"Mining and Mineral Development Management Policy in the Selenga River Watershed"
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Abstract

To describe these activities and their implications for the watershed, this paper identifies existing and proposed gold, base metal and coal mines, observed environmental and socio-economic impacts, and models for pollution prevention and watershed management.

Major mines and mineral processing facilities from the period of Soviet Power were abandoned without reclamation or land restoration plans resulting in significant impacts to water resources, riparian areas and fish habitat. In Russia, these facilities include a tungsten-molybdenum mining complex and placer gold mines near Zakamensk on the Dzhida River, a coal mine complex near Gusienozersk west of the Selenga River and coal mines at Tognui in the Khilok River watershed. In Mongolia, major mines include a copper-molybdenum complex at Erdenet; coal mines near Darkhan, and extensive placer gold mines along the Tuul River and other Selenga tributaries.

The most extensive gold mine proposals in the watershed 2004 are hardrock operations at Boroo, in commercial production since March, 2004 and placer operations seeking international funding at Zaamar along a 50 km stretch of the Tuul river.

Impacts of mines and mineral processing detected in the Selenga watershed include: increased sediment loads and associated habitat damage at gold operations; acidic drainage at hard rock mines; mercury pollution from the release of processing reagents; and damage to riparian areas including habitat for endangered sturgeon and taimen populations from riverbed disruption due to dredge mining. Socio-economic impacts include boom and bust conditions at the town of Zakamensk and Gusienozersk and rapid population growth, and associated grazing, community waste and vehicle impacts near Erdenet and Zaamar. Few examples of reclamation or watershed restoration are found in the watershed. International funding has supported extensive, but yet-to-be-completed, reclamation at the Gusienozersk coal mine. Regrading disturbed land to restore stream flows has been conducted at a placer gold deposit mine near Zakamensk being mined for the third time in the last century.

Introduction

Understanding and addressing mines and their impact on nature and society requires a multidisciplinary capacity. Mines are commercial and industrial activities that have environmental and social consequences, sometimes good - producing marketable commodities and employment – and sometimes bad - producing polluting emissions, damaged landscapes, destroyed habitats and disrupted traditional societies. As commercial enterprises, mines and their operators are powerful players in the political and economic life of the communities and regions where they locate their activities. Describing mining activities, identifying their impacts and implementing mineral development management policy requires a multi-disciplinary capacity as well. Identifying elegantly engineered ''best available technology'' extraction systems, continuous emission monitors or ground water clean-up systems don't eliminate the problems of mines, they are just some of the tools that are needed to address a wide spectrum of difficult challenges. Selecting the effective scientific methods, technical designs and administrative mechanisms to address the existing and potential problems requires action in scientific and political and social arenas and involvement of regulators, miners and active and motivate citizen organizations.

Developing effective mineral management policy on a Watershed wide-basis for a region as large as the Selenga Watershed therefore requires contributes from many sciences, or fields, and effective collaborations among specialists in many fields. For well-developed policies to be implemented and enforced, the capacity to be effective in the "politics of science," as well as political science, must be built and sustained. This paper attempts to contribute to the development of effective mineral development and management policies in the Selenga River Watershed by identifying prominent inactive and active mines in the watershed, prominent environmental impacts from some of those mines, and options for effectively addressing the challenges of the full range of mining activities in the region.

Mining and mineral development activities have been a major source of environmental and socio-economic impact in the Selenga River Watershed in Russia and Mongolia for more than one hundred years. Major mines and mineral processing facilities in Russia from the period of Soviet Power were abandoned without reclamation or land restoration plans resulting in significant impacts to water resources, riparian areas and fish habitat. In addition to addressing potential impacts from the one major mine in the country to sustain production through the transitions of the past decade, the giant Erdenet complex, Mongolia faces the development of booming gold production center that has become the largest single sector in its economy. Gold production from placer deposits, activities that are particularly damaging to riverside habitat and water quality, are a growing sector of the mining industry in the Selenga Watershed, affecting major tributaries of the Tuul, Orkhon and Boroo Rivers in Mongolia and the Dzhida, and Chikoi River in Russia. The scope of the inactive and active mining in the Watershed presents challenges that have yet to be effectively addressed and will worsen considerably without a large and sustained national and international commitment. Hopefully this paper help advance the process of bringing solutions to the problems identified. A Map locating mining districts mentioned in this paper is attached as Figure 1. A set of images of mines in Russian mentioned in this paper is attached as an Appendix.

Mines and Mineral Deposits in the Russian Portion of the Selenga River Watershed

Major deposits of tungsten, molybdenum, gold, coal and other minerals have been exploited in the Russian Portion of the Selenga Watershed for more than 150 years with the most extensive mining activities occurring during the period of Soviet Power. During the Czarist and Soviet periods, the exploitation of these deposits was conducted with little if any consideration for the management of hazardous constituents in the wastes created from mining and processing, the landscapes and watersheds downwind or downstream of the deposits or the human or ecological communities where the minerals were discovered.

A variety of sources can be identified to summarize the extent of mineralization and mining in the Russian Portion of the Selenga watershed. Mironov 2000 provides an overview mineral deposit information from the Geologic Institute of the Siberian Branch of Russian Academy of Science and the Buryat Republic Committee on Natural Resources. A collaborative effort among a US, Russian and international team of geologists to identify the literature on mineral deposits and occurrences including the Selenga Watershed is found in Ariunbileg 2003 and related publications. This paper identifies the largest and most prominent of the past, current and proposed mines in the Watershed.

The Dzhidinski mining district in Zakamensk Rayon is the site of the largest hard rock mines and mills in the Russian portions of the watershed. The area includes extensive tungsten and molybdenum workings from more than 50 years of production and placer gold extraction sites whose exploitation go back into the 19th century. These deposits occur in the along tributaries of the Dzhida River which enters the Selenga River from the west and drains the Southwestern part of the Buryat Republic.

Tungsten-molybdenum deposits in the area were discovered in 1932, leading to exploitation which began in 1935 and ended in the early 1990s. More than 60,000 tons of tungsten and 30,000 tons of molybdenum were produced from more than 40 million tons of ore and 400 million tons of waste rock which were mined from two large open pits and numerous associated underground workings. Ore in the district contained up to 0.1 - 0.2% molybdenum and 0.148% tungsten occurring primarily as sulfide minerals. The largest mine was the Pervomaiski pit which is now considered to be mined out and currently contains a large acidic pit lake. Ores were extracted from a series of underground mines in addition to several open pits. Ores from were transported by truck and aerial tram to processing facilities south of, and up gradient of, the town of Zakamensk. Tailings were deposits in two major piles also south of and up gradient of the town. While research has been conducted to identify the extent of residual minerals in the ore and tailings - including gold, copper and uranium as well as tungsten and molybdenum - to encourage remining of site wastes materials, all mineral extraction ceased following the end of the Soviet Union, with the exception of mineral gathering by small teams of "informal" miners. No reclamation activities have been conducted at the site and no impoundments contain the tailings deposited near the community.

Placer gold deposits in the Dzhida River watershed have been exploited during several episode including dredge operations prior to the 1917 Revolution, followed by remining in the 1930 - 1950 period and a current phase from 2000 to the present. Contemporary mining is conducted using bulldozers and site-built gravity jigs. Reworking previously mined areas produces roughly 0.5 tons of gold per year. Total gold resource potential in the Buryat Republic as a whole approach 100 tons and most recent production has been from mines outside the Lake Baikal Watershed. The current phase of gold mining by reworking dredged riparian materials includes regrading of worked materials and reestablishment of stream courses following extraction, the first metal mine reclamation identified in the Russian portion of the Selenga Watershed.

Coal deposits have been exploited in the Selenga watershed site since the arrival of the Trans-Siberian Railroad in the 19th century. The largest single coal mine complex in the Selenga Watershed is a 2,600 hectare open cut mine in Selenginskii Rayon between Ozero Gusien (Goose Lake) and the Selenga River. This mine was developed to provide fuel for a large coal fired-power station in the Rayon capital of Gusienozersk. More than 30 million tons of coal was extracted and approximately 300 million tons of overburden moved at two major mines prior to the cessation of mining. Currently coal is being extracted from an open cut mine just east of the former mine between city of Gusienozerk and the Selenga River.

Coal and metal mining has also been conducting in the Khilok River Basin east of the Selenga in both the Buryat Republic and Chita Oblast since before the end of the Soviet Union particularly in areas near the Trans-Siberian Railroad. The Khilok watershed is home to mining towns associated with deposits of gold, tungsten, tin, lead, zinc, molybdenum, and lithium. Specific clusters of deposits are near Shabur, Kusoty, and Khonkholoi. Contemporary coal operations are found along the Tognui River, a tributary of the Khilok in Buryat Republic and as well as along the Khilok River in the Buryat Republic and Chita Oblast at Kataevo, Balyaga, Kuli, Tarbagatai, and Novo Pavlovsk. (Mackey 2002) The primary use of this coal to fire electrical and thermal power stations in the Buryat Republic and Chita Oblast.

The Chikoi River watershed in Chita Oblast is the host for placer gold operations conducted near Krasny Chikoi and the Menzhy River. Placer mining using dredges and large scale, high-pressure hydraulics has been conducted since at least 1994 along the Chikoi River and its tributaries. (Laperdina 2004, this Conference)

Numerous unexploited mineral deposits have been identified in the Selenga River Watershed. Unexploited molybdenum deposits have been identified at Zharchikhinskii are located 40 miles from Ulan-Ude, 2.5 kilometers east of the Selenga River. The deposit are reported to contain 100,000 tons of molybdenum and molybdenum sulfide at concentrations in the range of 0.08 - 0.09%. (Mironov 2000)

Several significant mineral deposit in the Buryat Republic and Chita Oblast are found outside the Selenga Watershed but within the Lake Baikal Watershed and associated protected areas not drained by the Selenga River or its tributaries. Major metal deposits in the Lake Baikal Watershed outside the Selenga drainage include base metal deposits near Sosno-Ozerskoe close to the source of the Uda River and north of Severobaikalsk at the northern end of Lake Baikal. In addition to the prominent metal and coal mines already identified, an extensive limestone deposit in Kabanskii Rayon on the south shore of Lake Baikal has been exploited to feed the Tuimenski Asbestos-Cement Factory at Kamensk.

Of the four - five tons of gold produced annually in the Buryat Republic in recent years, most production has come from the Zun-Kholba mine in Okinskaya Rayon in the watershed of the Irkut River and placer operations in Bautnovskii and Muiskii Rayons in the Vitim River drainage which is tributary to the Lena River.

Mines and Mineral Deposits in the Mongolian Portion of the Selenga River Watershed

Since 1990, mining has grown rapidly in Mongolia primarily as a result expanded extraction of copper, molybdenum, gold and coal from the Selenga Watershed. The Selenga Watershed produces most of 10-12 tons of gold produced annual in Mongolia in recent years and the site of several newly opened and proposed gold mines. News of the boom in gold and base metal mining in Mongolia is a regular feature of the mining press.

> "Gold mining alone, legal and illegal, has become a key driver of the economy, spinning off smaller businesses such as shops, kiosks and bars in gold rush towns and in Ulan Bator. "In five to 10 years, mining will easily double gross domestic product," according to … the Chairman of the Mineral Resource Authority, "mining will change the whole country. Hopefully for the better." More than 30 percent of Mongolia has been licensed for exploration and mining with the copper, lead and other minerals produced being sucked up by booming neighbor China and other markets." (Macfie 2004)

In discussing the appeal of Mongolia to the world's mining community, Robert Friedland was reported to assert that Mongolia is a mineral exploration target since "the world needs another Oyu Tolgoi [a large copper/gold project being developed by Friedland's Ivanhoe Mines in southern Mongolia -] each year because mining in wet areas is now not possible on environmental grounds and no one wants to mine in Islamic countries because of terror threats. Mongolia is Buddhist." (Gottliebsen 2004)

Mining is a dominant sector of the Mongolian economy, reportedly representing in the range of 30% of total industrial output and 65.5 % of export revenues since the year 2000. Mongolia is rich in minerals and metals such as coal, copper, gold, uranium, iron ore, wolfram, molybdenum, phosphate, crude oil among other deposits. More than 6,000 deposits of 80 different minerals have been discovered and more than 160 of the 400 deposits surveyed are being exploited. The Mineral Resource Authority of Mongolia compiles data on mineral deposits, production and licensing. (MRAM 2004). US, Mongolian and international researchers have compiled the available the literature on metalliferous locations in Mongolia. (Dejidmaa 1999)

The booming gold mining industry is seeking to exploit gold resources – resources are an estimate of the unproven potential amount of a commodity - reported to be on the order of 3,000 tons. Mongolia has more than 100 known gold hard rock and placer deposits in 18 zones. Estimated reserves – reserves are proven, economically exploitable amount of a commodity - of these deposits is 157 tons, from which 98 tons belong to placer and 59 tons to hard rock. The major development gold mining districts are Zaamar, Boroo, Tolgoit and

Naran-Tolgoi located respectively 250 km west, 110 km northwest, 180 km north and 90 km west of Ulan Baatar city respectively. This paper identified the most prominent of the mineral developments in the Selenge Watershed in Mongolia. (MRAM 2004)

Expansion of the Zaamar gold mine, currently under review for funding by the Overseas Private Investment Corporation (OPIC) would result in dredge mining of placer gold deposits along a 50 kilometer stretch of the Tuul River between Ulan Baatar and its confluence with the Orkhon River. Prior to the initiation of mining activities along the Tuul River in 1992, reserve estimates for the Zaamar deposits were 21.1 tons at grade of 0.2 - 1.7 g/m3. Four properties - Shijiir Alt, Big Bend, Monpolymet and Khos Khas - comprising 17,400 hectares along the Tuul river are part of the Zaamar project proposed for funding by OPIC on behalf of the project sponsor WM Mining Company. Dredges, reminiscent of the dredges that operated in the Folsom, California and other placer districts, have been operating in the Zaamar area since the early 1990s. In addition to the industrial scale mining along the Tuul River, an enormous number of individual or "artisanal" miners have migrated to the Zaamar area - estimates range from 10,000 - 100,000 individuals - to try their hand at individual and family-scale mining in close proximity to the industrial scale mining along the Tuul. (ATAA 2003, Macfie 2004)

The Boroo Gold Project, the first operating large-scale hardrock gold mine and the first cyanide-based processing mill in the Selenge Watershed and the Lake Baikal Watershed as a whole, having begun commercial production in March 2004. Boroo's Canadian primary owner Cameco reports 10,175 million tons of ore and reserves of 1.14 million ounces (approximately 40 tons) at a grade of 3.2 g/t. and 3,387 million tons of resources containing 228,000 ounces of gold at 2.09 g/t. Cameco reports that the deposit was identified and outlined in the mid 1980s by a joint Mongolian-East German group 110 miles northwest of Ulan Baatar and 35 miles south of the Russian border. The Boroo operating company, ACG, announced the attainment of commercial production in March, 2004 and plans to remain in production for five – six years. AGR projects 210,000 ounces/year of gold production beginning in 2004 from the cyanide/carbon-in-leach mill and open pit complex. Gold production at this rate will generate more than 2,000,000 tons tailings per year. Cameco produces gold at the Kumtor mine in Kyrgyzstan as well as its primary business of uranium production in Saskatchewan, Canada, (Cameco 2004)

Most copper and molybdenum resources in Mongolia are found at the Erdenet-Ovoo and Tsagaan Suvarga deposits comprising estimated reserves are 8 million tons for copper and 240,000 tones for molybdenum. Erdenet, the largest metal mining operation in Mongolia, is located in Bulgan aimag near the confluence of the Orkhon and Tuul Rivers. It is largest single hardrock mine and mill complex currently operating in the Selenga Watershed. Erdenet opened in 1978 and utilizes solvent extraction (head leach)/electro winning technologies to process up to 20 million tons/year of ore and produce about 354000 tons/year copper concentrates and 3500 tons/year of molybdenum concentrate. A significant recently discovered deposit has been reported at Ivanhoe's Oyu Tolgoi project in southeastern Mongolia outside the Selenga Watershed in Mongolia.

Coal was the single mineral extracted in Mongolia prior to 1970, with production coming from the Nalayh mine in Selenge aimag. This deposit and others in Selenge aimag east of the Selenga River and south of the Russia-Mongolia border have been exploited for more than

30 years. More than 200 coal deposits and occurrences have been discovered in ten coal basins around Mongolia containing an estimated resources of about 50 billion tons of which 20% is hard coal and 80% lignite. Output has been in the range of 7 million tons/year from 17 deposits in recent years, though demand is reported to have risen considerably in the last few years. Significant deposits of other minerals including fluorspar, lead, and zinc among others have been identified as well as 22 oil fields, 13 of which are partially contracted by foreign companies from Britain, Canada, Australia and USA (Invest Mongolia 2004)

Consequences of Mining in the Selenga River Watershed

The inactive and abandoned mines in the Selenga Watershed have left a legacy of natural resource, ecological and socio-economic impacts that mimic the impacts of inactive and abandoned mines throughout the world. A thorough review of the impacts of inactive and abandoned mines is available in the USA Environmental Protection Agency's "Abandoned Mine Site Characterization and Cleanup Handbook," (EPA 2001).

Historically there had been no organized reclamation activities for any of the mining projects in the Selenga Watershed. (ATAA 2003) Lacking effective reclamation, the consequences of inactive and abandoned mines include landscape destruction, habitat destruction, releases of sediment and hazardous constituents through wind and water erosion and occasional release from failed or flooded tailings dams and waste rock dumps. Social consequences can include; permanently disrupted rural and indigenous communities, degraded health among nearby people and wildlife, boom and bust economies and social stresses from lifestyle and economic changes.

The consequences of inactive and abandoned mines can often be addressed by effectively planned and carefully operated mines. Failure to insure that effective pollution prevention and reclamation practices are designed into the mine or provide effective enforcement to insure than competent plans are fully implemented can result in a similar set of consequences for operating mines. An example of reclamation following immediately following mining – contemporaneous reclamation – can be seen in the Selenga River watershed at the placer gold mine in the Dzhidinski mining district where the operator is regrading waste piles and reestablishing stream courses following mining.

This paper summarizes environmental and socio-economic consequences identified at inactive and as well as active mines in the Selenga River Watershed to provide insight in to the enormous backlog of environmental remediation needs in the region. As some of the operating or proposed mines at site of historic mining, particularly those at Zaamar and Boroo in Mongolia and Dzhidinskii in the Buryat Republic, opportunities exist to remediate existing environmental damage while new mining is conducted, if operators are willing. The direct and indirect social consequences of mining, such as population migrations, whether voluntary or "forced," and associated overgrazing, hunting or fishing, cultural disruptions and sanitation, solid water disposal, energy consumption and water supply and housing crises are at least as difficult to control of environmental releases from mines.

No effort to gather baseline environmental data prior to mining before1990 has been identified in either Russia or Mongolia, as was the case in most mining regions around the world. Even in the past 12 -15 years, little effort has been made in either Russia or Mongolia to systematically organize pre-mining environmental data or compile environmental monitoring data contemporaneous to mining. The lack of a diverse and comprehensive database prevents quantitative assessment of mining impacts. Papers being prepared for this Conference provide some of the first sets of published data on mine sites and areas affected by mine-related releases in the Selenga Watershed.

Environmental and Social Impacts of Mining in the Russian portion of the Selenga Watershed

In the Selenga River Watershed, a century of placer, open pit and underground mining exploiting gold, tungsten, molybdenum, copper, coal deposits have left a widespread environmental and social legacy.

Environmental impacts identified at mines investigated in the region include:

- increased metals in waters ground and surface waters due to oxygenation of sulfide deposits;
- degraded landscapes in mining areas and areas of associated infrastructure resulting in soil loss and erosion; and
- destruction of vegetation and soil cover in alluvial valley floors and terraces mined for placers deposits.

Sites investigated show mine waters enriched with Au, W, Mo, Cu and Fe and high concentrations of these elements have been found in grass, brushwood and pine, birch and larch tree samples. (Taisaev 1999).

The Dzhidinski mining district in Zakamensk Rayon and the Gusienozersk area coal mines in Selenginskii rayon west of the Selenga River are the largest identified mining districts in the Russian portions of both the Selenga River and the overall Lake Baikal Watersheds and were abandoned by their Soviet era operating agencies without any reclamation activities. Though a series of studies of health and ecological consequences have been conducted at Zakamensk, the huge waste piles there are still open to the wind and rain and hazardous constituents are continuously released to nearby soil, ground water and tributaries to the Dzhida River. (Tulukhanov 2000)

The Dzhidinski area tungsten-molybdenum mines, mills and waste piles are upgradient of the Zakamensk town, a community of 10,000 -15,000 and the administrative center of the surrounding rayon. Towns such as Zakamensk, home to the largest historic metal mining operation in the Selenga Watershed, are examples of job-short, socially-stressed economically-depressed mining towns in many countries, signs of the bust following the boom days of production.

The area was a center of Buryat culture for more than five hundred years and isolated from Russian and Soviet influence until it became a mining-centered community controlled by the Soviet Defense Establishment for major production of tungsten and molybdenum - both important alloying metals - beginning in the 1930s. Zakamensk was a also exclusively an ethnic Buryat community prior to the influx of Russians and German and Japanese prisoners-of- war who built and operated the mines in the region. Regional administrators are attempting to restore the rich cultural heritage and establish a diverse sustainable economy now that al mining except for placer gold mining has ended.

Extensive studies during the past ten years document extensive soil, ground water and surface water impacts as well as human health consequences associated with exposures to metals and other hazardous materials at the site. Metals such as cadmium, zinc, lead, chromium and copper has been detected at tens to hundreds of times Russian standards (PDKs - maximum permissible concentrations) in soil and water samples. The sulfide-rich Dzhidinski ores, waste rock and tailings are a spreading source of soil and water contamination found in mine and mill tailings-affected waters, and outflows from underground mine tunnels. (Tulukhanov 2000, Khondinovich 1999a and 1999b)

The 40 million tons of mill waste, tailings, lie in two piles covering 700 hectares upgradient of and next to - within one hundred yards of - apartment blocks and farms. Ground waters affected by leachate from these tailings show increased in cadmium, zinc, lead and other constituents. Factors favorable to migration of metals from the Zakamensk area mill tailings are:

- significant excess of pyrite in relation to other sulfides as a source of free H_2SO_4;
- predominance of quartz and acid plagioclase in hosted rocks; and
- the absence of carbonate and dark-colored minerals acting as neutralizers of acid solutions.

Acid generation processes are estimated to have affected 15% of the tailings by the year 2000 and are projected to continue for more than 50 years. (Plyushnin 1999, Bortnikova 1996).

In addition to the dispersion of metals released by acid mine discharge, the mine waste dumps and mill tailings piles appear to be geotechnically unstable. The tailings lack any containment structure of any kind and every rainfall event carries tailings towards the town and into a rapidly eroding diversion ditch made of tailings which is only barrier between the wastes and apartment blocks less than 100 meters away. Water-borne tailings are visible between the tailing piles and the Dzhida River several kilometers downgradient.

Waste rock piles more 300 – 500 meter tall surround the mines. Extensive geochemical weathering and acid generation is visible at the waste rock. Stress cracks parallel to the face of the waste rock dumps and million ton slump blocks demonstrate that massive slope failures have occurred at the mine site.

At the Selenginskii coal mines, a major environmental reclamation effort was planned and funded by international financial institutions but the reclamation has stalled following exhaustion of the allocated funds. Open pit workings approached within 200 meters of Ozero Gusien (Goose Lake) - a 25 kilometer long and 6 kilometer wide lake west of the Selenga River. Ozero Gusien has been used a cooling lake for the coal fired power station in the region and fly ash from the plant is deposited on the surface between the power plant the city of Gusienozersk, a community approximately 50,000 souls.

Environmental impacts of mining in the Khilok River basin including, extensive landscape disturbances and effects on water quality and fisheries have been the focus of attention a the Institute of Natural Resource of Siberian Academy of Science at Chita. The "Khilok River Watershed Project" provides useful model of watershed data compilation and may provide a strong foundation for the identification of environmental consequences of in that watershed. (Malchikova 2001)

Gold placer mining in the Chikoi River portion of the Selenga Watershed has affected portions of Chita Oblast. Field investigations showed significant deterioration of hydrologic characteristics - increased content of heavy metals, pH and turbidity, significant decreases in fish diversity and reduced grayling populations, degradation of terrestrial ecosystems bordering mine sites and violations of requirements to conduct planned measures for reforestation and water restoration. (Laperdina 2004 this Conference).

Environmental Impacts of Mining in the Mongolian Portion of the Selenga River Watershed

The gold boom in the Mongolian portion of the Selenga River Watershed has resulted in a pattern of widespread environmental impacts typical of the impacts of placer mining in other regions (EPA 1995) including landscape and riparian area disturbance, sediment loading of downgradient streams drowning fishery habitat in silt and accumulations of heavy metals from mineral deposits and reagent releases. Environmental Impact Assessments and associated studied to address concerns of international funders and other potential mine investors have resulted in several assessments of impacts to the region.

Following exploration in the 1980s, the Tuul River between Ulan Baator and its confluence with the Orkhon River has become an area of extensive gold placer mining. A series of observations in the region resulted in the following conclusions.

- Individual mines are spread out along more than 50 kilometers of the Tuul River Valley.
- Placer gold activities are the source of wide spread destruction of the Tuul River Valley's riparian ecosystem, natural meandering river channel and adjacent floodplain, river terrace and alluvial fan grassland ecosystems.
- Damage results from open pit extraction and injection of large amounts of silt and sediment in the Tuul River.
- Sources of sediment include mine pits, mine roads, and unreclaimed or ineffectively reclaimed mine areas.
- Damage includes habitat destruction from open pits, wash plants and settling ponds.

Identified and potential impact of siltation include:

- Destruction of fish spawning habitat by burial of spawning gravels and fish eggs in silt
- Physical abrasion of fish, especially juveniles

- Suffocation of fish by clogging of gills with sediment
- Instability and braiding in river channel
- Increased erosion and loss of vergetation
- Channel incision and filling of channel pools
- Channel capture by mine pits
- Reduce floodplain groundwater levels
- Proliferation of invasive plant, insect and invertebrate species
- Diminished water quality downstream
- Contribution to eutrophication of Lake Baikal.

In association with ecosystem destruction, environmental impacts observed in association with the Zaamar goldfields include:

- High levels of airborne dust from open pit mines and unsealed mine and camp roads and multi-tracking
- Hydrocarbon spills from improper storage and disposal of fuels, lubricants and solvents
- Handling and disposal of mercury used in gold concentration processes
- Sewage and solid waste disposal
- Coal and wood smoke emissions from mine camps
- Increased erosion from increases in local livestock herds to feed miners
- Increased deforestation due to wood use by miners (Farrington 2000

While a range of existing technologies can be identified to address the environmental impact observed in the Tuul River Valley, ineffective enforcement environmental standards and poor mine planning an operation result in a lack of effective pollution control, pollution prevention, and contemporaneous reclamation practice being used at the mines. Investigators report that landscape destruction has affected more than 70,000 hectares, four times that reported in the Zaamar EIA. This landscape destruction has involved obliteration of archeological resources dating to 1500 BC or older. (Enviroplan 1999)

Of particular concern in the mining districts along the Tuul River are populations of two threatened and endangered fish species identified in the Selenga watershed in general and the Tuul River system specifically - the very rare Baikal sturgeon (Acipenser baeri baicalensis) and the Taimen (Hucho taimen) a rare salmonid. The Zaamar Environmental Impact Assessment (EIA) identifies potential impacts to these species including habitat loss and population decline resulting from dredging, tailings and overburden deposition, sediment ponds, increases in soil erosion, and activities associated with miners' settlements, such as poaching. (ATAA 2003 Chap. 5 p. 31)

The Selenga River is described as the major spawning ground for Baikal sturgeon - Acipenser baeri baicalensis, a threatened and endangered species listed in the Mongolian Red Book of threatened and endangered species - which undertakes spawning migrations in Watershed. In Mongolia, the Baikal Sturgeon habitat is found in the Selenga River and its tributaries, including the Orkhon, Tuul and Dergen Rivers. Two migrations cycles have been identified for the Baikal Sturgeon during the warmer part of the year. One starts in the second half of April at a water temperature of 3-5oC and ends in mid-June. The second migration, which is the major migration of this sturgeon, starts at the end of July and it ends in mid-September. This migration coincides with summer floods in the Selenga. When water temperatures decline, the migration ends. Sturgeons have often been observed to overwinter in deep pools of the Selenga and its tributaries. In both migration periods the migrants include sexually mature individuals as well as younger fish. Apart from the migrating sturgeon there is a also non-migrating sturgeon population in the rivers Orkhon and Tuul of the Selenga catchment. (Dulmaa 2003)

In the Selenga drainage the Siberian Baikal sturgeon spawns from the second half of May to early June when the water temperature is between 10 and 15oC. It spawns on rocks, stones and coarse sand. Baikal sturgeon feeds on chironomid larvae, oligochaetes and larvae of caddis flies. (Dulmaa 2003)

Taimen - Hucho taimen - inhabits the Selenga River and its tributaries as well as the Shishhid, and Amur Rivers and some of their tributaries. The fish prefers mountain streams and sub-montane rivers with clear, well-oxygenated cold water. The piscivorous taimen starts spawning in the second decade of May when water temperature reaches 10oC. The spawning takes place in deep sections of rivers and in lakes. In the drainage of the Selenga, the largest taimen captured was 180 centimeters long and weighed 45 kilograms. Taimen is a valuable commercial fish species, well appreciated especially by anglers and very prominent in the marketing of tourism in Mongolia. This is due to the delicate taste of its flesh, its large size, and its fighting behavior during angling. A special angling license is required to capture taimen in Mongolia as a result of decline in the taimen population in the Onon, Herlen, Selenga, Orkhon and Tuul Rivers. (Dulmaa 2003).

Baikal sturgeon habitat loss includes removal of pool-riffle river channel complexes, sand bars and gravel substrates of particularly important to sturgeon spawning. Modifications of the river's flow regime are associated with damage to fish migration patterns that reflect historical seasonal flow conditions. Increases suspended solids loads reduce and modify invertebrate populations, and import source of food in the riparian ecosystems of the Selenga Watershed, causing ecological impacts beyond the mining districts. Habitat loss due to landscape damage and siltation and over fishing resulting from the large influx of people into the Zaamar area are impacting Taimen populations. Poaching by miners, residents and travelers to the region also devastates fish populations.

Impacts on fisheries and other riparian resources in the Tuul River at the Zaamar sites to result in a conclusion that:

> "Mongolian government is left with three choices and either:
>
> 1) accept the impact, continue mining as practices, destroy the Tuul River fisheries in the area and for a distance downstream probably default on the Selenge Treaty and continue to exist at odds with herders while destroying the local economy and culture;
> 2) prohibit river and floodplain mining by establishing a defined set back from river areas;
> 3) establish a 20-year moratorium on new projects until it can be demonstrated by research and field trials on the existing operations that the

> sequence of river and floodplain dredging combined with riparian zone and river channel rehabilitation can be successfully carried out in an environmentally acceptable manner." (Enviroplan 1999)

Cameco's summary of the history of gold extraction at Boroo (Cameco 2004) does not mention the 100 years of placer gold mining along the Boroo River reported in Tumenbayar 2000. This activity left a legacy of mercury that is reported to be a source of exposure to farm fields and livestock grazing along the river, and men, women and children conducting informal mining. Mercury releases are reported to have created a "mercury placer" with mercury concentrations ranging from 1 - 2,000 grams/ton at a former gold processing site. Human exposures are reported to be the result of informal miners living in and working on the mercury placer. Cycles of gold mining at the Boroo River site have reported for the 1900 - 1919, 1926-1927 1942 and 1951-1956. Based on concentrations of mercury in the g/t range more than 10 tons are estimated to have been released the gold processing facilities abandoned at the site in the 1950s. (Tumenbayar 2000, Oyundar 2001, and Tumenbayar 2004, this Conference)

The gold boom in northern Mongolia has attracted international mining companies and enormous horde of Mongolian citizens looking to benefit from the gold in the region. A major migration on the scale of an international refugee migration to the region is associated with the rapid development of informal gold mining, called by some "ninjas". The allure of potential income from gold has drawn an estimated 50,000-100,000 workers, hoping to provide income for families who lost their herds in past harsh winters ("dzud") and who failed to find employment in rural or urban areas. Without any regulation, however, informal gold mining can contribute to environmental degradation of rivers and streams due to mining practices and releases of human, petroleum products and solid wastes as well as impacts such as illegal and excessive fishing and hunting livestock and wildlife.

Managing Mineral Resource Development

National policies governing the management of mineral resource development and associated environmental consequences in Mongolia and Russia have changed radically since the end of the Soviet Union. Both nations have adopted environmental, resource allocation and taxation statutes as part of the wholesale restructures of their national political system. In addition to mineral resource and environmental statutes both nations have established extensive administrative systems to address management concerns in the Lake Baikal Watershed specifically. Designation of the Lake Baikal as a United Nations-designated World Heritage Site, investments by international financing institutions and international treaties demonstrate the global awareness of the important of effective management of the Baikal Watershed, and lack of demonstrated capacity to provide effective management in the past.

This legal framework has evolved as the mine abandonment, mineral exploration and mine development activities of the past 15 years have proceeded. Similarly the administrative mechanisms for addressing the Lake Baikal watershed and the Selenga River portion of that Watershed have been evolving as activities have proceeded. "Lake Baikal Watershed: Lake Basin Management Initiative" provides a current overview of the complex mix of national statute and regulation, bi-national and international agreements that play a role in Lake

Baikal Watershed activities. (Brunello 2004) The report chronicles the evolution of Russian, Mongolian and International management authorities in the Lake Baikal including the Selenga River Watershed. The current Russian Federation coordinating agency for the Baikal Watershed is “Baikalpriroda” - a Federal Environmental Protection Agency created in 2002 - with special jurisdiction to enforce Russia’s “Baikal Law,” coordinate the numerous federal and state agencies activities in the region, and coordinate all transboundary issues with Mongolia. The “national and international coordinator role“ establishes Baikalpriroda as a potentially important point of contact of interagency communication as well as local government, businesses, civil society organizations and public service organizations. (Brunello 2004)

But Baikalpriroda also has begun to show the consequences of a sharp contrast between broad legal authority and an inadequate funding base to initiate or sustain enforcement of that authority. In contrast to its importance as a focal point for governmental coordination the staffing of the agency is inadequate to start that job strongly. Baikalpriroda’s 2002 budget was less than 30 million rubles - $1,000,000 USD - and a total staff of 15. Baikalpriroda’s budget has remained constant for two years as international funding from UN, European Union, USA and other international bodies has slowed down significantly. (Brunello 2004)

The lack of adequate funding for start-up operations and the lack of sustainable source base to fun effective policy implementation and enforcement leaves the management of the Baikal Watershed suffering the same set of problems that were identified when Baikalpriroda was created. Those deficiencies include:

- little or no coordinated management between the Russian and Mongolia to allow policy makers, scientists and civil sectors organizations to collaborate on monitoring, enforcement or policy development;
- declining federal, state and international funding for environmental protection and sustainable develop programs;
- Federal and State economic development policy that prioritizes, rather than balances, resource development projects over environmental protection and conservation projects;
- no coordinated efforts to establish and maintain environmental research and monitoring programs to provide baseline data and document impacts of activities in the Lake Baikal Watershed. (Brunello 2004)

Mining has yet to be a very prominent source of concern for the sustainability of the ecosystems in the Lake Baikal Watershed when compared to multi-decade debates concerning the impacts of the paper product plants, the Angara Dam raises and agricultural runoff and domestic and municipal waste discharges. This lack of focus on the environmental and social consequences of mineral developments has allowed the associated problems to worsen and become even more expensive to address.

The severity of the impacts of abandonment without reclamation in the Zakamensk is a legacy of continuous, permanent source of pollutants leaking into the watershed and a devasted socio-economic environment offers. Technical remedies already existing could be implemented at Dzhidinski mining district problem if sufficient resources can be mobilized to accomplish the goal. A remedy for the mine impact problems on the scale of Dzhidinski district – such as that currently being implemented at the Quest, New Mexico, USA molybdenum mine where more than $150 million USD has been budgeted by the mining company to reclaim open pits, underground mines, 85 million tons of tailings and more than 400 million tons of waste rock - will take a new and sustained national and international commitment. This site is an example of the environmental and social consequences of abandonment as a sustainable mine closure strategy and will remain a memorial to mining without reclamation until a sustained remediation effort is mounted.

The stalled reclamation of the Gusienozerk-areas coal mines demonstrates the challenge of implementing mine reclamation at an abandoned site, even with international design and funding support. The site is an example of the consequences of funding environmental technologies based on design, rather than completion, of environmental projects.

Many of the impacts of mining in Mongolia are very different in character than those in Russian and will require different management strategies to address. Mining impacts in Mongolia include widespread destruction of riparian ecosystems. The devastation of dozens of kilometers of the Tuul River shows the inability of regional, national or international agencies to effectively enforce either monitoring, technology performance or emission control requirements. The Zaamar EIA - written by contractors to the Zaamar operators and not an independent assessment - considers the current site impacts as part of the existing environment and does not proposed to rehabilitate the areas of its operating licenses to pre-mining condition. (Farrington 2000)

The migration of tens of thousands of Mongolian families for direct and indirect work in the gold mines is a population transfer on the scale of international refugee crises, with all the associated social impacts. The Zaamar EIA identifies the arrival of thousands and thousands of migrant workers as a workforce with providing sufficient housing and services for them to live a health life. The 10-ton mercury legacy of the abandoned gold factory along the Boroo River presents a human health and ecological risk that affect a portion of the watershed that is host to the newly opened Boroo open pit-cyanide leach gold complex nearby.

Both Russia and Mongolia have adopted legislation regarding environmental assessments and reclamation of mined areas along with full selection of other environmental statutes however resources to compile monitoring data, conduct inspections and implement enforcement are severely limited. Enforcement is fundamental to effective good governance and good environmental policy but difficult to fund in any jurisdiction, and the enforcement and funding shortage for environmental management in Mongolia is as severe as anywhere in the world.

The mining laws of Mongolia - the Mongolian Mineral Resource Law of 1997 is available at: http://www.mram.mn/M_Legis.htm - provide comprehensive authority similar in tone at other recent national or state-level mining laws, such as the New Mexico Mining Act of 1993. Though deficiencies can be identified, the "main problem is one of enforcement" as is the case in many jurisdiction, Russia New Mexico included. While the adequacy of enforcement is a very subjective determination, an investigation of the Zaamar gold mining area noted, "….if existing laws had been effectively enforced many of the current and serious environmental impacts in the Zaamar Field would not exist today." (Enviroplan

1999). Responsibility for enforcement exists at all levels from local to national institutions and all have claimed lack of sufficient funding to achieve the required degree of compulsion. (Enviroplan 1999).

Other commentators have been even more direct in their acknowledgement of the limitations on enforcement as well as the posture of some of the mining companies. A Canadian observer noted recently:

> "Mining companies in Mongolia have an atrocious environmental record, according to a UNDP report on mining. The largest mine in the country, the Erdenet copper mine (a joint venture between Russia and Mongolia) is reportedly fined US$500,000 per year, and just chalks it up as a cost of doing business rather than the more costly option of improving their processes. Enforcement of environmental standards is weak, and the nascent environmental elements of civil society are silent with few exceptions. In other words, a company can do pretty much what it likes." (Heap 2004)

Conclusion

Effective management of the Selenga Watershed will take much more than well stated legal authorities and thoughtful conferences. It will take an sustained national and international support to provide a permanent set of programs at a funding level that matches the scale of the Baikal Watershed - a region the size of France - and supported with resources to balance the technical and political capacities of mining companies and other resource development organizations.

Effective application of international standards and norms established by law and company or lender policy is a primary objective of regional policy agencies and non-governmental organizations to address current and future mineral developments and provide for remediation of inactive mines. (Enviroplan 1999, Farrington 2000, Brunello 2004)

Egos in the region concerned about mining and its impacts have identified a series of policy recommendations applicable to the Baikal region as well as other regions with mining districts across Asian Russia. A recently formed network of Russian Egos concerned about mining, and including the Buryat Center for Public Environmental Expertise (BCPEE) and the Buryat Regional Organization on Baikal (BRO Baikal) has establish policy objectives. This network, The "Sosnovka Mining Working Group," describes it purpose as:

> "Mining in Siberia and the Russian Far East began in the 1800s and although it has been a source of valuable commercial goods, it has caused irreversible destruction to the biosphere and to human health. The Sosnovka Mining Working Group has identified problems with projects undergoing government environmental 'ekspertiza' [expert reviews], especially with respect to public participation in discussing these projects, and the lack of independence of the state environmental monitoring and control service from the Ministry of Natural Resources. There are also major concerns about the reclamation of former mines (legacy sites) that are public health hazards.
>
> "As a result the Mining Working Group has identified a series of policy objectives:

1. continue public monitoring of environmental conditions during mining and during planning of new mines in Buryatia, Kamchatka, Chukotka, Magadan, Yakutiya and Krasnoyarskii Krai;
2. support reclamation projects at former mines that are a public health hazard and that threaten the environment;
3. continue to lobby Russian Federation agencies on separation of the state environmental monitoring and control service from the Ministry of Natural Resources;
4. send appeals to the Russian Federation government environmental 'ekspertiza' service with a demand for compliance with the Rules on Environmental Impact Assessment; and
5. let the public know how comments and recommendations from public environmental 'ekspertiza' are considered in government environmental 'ekspertizas'." (TRN 2003)

As metal prices rise and contemporary mineral exploration methods are applied to deposits identified during the Soviet era, mineral development will increase in the Selenga River watershed. Effective enforcement of existing laws, application of international standards for pollution prevention, reclamation planning and financial guarantees, and restoration program targeting inactive and abandoned mines are needed to minimize or eliminate impacts of existing facilities and future operations. Models are being developed around the world that can address these challenges.

Developing indigenous models that can work in the Selenga River Watershed and adapting other examples and models to work in the Selenga River Watershed are enormous challenges. And challenges well worth committing the resources to successfully overcome.

Paraphrasing V. Rasputin in "Siberia, Siberia:"

> "If Baikal is to be saved, we will have to clean up the Selenga."

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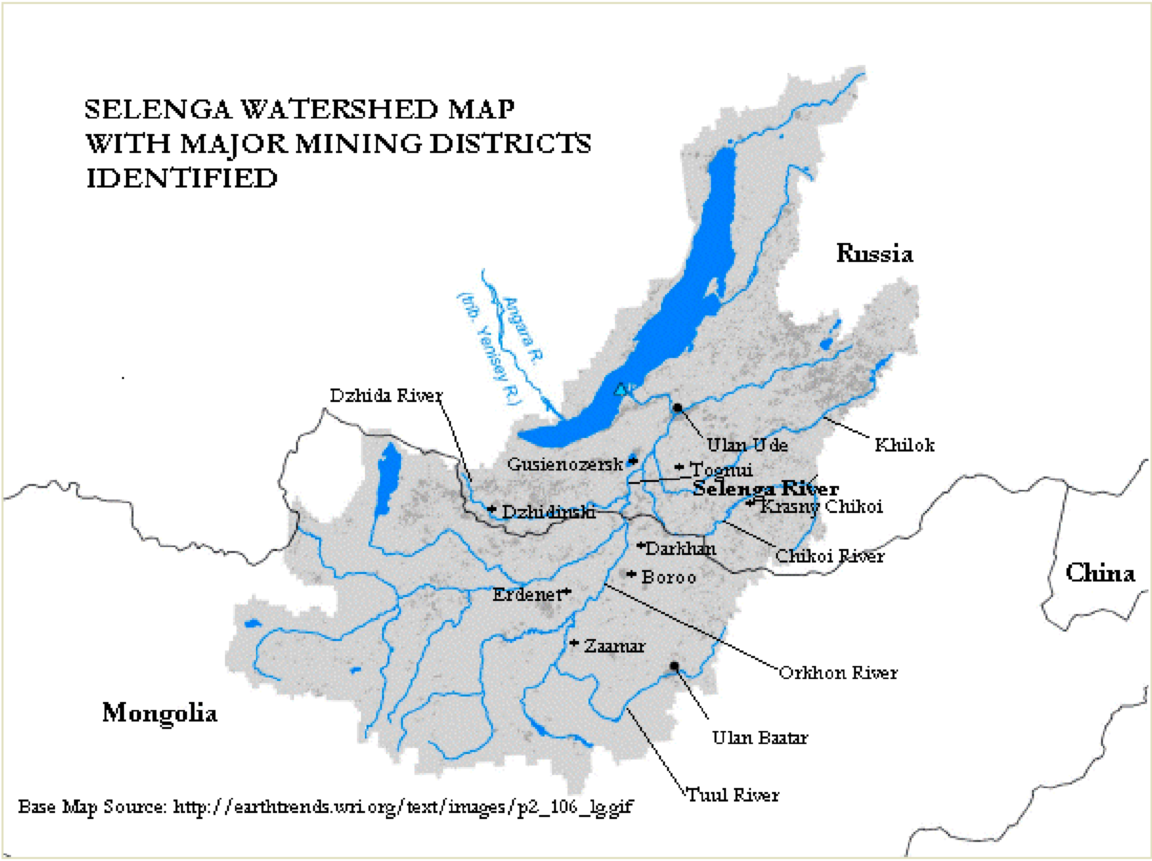
FIGURE 1



SELENGA WATERSHED MAP
WITH MAJOR MINING DISTRICTS
IDENTIFIED
Russia
Angara R.
(trib. Yenisey R.)
Dzhida River
Ulan Ude
Khilok
Gusienozersk
Tognui
Selenga River
Krasny Chikoi
Dzhidinski
Darkhan
Chikoi River
China
Boroo
Erdenet
Zaamar
Orkhon River
Mongolia
Ulan Baatar
Tuul River
Base Map Source: http://earthtrends.wri.org/text/images/p2_106_lg.gif