grounds. Failures can be irreversible and sometimes catastrophic, and mining disasters continue to occur in modern times and with alarming frequency. For the Great Lakes region, an area so abundant in water resources, the threats of metallic mining are real and potentially devastating.

When mining ventures cause the loss or contamination of natural resources, it affects Anishinaabe culture in ways far beyond the loss of food sources. It violates the solemn promises made to the Anishinaabeg and goes to the core of what is necessary to sustain them, consistent with what the US has promised. When mining projects damage or destroy treaty resources, treaty promises are broken. Treaty rights are legal protections that cannot be undermined.

Indian tribes with reservations and off-reservation harvest rights in the Great Lakes region are particularly susceptible to the impacts of metallic mineral mining. To the Anishinaabeg, the cost of mining is qualitatively and quantifiably different than the cost to those who make and administer state and federal mining laws and regulations. Anishinaabe culture mandates respect for the earth and humility and gratitude for the resources it provides. Mining laws not written by tribes come from those whose decisions do not reflect this culture. For the Anishinaabeg, the price of the mining process may well be too dear—a price that goes to the core of this nation's treaty and trust obligations.

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Maps and Images

All maps were produced at the GLIFWC office in Madison, Wisconsin unless otherwise credited.

Glossary

Acid mine drainage (or acid rock drainage) is produced by the oxidation of sulfide minerals. Many metallic ore bodies contain significant quantities of sulfide minerals—often including the ore minerals themselves. When sulfide minerals are brought to the surface, they react chemically with air and water and produce sulfuric acid. These acidic conditions can cause metals in geologic materials to dissolve, impairing water quality when the discharges enter waters used by terrestrial and aquatic organisms. Once acid mine drainage has started, it is difficult to stop without long-term treatment.

Anishinaabe is an Ojibwemowin word that means person. Other tribes such as the Cree, Menominee, and Potawatomi also call themselves Anishinaabe and speak languages closely related to Ojibwemowin. Anishinaabeg is the plural of Anishinaabe.

Beneficiation refers to the various processes that mines use to separate the valuable target mineral from the extracted ore. The beneficiation method a mine uses depends on the target metal, ore grade, and specific chemical characteristics of the ore.

Bulk sampling means removing material from a potential mine site to obtain site-specific data to assess metallurgical characteristics and the quality and quantity of a deposit.

Ceded Territory/Ceded Territories are lands in Michigan, Wisconsin and Minnesota ceded by Ojibwe (or Chippewa) tribes to the United States in various treaties. In the treaties of 1836, 1837, 1842 and 1854, the signatory tribes reserved the continued right to hunt, fish and gather on the land ceded. First Nations entered into similar land cession treaties with the Canadian government.

Clean Water Act (CWA) is a federal act that forms the basic structure for regulating discharges of pollutants into the waters of the United States and regulating quality standards for surface waters. Under the CWA it is unlawful to discharge any pollutant from a point source into navigable waters without a permit.

Concentration is the process of increasing the amount of the target mineral in ore by separating it from the crushed and milled rock.

Cone of depression refers to a drop in water levels in the ground resulting from pumping water out of a mine to keep the workings dry. As the cone of depression expands away from the mine, the drawdown can lower the water table in that area, meaning area wells may go dry.

Dewatering refers to the removal of water from the mine pit by pumping or evaporation.

Drill sludge (or drill cuttings) are broken bits of solid material brought to the surface in the process of drilling holes during metallic mineral exploration.

Effluent is a liquid that is discharged from a mining operation.

Financial assurance is a financial guarantee, ideally in the form of cash or an equivalent financial instrument, meant to ensure the costs of all mine clean-up and remediation activities will be paid. The amount of financial assurance should be based on a prediction of the mine's impacts.

Fragmentation is a decrease in the area of contiguous habitat available to wildlife.

Fugitive dust is particulate matter not emitted from a stack, vent, or hood and includes emissions from haul roads, wind erosion, and exposed surfaces.

Gangue refers to the worthless or unusable material that surrounds or is closely mixed with a desired mineral in an ore deposit.

Groundwater is the water located beneath the ground surface in soil or rock pore spaces or fractures.

Invasive species are organisms that cause or are likely to cause harm to the economy, environment, or human health due to their tendency to out-compete native species.

Leachate refers to liquid that extracts the soluble or suspended solids of the material though which it has passed; in mining, it typically means liquid that drains from stockpiled material.

Milling refers to the process of grinding or crushing the ore in a mill to create small sized pieces best suited to mineral extraction.

Ojibwe refers to a group of Anishinaabe who speak a distinct language called Ojibwemowin. The US government recognized these tribes as "Chippewa" during the treaty-making era.

Ore is a type of rock containing minerals with economically valuable elements, including metals, that are removed through the mining process.

Overburden refers to all materials that overlie a deposit, including waste rock and other materials, which must be removed to reach the underground ore body. The mine does not process the displaced overburden.

Remediate/remediation are terms that generally refer to the environmental clean-up of land and water contaminated by the mining process.

Reclamation is the process of returning the mine area as close as possible to its pre-mine condition. Reclamation typically involves activities such as removing any hazardous materials, reshaping the land, restoring topsoil, and planting native grasses, trees, or ground cover.

Riparian means relating to or located on the banks of a natural watercourse or a river or stream.

Sintering is the pyrometallurgical process of forming a solid mass of metal by heat or pressure.

Smelting is the process of heating the metal concentrate beyond its melting point, typically the final step in concentrating a metal that can be sold to manufacturers.

Subsidence refers to the downward motion (or sinking) of a land surface; in mining, this is most commonly caused when underground mine workings collapse, leading to subsidence at the surface.

Sulfate: A negatively charged ion that can be produced when metal sulfides are oxidized, consisting of one atom of sulfur and four atoms of oxygen, SO4. Sulfates are salts of sulfuric acid.

Sulfide: A form of sulfur that often is found in the environment bound to metals. Under acid conditions, sulfide can convert to hydrogen sulfide (H2S) and a metal. Oxidation of sulfide produces sulfur or sulfate.

Sulfide mineral: A class of mineral ore containing sulfides, many of which contain metals. Common sulfide minerals are Pyrite (FeS2) and Cholcocite (Cu2S).

Surface water includes water in rivers, streams, creeks, lakes, and reservoirs and can be replenished through precipitation or through the movement of groundwater to the surface.

Taconite is low-grade iron ore, found extensively in the iron ranges of Michigan, Minnesota, and Wisconsin. Once the taconite ore is removed from the ground, it is concentrated into pellets slightly smaller than a marble. The pellets (also called taconite) are a concentrated iron product, more economical to transport and process into finished goods.

Tailings are the main byproducts of the beneficiation process, composed of rock particles and minerals which could not be recovered or have no value along with the water and chemicals used in the beneficiation process. Tailings can be in a slurry, paste or granular form and must be stored in a reservoir, often a pond or basin. Because tailings range in size from coarse sand to fine powder, their stability varies depending on their placement and moisture content.

Tailings basins (also called tailings ponds or impoundments) typically are large facilities or systems used to isolate tailings and tailings water from the surrounding environment. They may contain acidic water and elevated concentrations of toxic elements.

Treaty rights are rights retained in treaties that were negotiated between governments in which tribes sold the land but did not give up the right to use the land. Treaty rights are not individual rights but are held and regulated by the signatory tribes.

Waste rock is the waste produced during mine development, including overburden and gangue, and those parts of an ore deposit that fall below the economic cut-off grade. Waste rock is usually stored at the surface in large piles and may contain sufficient sulfide mineral concentrations to generate long term acid drainage problems.

Wetlands are areas that are inundated or saturated by surface water or ground-water at a frequency and duration sufficient to support vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, and bogs.

Great Lakes Indian Fish & Wildlife Commission