5.0 Human Environment

In addition to the environmental baseline information provided in previous sections, an advanced social baseline study is required under OPIC and IFC guideline for the Project. The high need to achieve and maintain a social license to operate also requires considerable understanding, knowledge and coordination with local, national and international stakeholders. Broad community support not only facilitates the mine operation, it serves as the social license to operate as required by the IFC Performance Standards and EPFIs (as discussed in **Part II**).

A Project social report (**Attachment 1** of **Appendix E**) was prepared through desktop research and one-on-one interviews conducted in Mongolia. The desktop research involved the review of project documents, legislation, and socioeconomic references. Interviews and surveys of stakeholders were conducted within and near the Project area, and in Ulaanbaatar. These stakeholders include residents, NGOs, and government representatives.

The social report discusses the cultural background as well as the human environment and legal framework in which the Project will operate. In addition, the potential impacts from the Project and the proposed mitigation measures are identified. In compliance with IFC Performance Standards, a Social Engagement Program is defined and will be implemented by WMMC in order to efficiently involve stakeholders on issues potentially affecting them.

5.1 Population Distribution

The population dynamics of Mongolia are similar to the majority of other developing countries in the Asia-Pacific Region, with annual population growth rates of 1.2 to 1.5 percent (**Table III.5-1**). However, many important changes have marked the demographic patterns of Mongolia since the beginning of the political /economic/ social transition in 1990. Over the past 15 years of transition, Mongolia has shown a decreasing fertility rate, increasing life expectancy, decreasing death rate, decreasing infant mortality rate, and a high rate of rural-to-urban migration in the context of an extremely low population density. At the end of 2007, the population of Mongolia was 2.63 million, an increase of 1.4 percent compared to 2006.

Table III.5-1 Selected Indicators of the Mongolian Population 1989 - 2007

Indicators	1989	2000	2005	2007
Total population (*1000)	2,044	2,374	2,562.4	**2.635.2**
Aged 0-4 (%)	15.9	10.4	9.2	**8.9**
Aged 5-14 (%)	26	25.4	23.4	**19.7**
Aged 15-64 (%)	54.1	60.8	63.8	**67.3**
Aged 65+ (%)	4	3.5	3.5	**4.1**
Crude birth rate	35.5	20.4	17.8	**21.7**
Crude death rate	8.3	6.5	6.5	**6.2**
Total fertility rate	4.6	2.2	1.9	**2.3**
Life expectancy	62.9	63.2	65.4	**66.5**
Population growth rate (%)	**2.5**	**1.4**	**1.2**	**1.4**

Source: National Statistical Office of Mongolia, 2008

For the period 1990 to 2005, all regions in Mongolia (i.e., West, East, Central and Khangai) recorded population losses through migration but gains through natural change. Ulaanbaatar is the only location where both in-migration and natural increase contributed to an overall population increase. This is reflected in the high levels of migration towards urban centers, especially the capital Ulaanbaatar as shown in **Table III.5-2**.

Table III.5-2 Natural Increase and Net Migration, 1990 - 2005

Region and the Capital City	1990		1999		2005	
	Natural Increase	**Net Migration**	**Natural Increase**	**Net Migration**	**Natural Increase**	**Net Migration**
West	12,691	430	8,495	-14,686	6,623	-14,425
Central	11,643	-1,135	6,296	-1,938	4,913	-16,534
East	5,250	-331	2,702	-4,829	2,322	-4,553
Khangai	14,952	-786	8,311	-8,974	6,461	-13,981
Ulaanbaatar	11,114	2,619	7,552	32,678	8,778	67,462

Source: National Statistical Office of Mongolia, 2008

In both the Buregkhangai and Zaamar Soums, population dynamics follow the national trend: a decreasing fertility rate, increasing life expectancy, a decreasing death rate, decreasing infant mortality rate, and a high rate of rural-to-urban migration in the context of an extremely low population density. At the end of 2007, the resident population of the Buregkhangai Soum was 2,376 people – with a total of 149,567 livestock. Zaamar Soum's population was 5,841 people with a total of 69,265 livestock. These low population figures reflect the low population density of the country and the region. Yet, it should be noted that the Tuul River

Valley, as a lush grazing area with access to surface water, has considerably higher levels of population density than other regions of the country. This population density has increased with the arrival of mining in the Tuul River Valley.

The population figures detailed below in **Table III.5-3** and **Table III.5-4** reflect this changing population dynamic. It is worth noting that about 27 percent of the Zaamar Soum population lives in the soum center, with people in this semi-urban settlement largely relying on government subsidies and state-based employment for their welfare. However, a comparison between (and within) these soums is made more difficult by the different statistics available and by questions about the reliability and verifiability of these data.

Table III.5-3 Selected Indicators for the Buregkhangai Soum, 2007

Indicator	**2003**	**2005**	**2007**
Total area (1,000 sq km)	349.8	349.8	349.8
Total population	2,394	2,194	2,376
Population aged 0-16 years	851	851	744
Labor aged population	1309	1288	1508
Labor aged popn. (Female)	632	645	777
Total employed	1001	895	971
Total unemployed	176	226	121
Total number of families	638	559	627
Families living under the poverty line	201	232	110
Birthrate	25	6	39
Mortality rate	19	8	15
Total livestock	84,839	96,465	149,567
Number of families without livestock	176	174	188

Source: Buregkhangai Social Welfare Officer, 2008

Table III.5-4 Socioeconomic Indicators of the Zaamar Soum, 2007

Indicator/Bagh	**Toson**	**Tomstii**	**Khailaastai**	**Zaamar Center**	**Total**
Total population	522	640	3124	1555	**5841**
Total number of families	143	173	828	420	**1564**
Number of herder families	82	100	69	12	**263**
Poor and very poor families	43	29	99	170	**341**
Total number of livestock	16,887	28,796	13,212	10,370	**69,265**

Source: Zaamar Soum Social Welfare Officer, 2008

What these figures illustrate, despite the differences in how they are presented and what data are available, is that the economic performance of the region is linked closely with the fortunes of herders. The high levels of animals, which have grown in recent years despite fears of overgrazing, illustrate the importance placed on herding as a source of income.

There is considerable potential for the extractive industries operating in Zaamar and Buregkhangai to provide limited new job opportunities as well as infrastructure to the region. These include providing industrial employment and non-agricultural employment opportunities that have eroded since the collapse of communism.

5.2 Land Use

Rural livelihoods in Zaamar and Buregkhangai as well as in Mongolia have become much more diverse than they were at the start of the 1990s. The liberalization of fuel prices coupled with the vast distances and low population density of rural Mongolia led to marked differentials in the prices of consumer goods and the prices paid for producer goods such as livestock products. As a result, geographical location became an important driver of economic opportunity, and migration became the livelihood strategy of choice for those in a position to take advantage of opportunities in more central regions or larger urban centers. However, 81 percent of the land area is designated as pasture land; herding remains the dominant source of income for most households.

In the Tuul River Valley, rural livelihoods remain characterized by an extensive livestock industry with an absolute dependence on an extremely harsh and highly variable natural environment, which has been subject to considerable over-grazing. This pressure on grasslands is evidenced in the significant number (and increase) in livestock in the region, as shown in **Table III.5-3** and **Table III.5-4**.

This overgrazing, combined with a series of harsh winter “zuuds” or deep freezes which killed off large numbers of livestock, contributed to the growth in artisanal (ninja) mining in the region. Former herders, coming from both the local soums as well as from further distances, gravitated towards the Tuul River Valley as a source of employment and livelihoods.

Artisanal mining, was until recently a major employer in the region, involving as many as 10,000 individuals in 2006 (many from other regions), is now illegal and government effort has reduced the incidence of ninja miners in the Tuul River Valley. Since 2006, most of the ninja miners have been resettled in their home soums and encouraged to return to herding. For many former ninja miners, the lack of economic opportunities has led them to move towards Ulaanbaatar and other centers, to seek employment. Some limited artisanal, placer, and dry mining has occurred in the Project area in the past, unrelated to the proposed WMMC Big Bend Placer Gold Mining Project. Currently, no ninja miners are within the Project area.

Of the total area of Zamaar Soum of 281,000 km^2, 87,000 km^2 is currently allocated as mining concessions to over 130 companies (source: Governor of Zamaar Soum). This equates to over 30 percent of the total land area.

The majority of the population remains dependent – to varying extents – on seasonal grazing of livestock. There are signs that families are, however, turning to a diversity of livelihood options – including sending family members abroad (e.g., to South Korea), engaging in small businesses, including those servicing the mining industry.

6.0 Environment Quality of Project Area

6.1 Ambient Air Conditions

6.1.1 Background

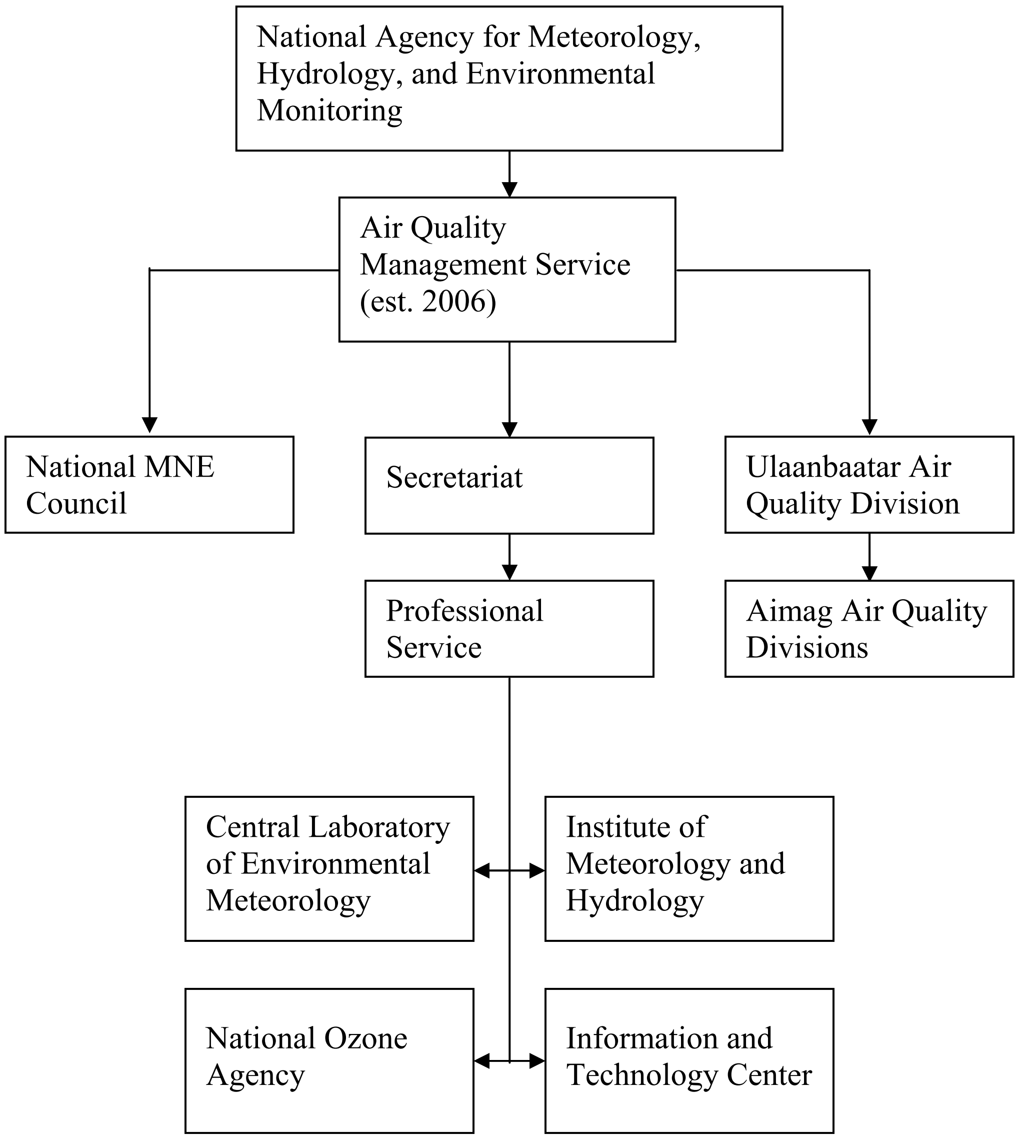
In Mongolia, air pollution has become a serious problem in urban areas within the last two decades (World Bank, 2004). Topography and meteorology exacerbate the ambient air quality. The surrounding mountains inhibit the dispersion of emissions. In addition, a stable atmospheric inversion occurs during the winter, when peak emissions occur from heating due to cold temperatures.

To minimize adverse air quality, Mongolia has established a legal and institutional air quality framework. This legal framework includes the:

- Environmental Protection Law (1995);
- Air Law (1995);
- Meteorological and Hydrological Monitoring Law (1997);
- Environmental Impact Assessment Law (1998);
- Air Protection Program (1999); and
- National Ambient Air Quality Standards.

The 1995 Air Law establishes the basic air quality legal framework. The Air Protection Program of 1999 addresses environmental conservation, pollution prevention and control, the operation of environmental funds, incentives to minimize pollution, and compensation for environmental damage. **Figure III.6-1** shows the air quality institutional framework of Mongolia.

Figure III.6-1 Air Quality Institutional Framework of Mongolia



Operating under MNE, the National Agency for Meteorology, Hydrology, and Environmental Monitoring is responsible for monitoring air pollution, developing pollution inventories, and implementing ambient air quality action plans (World Bank, 2004). In order to develop, implement, and monitor the air quality action plans, MNE established the Air Quality Management Service in 2006.

In 1998, the ambient air quality standards were legislated under MNS4585-98. **Table III.6-1** lists these standards.

Table III.6-1 Ambient Air Quality Standards of Mongolia

Air Quality Parameter	**Averaging Time**	**Standard (micrograms per cubic meter [μg/m^3])**
Benzo(a)pyrene	24 hours	0.001
Lead	24 hours	1
Nitrogen dioxide (NO_2)	20 minutes	85
	24 hours	40
Ozone (O_3)	1 hour	120
Sulfur dioxide (SO_2)	20 minutes	500
	24 hours	30
Total Suspended Particulates (TSP)	20 minutes	500
	24 hours	150

6.1.2 Air Quality Parameters

Mongolia's emissions inventory includes carbon monoxide (CO), ozone (O_3), nitrogen oxides (NOx), nonmethane volatile organic compounds, particulate matter (PM), and sulfur dioxide (SO_2). Mongolia's greenhouse gas inventory includes methane (CH_4), CO, carbon dioxide (CO_2), NOx, and nitrous oxide (N_2O). The air quality parameters of particular concern are CH_4, CO_2, PM, NO_x, and SO_2, which are described below.

Even though Mongolia has very low greenhouse gas emissions due to its low population density, the annual per capita greenhouse gas emission is relatively high in contrast to other countries. The two primary greenhouse gases in Mongolia are CH_4 and CO_2 (Dagvadorj, 2003). The major source of CH_4 is enteric fermentation in livestock. CO_2 is largely produced from the combustion of fuel for power generation, heat production, and conversion of grasslands to crop land.

PM is a mixture of small particles and liquid droplets, which may include acids, organic chemicals, metals, and soil particles. The way in which PM may affect human health and the environment is largely dependent on the diameter of the

PM. As such, PM is typically categorized as $PM_{2.5}$ or PM_{10}. $PM_{2.5}$ is fine with a diameter of particles less than or equal to 2.5 micrometers, and may result from fire and vehicle emissions. Otherwise known as inhalable coarse particles, PM_{10} has a diameter greater than 2.5 micrometers and less than or equal to 10 micrometers. These are often near roadways. The elderly, children, and people with chronic lung disease, influenza, or asthma, are especially sensitive to particulate matter (United States Environmental Protection Agency, 2008).

NO_x is any binary compound of nitrogen and oxygen. NO_2 is a common NO_x and is produced during combustion. NO_x may be harmful to human health and the environment (e.g., smog, acid rain, water quality deterioration).

SO_2 is one of the sulfur oxides. Sulfur oxides are prevalent in all raw materials and are formed when materials with sulfur content are processed. SO_2 dissolves in water vapor to form acid and interacts with other gases and particles in the atmosphere that may be harmful to human health and the environment.

6.1.3 Sources of Emissions

Mongolia is one of the world's coldest countries, and Ulaanbaatar is the world's coldest capital. Heating is required almost nine months annually. According to a 2004 World Bank working paper, approximately 5.7 million tons of coal and 160 cubic meters of wood are used for energy generation, heating and cooking in Mongolia annually (World Bank, 2004). Air pollution has a seasonal pattern that relates to air temperature, with emission peaks occurring during colder periods.

Common sources of air pollution include emissions from mobile sources or vehicles; from stationary sources such as heat and power plants, heat-only boilers, and industry; from area sources such as household stoves, refuse burning, and road dust; and noise. As noted by the Vice Minister of MNE, approximately 90 percent of emissions are produced from domestic source; six percent from power plants; three percent from vehicles; and one percent from boilers during the winter months in Ulaanbaatar (Delgertsogt, 2008).

PM is perhaps the primary air quality parameter of concern in Mongolia. PM typically peaks in April, when strong wind occurs. NO_2 concentrations are rising in direct relation to the rising number of vehicles. SO_2 concentrations are increasing as well; peak SO_2 concentrations (45 $\mu g/m^3$ between 1600 hours and 2000 hours) occur from October to March during the peak emission period.

6.1.4 Air Quality Management

In Mongolia, air quality management is primarily focused on Ulaanbaatar. In 2004, four permanent air-quality monitoring stations existed in Ulaanbaatar and no other stations existed outside the city (Asian Development Bank, 2006). Ambient air measurements at these four meteorological stations were discontinuous and the results of numerous air quality studies were conflicting (World Bank, 2004).

Mongolia continues to face challenges in air quality management. Reductions in emissions from the power sector have been partially offset by higher emissions produced from households in the growing ger areas (World Bank, 2004). In addition, the number of vehicles in Mongolia has increased. For example, the number of vehicles in Ulaanbaatar increased from 28,119 to 52,000 vehicles between 1995 and 2002, with the majority of the vehicles exceeding fuel consumption and emission standards. While Mongolia performs limited testing of tailpipe emissions, no comprehensive vehicle emissions standards or fuel quality standards exist (e.g., leaded gasoline is still being sold) (Asian Development Bank, 2006).

Mongolia continues to improve air quality management and monitoring by introducing more efficient stoves, boilers, and furnaces with alternatives to coal and wood. The Ministry of Mining and Energy is also promoting clean coal technologies and offering incentives to develop smokeless, carbonized coal briquette. Incentives, such as lower taxes, are also being considered to promote cleaner technologies and energy-conserving methods in the industrial sector.

6.1.5 Local Air Quality

Since no permanent air quality monitoring stations exist near the Project area, definitive conclusions cannot be drawn about the existing air quality. Therefore, data are based on knowledge of local anthropogenic activities and literature research. The regional air quality of the Project area is expected to be natural and unpolluted due to the remote location with much air dispersion and the small population density. Activities by local people (burning, use of diesel generators) can potentially affect local air quality; however, these effects are expected to be small due to the scale of these activities and air dispersion.

6.1.5.1 Historical Studies

The principal regional industrial activity of the immediate area is placer mining. About 135 exploration licenses have been issued for the Zaamar Soum alone, which cover about two-thirds of the soum. Approximately 10 to 13 mines currently operate along the Tuul River near the Project area. These mines (as well as the illegal artisanal mining, supporting services, and other land uses) affect the background regional air quality.

The land in the vicinity of the Project area is not agriculturally productive for crops; therefore, animal husbandry is the main agricultural activity. However, due to historic and current mining, much of the land near the Project area does not sustain animal husbandry. Historically, mined areas were not reclaimed; tailings and overburden piles remain bare, with no vegetation and unnatural contours that contrast with the surrounding landscape. In addition, current mining reduces the amount of land available for agricultural land use. The land available for animal husbandry has been largely overgrazed, reducing soil stability and increasing the exposure of soils to weathering. All of these factors can cause an increase in dust or PM concentrations in the airshed during dry periods.

As previously noted in **Part II**, air emissions should not exceed the relevant ambient air quality guidelines and standards by applying national legislated standards (**Table III.6-1**) or the current WHO Air Quality Guidelines (2006a). Ambient air quality is to be monitored at the Project boundary and/or off-site, depending on the results of scientific methods and modeling. The Air Quality Guidelines are provided in **Table III.6-2**.

Table III.6-2 Ambient Air Quality Guidelines

Parameter	Averaging Period	WHO Ambient Air Quality Guideline ($\mu g/m^3$)
CO	8-hour mean	10
	1-hour mean	30
$PM_{2.5}$	annual mean	10
	24-hour mean	25
PM_{10}	annual mean	20
	24-hour mean	50
O_3	8-hour mean	100
NO_2	annual mean	40
	1-hour mean	200
SO_2	24-hour mean	20
	10-minute mean	500

Due to the lack of reclamation, size of the existing disturbed area, and intense grazing, particulate matter is one of the principal air quality parameters of concern. The regional climate, particularly wind and precipitation, greatly influences the regional air quality. As such, the concentrations of particulate matter are anticipated to be variable and are expected to be quite high at times, depending on climate conditions.

An environmental study by the Institute of Geology and Mineral Resources in the Zaamar region included limited air quality monitoring for particulates around mine camps, roads, and placer mining operations using a portable dry test gas meter in September 1997. The summary report states that low concentrations of dust in the air were recorded near the mine camps at night, but high concentrations were recorded near placer mine operations and roads. TSP exceeded the Mongolian hourly maximum standard of 500 µg/m^3 during the day at the locations specified in **Table III.6-3**.

Table III.6-3 Airborne Particulates at the Zaamar Goldfield

Date (MM-DD-YY)	Time of Day	Total Suspended Particulates (µg/m^3) [1]	Sample Location
09-12-97	night	441	Right corner of Erel Company settlement
09.13.97	day	8180	700 m south west from Erel Company settlement
09.13.97	night	374	500 m south from Erel Company settlement
09.14.97	day	4857	Near Aranjin Company, Bayangol, Khargui
09.15.97	day	560	800 m south east from Erdes Company
09.16.97	night	98	Center of Tsagaanbulag Company

Source: Jadamba and Doloonbayar, 1998
[1] TSP 20-minute average standard for Mongolia is 500 µg/m^3. TSP 24-hour average standard for Mongolia is 150 µg/m^3.

Regional air transport issues (e.g., emissions from mining and agriculture) are expected to be minimal due to the remoteness of the area and the atmospheric dispersion. Background levels of emissions are estimated to be insignificant due to the small scale of the operations from mining activities and support services compared to the size of the airshed.

Adverse air quality conditions may potentially occur during dust storms, fires and temperature inversions. Temperature inversions occur occasionally, but due to the low population density and low levels of industrial activity, are not anticipated to cause a significant air quality problem. Dust storms are relatively rare and are not chronic. Fires are rare but their frequency has been increasing in Mongolia.

6.1.5.2 On-Site PM_{10} Study (2008)

Of special concern among the particulates in the dust, are those with a diameter of 10 micrometers or less (PM_{10}). These smaller particles are likely responsible for adverse health effects because of their ability to reach the lower regions of the respiratory tract (larger particles are not generally deposited in the lungs). PM_{10} can affect breathing and respiratory systems, cause damage to lung tissue, and lead to cancer and premature death. The elderly, children, and people with chronic lung disease, influenza, or asthma, are especially sensitive to the effects of particulate matter (USEPA, 2008).

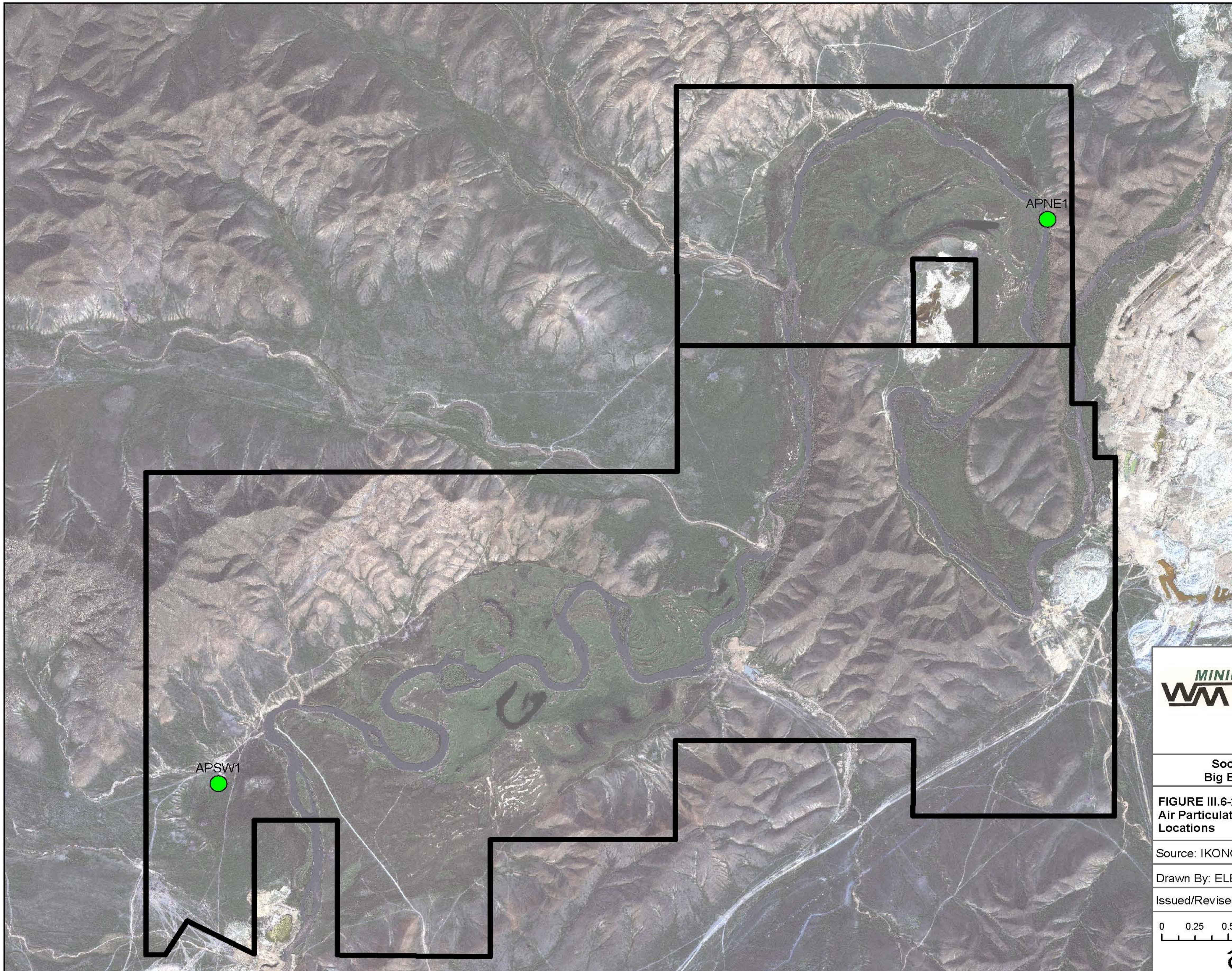
To measure background and potential increases to dust levels, an air sampling campaign was initiated in October 2008 within the Project area. Previous meteorological data were used to determine the dominant wind direction (typically from the southwest in October). Mini-vol samplers (from Airmetrics in Oregon, United States) were installed in locations that represent both upwind and downwind conditions of the Project site. A total of six air quality samples (three pairs) were collected from two locations as shown in **Figure III.6-2.** PM_{10} dust particles were collected on pre-weighed filters; and, pump information was recorded (date, unit number, flow rate, and run time). Afterwards, the filters were returned to Airmetrics for weighing and the concentration was then calculated (results are presented in **Table III.6-4**).

Table III.6-4 PM_{10} Air Particulate Monitoring Results

Pair	Location	Date	Filter No.	Total Flow Time (hour)	Ave. Flow Rate (liter/minute)	Total Volume (liter)	PM_{10} (µg/m^3)	Notes
1	APSW1	6-Oct-08	0065	23.0	5.4	7420	23.0	Upwind
	APNE1	6-Oct-08	0066	22.8	5.5	7498	15.9	Downwind
2	APSW1	7-Oct-08	0051	24.6	5.4	7936	7.2	Upwind
	APNE1	7-Oct-08	0052	24.5	5.5	8057	8.1	Downwind
3	APSW1	8-Oct-08	0053	23.5	5.4	7581	11.6	Upwind
	APNE1	8-Oct-08	0054	21.4	5.5	7038	8.5	Downwind

As shown in **Table III.6-4**, the PM_{10} air particulate concentrations were well below the WHO ambient air quality guidelines for a 24-hour period (50 µg/m^3). Only one of the samples would be in violation of the WHO annual mean guideline (20 µg/m^3) if the high concentration was sustained. In addition, the downwind concentrations are not significantly different from the upwind concentrations. This indicates that the air particulate concentrations entering the Project airshed are similar to the concentrations exiting the Project airshed.

The first day of the monitoring had the highest readings because there had been no precipitation within at least the previous 24 hours. In contrast, the second day had the lowest readings because there was precipitation during monitoring. The precipitation most likely wetted the soil, which suppressed the dust from wind, vehicles and other human activity. It did not rain during the third sample pair, but the weather was overcast, and the soils were completely dried from the previous precipitation event. Winds were not noticeably different during the three monitoring days.



WM Mining Company, LLC

AATA INTERNATIONAL, INC.
Denver, Colorado, USA

Social and Environmental Impact Assesment
Big Bend Placer Gold Mining Project, Mongolia

FIGURE III.6-2
Air Particulate Monitoring Locations

Source: IKONOS July 2008

Drawn By: ELB

Issued/Revised: 10.21.08

0 0.25 0.5 1 Km

N

Legend

Air Particulate Sampling Locations

Big Bend License Area

6.2 Water Supply, Quality, and End Use

6.2.1 Surface Water

Surface waters in Mongolia are classified into five categories based on the Mongolian State Standard 4586-98 Water Quality Standard: very clean (Class 1), clean (Class 2), slightly polluted (Class 3), moderately polluted (Class 4) and very polluted water (Class 5). The Tuul River is classified as clean water (Class 2) in the Project area. In the vicinity of Ulaanbaatar, the Tuul River is classified as moderately polluted (Class 4).

Attachment 4 to the Directive 143/a/352 of the Minister of Nature and Environment and Minister of Health, 1997 defines the types of treatment for each category of water before it can be used, and the types of uses for that water after treatment. In the following discussion, a comparison of water quality analysis results with the Class 2 standards will be made.

Surface water quality results were also compared to US EPA criterion maximum concentration (CMC), which applies to short (acute) exposure, and the Criterion Continuous Concentration (CCC), which applies to longer (chronic) exposure, varied with temperature, pH, and with the type of fishery involved for aquatic life.

6.2.1.1 Historical Water Quality Data from the Tuul River

Stubblefield and Smallwood (2001)

Water quality data from the Tuul River during the active summer mining season was obtained from two main sources. Dr. Andrew Stubblefield (University of California, Davis) provided preliminary summary of results on the water quality of the Tuul River from samples collected in August 2001 at a few sites in the Zaamar region, and a site above the confluence of the Orkhon River as part of a wider Lake Baikal watershed study by the Tahoe-Baikal Institute (Stubblefield and Smallwood, 2001). Parameters analyzed in the unpublished study included turbidity, nitrate (NO_3), phosphate (PO_4), ammonium (NH_4), dissolved oxygen, pH, temperature, conductivity, total dissolved solids (TDS), total suspended sediment (TSS), total phosphorus (P), and discharge.

Dr. Stubblefield provided data on discharge, total suspended solids, turbidity and total phosphorus for sites sampled along the Tuul River in August 2001 **(Table III.6-5**). Note that average TSS (188 mg/L) was highest at the site above the active mines in the Zaamar Goldfield. The comments column indicated that horses were observed in the channel stream upstream of the sample site. Two to four km above the public highway bridge average TSS was reduced to 73 mg/L. TSS increased in the downstream sites to 117 mg/L at a distance of 25 km below the bridge, then decreased 35 km downstream of the bridge at the end of the Zaamar mining district to 105 mg/L. TSS of the Tuul River above the Orkhon confluence varied between 59 and 74 mg/L (**Table III.6-5**). The concentration of TSS in all the samples from this study exceeded the Mongolian Class 2 standard (20 mg/L).

TSS loads were calculated based on calculated and estimated discharge of the Tuul River, and TSS concentrations obtained from water sampling. TSS loading varied between 2,800 milligrams per second (mg/s) upstream of the Zaamar gold district to an estimated 1,200 mg/s to 1,900 mg/s TSS loading within the mining region (**Table III.6-5**). TSS loading varied from 600 mg/s to 1,100 mg/s in the Tuul River at the Orkhon confluence.

Turbidity in the Tuul River in the Zaamar Goldfield ranged between 61.3 and 94.1 Nephelometric turbidity units (NTUs) from Stubblefield's August 2001 data.

As **Table III.6-5** shows, total phosphorus ranged between 75 μg/L (0.075 mg/L) and 185 μg/L (0.185 mg/L) in the river in the Zaamar region, and was as high as 206 μg/L above the confluence with the Orkhon River. The concentration of total phosphorus exceeded the Mongolian Class 2 standard (10 μg/L) or most samples. Loading of total phosphorus (mg/s) was estimated to range between 1,237 and 3,079 mg/s within the Zaamar region. Total iron concentrations ranged from less than detection to 0.14 mg/L. Silica (Si) was abundant and ranged from 1.2 to 4.5 mg/L (Stubblefield and Smallwood, 2001).

Stubblefield and Smallwood (2001) reported that the Tuul River had the worst water quality of all the rivers sampled (Yeroo River, Yalbag River, Bugant River, Orkhon River, Eg River, Khara River, and Sharyn River). Total suspended solids were reported as high as 200 mg/L for a Tuul River site as compared to 10 mg/L in other parts of the Selenge. TSS exceeded the Class 2 standard. The authors acknowledged that the Tuul River flows past the city of Ulaanbaatar 200 km upstream of the Zaamar district, but conclude that "the research group had the impression that most of this suspended sediment was due to mining" (Stubblefield and Smallwood, 2001).

Table III.6-5 Water Quality and Discharge Data Results from the Tuul River (after Stubblefield and Smallwood, 2001)

Date 2001	Location	Discharge (m^3/sec)	TSS Avg (mg/L)	TSS Load (mg/s)	Turbidity (NTU)	TP Avg (µg/L)	TP load (Mg/s)	N deg	N min	N sec	E deg	E min	E sec	Comments
22-Aug	Tuul above all Zamaar mines	14.90	187.65	2796	ND	ND	ND	ND	ND	ND	ND	ND	ND	Horses in channel
22-Aug	Tuul 2-4 km above Zamaar bridge	16.60	72.55	1204	94.1	125.00	2075.00	48	12	742	104	17	324	From the campsite
23-Aug	Tuul 3 km below bridge	16.60	92.20	1531	61.3	74.50	1236.70	48	14	624	104	21	25	Discharge estimated from above sites.
23-Aug	Tuul 10 km below bridge	16.60	92.40	1534	76.8	138.50	2299.10	48	20	177	104	24	608	Discharge estimated from above sites.
23-Aug	Tuul 20 km below Zamaar bridge	16.60	110.50	1834	85.5	169.00	2805.40	48	23	33	104	30	481	Discharge estimated from above sites.
23-Aug	Tuul 25 km below bridge	16.60	117.35	1948	ND	185.50	3079.30	48	26	932	104	32	946	Discharge estimated from above sites.
23-Aug	Tuul 35 km below bridge	17.00	104.75	1781	89.5	173.50	2949.50	48	31	81	104	32	471	Below all Zamaar mines
11-Aug	Tuul abv Orkhon confluence	10.80	58.55	632	46.7	ND	ND	ND	ND	ND	ND	ND	ND	
21-Aug	Tuul abv Orkhon confluence	15.00	74.08	1111	111	205.50	3082.50	48	54	180	104	46	790	
25-Aug	Tuul abv Orkhon confluence	15.50	88.20	1367	—	179.00	2774.50	48	54	75	104	46	715	

Highlighted numbers represent values that exceeded the Mongolian Class 2 surface water standard
Mongolian Class 2 surface water standard for TSS is 20 mg/L; and the Mongolian Class 2 surface water standard for total phosphorous is 0.1 mg/L (100 µg/L)
ND – means there is no data

Jadamba and Doloonbayer (1998)

The second main source of historical water quality data obtained during the summer active mining season was from Jadamba and Doloonbayar (1998). Jadamba and Doloonbayar (1998) conducted an environmental study of the Zaamar region as research for Ministry of Agriculture and Industry, State Agency of Minerals Authority, and Institute of Geology and Mineral Wealth. Water quality samples were analyzed from various locations along the Tuul River, drainages and springs, and mine influent and effluent sites in the summer of 1997. **Table III.6-6** presents a summary of the water quality data obtained from the Tuul River. Two samples were collected upstream of the public highway bridge (Tuul River near Tomin Company pit, and Tuul River downstream of Ikh Alt purifier site), while the remaining samples were collected at the bridge or downstream of the bridge (**Table III.6-6**).

The pH of the Tuul River was slightly alkaline, ranging from 7.85 to 8.39. The major cations are calcium (Ca^+) – sodium (Na^+) and potassium (K^+). Bicarbonate (HCO_3^-) is the major anion. Water hardness ranged from 1.23 to 1.79 meq/L (**Table III.6-6**).

Ammonium concentrations in the Tuul River ranged from 0.11 to 0.42 mg/L, except for a high concentration of ammonium (1.09 mg/L) at a site in the river downstream from Darkhan 26 property. Nitrite (NO_2) ranged from 0.004 to 0.023 mg/L, and nitrate varied widely from 0.02 to 1.14 mg/L. Total phosphorus also ranged widely in the Tuul River from 0.01 to 0.129 mg/L. Nutrients often exceeded the Class 2 standards (**Table III.6-6**).

Metals data collected from the Tuul River public highway bridge from the Jadamba and Doloonbayar (1998) study is shown in **Table III.6-7.** Duplicate water samples were analyzed by two separate laboratories in Mongolia, and the results showed a wide and unacceptable difference between the samples, casting doubt on the validity of the metals data.

Table III.6-6 Summary of Tuul River Water Quality Data Obtained from the Environmental Report (Jadamba and Doloonbayar, 1998)

Sample No./ Observation Pt.	Sampling location	pH	SO_4	Cl	HCO_3	Ca	Mg	Hardness	Na+K	NH_4	NO_2	NO_3	P	Si	Fe
85/45	Tuul river near Tomin company pit (at 50 m)	7.85	43.0	8.2	107.4	23.6	5.4	1.6	32.2	0.42	0.015	0.10	0.072	1.2	0.02
83/47	Tuul river down from Ikh Alt purifier site	7.99	45.4	16.3	84.2	22.8	7.7	1.77	25.2	0.11	0.004	0.07	0.011	2.9	0.08
1/1	Tuul river bridge upon arrival	8.24	2.8	9.6	74.4	18.2	4.1	1.25	7.5	0.32	0.014	ND	0.01	3.5	0.09
99/1	Tuul river bridge upon departure	8.04	24.3	5.7	83.0	19.8	4.1	1.33	17.5	0.11	0.003	0.04	0.009	2.5	0.02
2/2	1 km downstream from Tuul river bridge	8.25	2.6	11.3	75.6	19.0	3.4	1.23	9.5	0.24	0.015	ND	0.05	3.6	0.08
3/3	2 km downstream from Tuul river bridge	8.28	3.3	9.6	78.1	19.4	3.4	1.25	9.2	0.33	0.02	ND	0.063	2.9	0.11
4/4	3 km downstream from Tuul river bridge	8.06	2.7	11.3	76.9	19.0	4.6	1.33	7.7	0.19	0.012	ND	0.065	3.8	0.05
5/5	4 km downstream from Tuul river bridge	8.03	3.0	11.3	79.3	19.8	3.4	1.27	10.2	0.30	0.011	ND	0.049	2.6	0.11
6/6	5 km downstream from Tuul river bridge	8.36	3.3	9.6	85.4	18.6	4.4	1.29	11.2	0.31	0.012	ND	0.059	3.9	0.10
8/9	6 km downstream from Tuul river bridge	8.39	4.7	12.0	97.8	22.0	4.8	1.48	36.0	0.32	0.009	ND	0.025	3.9	0.08
12/12a	7 km downstream from Tuul river bridge	8.19	4.3	9.6	78.1	20.6	2.9	1.27	9.2	0.33	0.012	ND	0.067	4.5	0.10
15/15	Tuul river bend near MonRostsvetmet dredge	8.18	5.4	9.6	78.1	19.0	6.0	1.44	5.5	0.39	0.017	ND	0.068	3.9	0.10
18/19	First point at the right side of the Tuul river bend	7.99	28.0	2.8	81.1	19.8	3.9	1.31	17.0	0.19	0.004	0.02	0.129	3.8	0.07

Sample No./ Observation Pt.	Sampling location	pH	SO_4	Cl	HCO_3	Ca	Mg	Hardness	Na+K	NH_4	NO_2	NO_3	P	Si	Fe
96/56	Tuul river, at the bed of an outlet from Uguumur mountain	8.15	59.0	9.6	103.7	27.4	5.1	1.79	35.2	0.19	0.011	0.29	0.022	3.0	0.00
91/51	Tuul river across from Bel company	8.18	27.4	6.7	83.0	21.2	3.3	1.33	19.8	0.10	0.021	0.19	0.017	2.6	0.02
20/59	Tuul river, across from Ikhzagtsag company	8.19	23.7	3.2	92.1	23.7	4.1	1.52	14.2	0.51	0.015	0.78	0.111	2.9	0.14
67/36	Tuul river, 50 m down from MonMet property	8.23	23.9	9.6	85.4	21.2	4.2	1.41	19.0	0.13	0.019	0.28	0.026	2.3	0.00
65/35	Tuul river, down from Erel open pit	8.18	23.0	8.9	86.6	21.2	4.4	1.42	18.2	0.18	0.023	0.23	0.033	2.4	0.03
77/44	Tuul river meandering near Mongol Alt Co	8.21	29.8	7.4	86.6	21.2	6.6	1.60	16.2	0.12	0.005	0.24	0.005	2.6	0.02
56/74a	Tuul river near Monpolymet Co	8.11	19.3	5.3	78.7	19.0	4.4	1.31	13.2	0.10	0.038	1.14	0.035	3.2	0.04
54/72a	Tuul river, Erdes Co's water pumping point	8.15	22.5	8.9	86.6	22.0	3.5	1.39	18.8	0.19	0.023	0.33	0.05	3.4	0.07
93/53a	Tuul river, down from Darkhan-26 property	8.19	29.3	6.7	90.3	21.2	5.1	1.48	20.0	1.09	0.008	0.09	0.088	2.4	0.05
Mongolian Class 2 surface water standard		6.5-8.5	100	150	—	90	30	15	—	.05	0.005	3	0.1	—	0.5

All units are mg/L except pH (standard units) and hardness (meq/L)
Highlighted numbers represent values that exceeded the Mongolian Class 2 surface water standard
ND – means there is no data
"—" indicates that there is no standard

Table III.6-7 Comparison of Metals Analysis Between Two Laboratories from a Water Sample Collected from the Tuul River at the Public Highway Bridge

Metal	Central Environmental Lab (mg/L)	Nuclear Physics Research Lab (mg/L)
Copper, total	0.0017	0.057
Lead, total	0.0012	0.398
Nickel, total	0.0005	0.054
Manganese, total	0.0023	0.086
Chromium, total	0.0015	0.284

In addition, some limited water quality data for the Tuul River in the Uguumur area was presented in the Khos Khas EIA (EcoTrade, 2002). Six samples were analyzed with the reported ranges presented in **Table III.6-8**.

Table III.6-8 Water Quality Data from the Tuul River near Uguumur[1]

Parameter	Range	Average	Mongolian Class 2 Surface Water Standard
Calcium	5.5 – 18.0	11.4	90
Magnesium	1.2 – 5.4	3.1	30
Sodium + Potassium	2.15 – 21.5	10.8	—
Bicarbonate	25.8 – 90.7	61.5	—
Sulfate	1.65 – 19.7	9.7	100
Chloride	0.9 – 2.1	1.5	150
Phosphorus, total	0.0014 – 0.015	ND	0.1
Ammonium (NH_4)	0.36 – 2.68	ND	0.05
Silica	0.42 – 3.6	ND	—
Chemical Oxygen Demand	1.071 – 7.7	ND	15
Dissolved Oxygen	3.78 – 10.64	ND	8

All units in mg/L
ND – means there is no data
"—" indicates that there is no standard

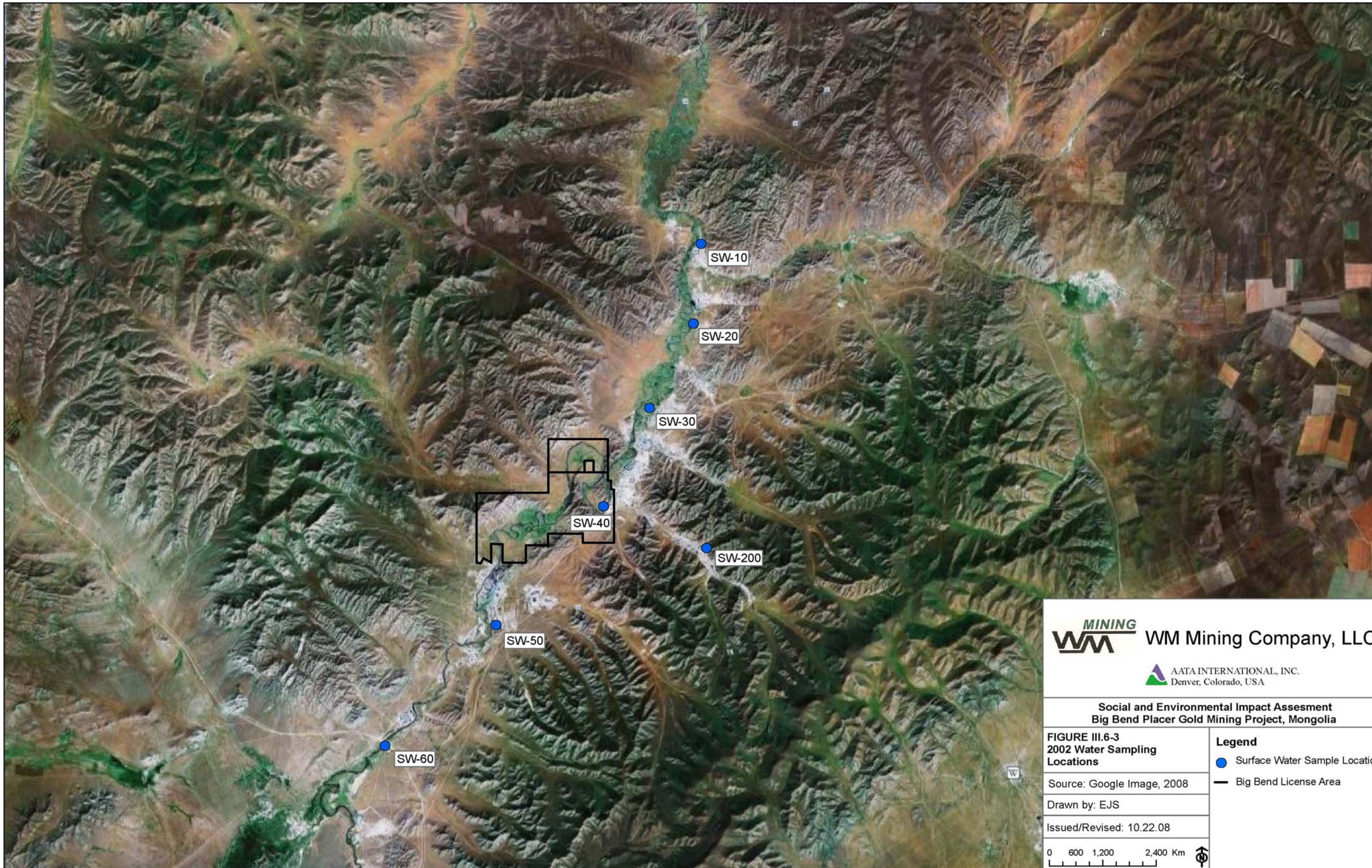
In conclusion, the Tuul River in the Project region experienced higher total suspended solids and turbidity during the summer than in winter. A few parameters exceeded the Class 2 standards during historical and recent sampling. Poor environmental management practices of some mining companies have been documented by Farrington (2000). This has led to sediment-laden discharges in the Tuul River.

6.2.1.2 Tuul River – December 2002 Baseline Study

Water quality data for the Tuul River in the Project area is scarce despite the level of mining activity within the region. As a result, AATA collected several sets of water quality samples for analysis from the Tuul River during two on-site baseline studies: once in December 2002, and the other in July 2008 (see **Section 6.2.1.5**).

During the December 2002 study, the AATA team collected water quality data at six sites along the Tuul River, and one sample from a spring in the Hailaast Valley during the site visit. Sampling sites included the following (**Table III.6-6**):

- Site SW-60 – Tuul River just north of the public highway bridge in the Zaamar Gold Region, and south of the Shijiir Alt South Dredge operations;
- Site SW-50 – Tuul River just north of the mine bridge connecting the Shijiir Alt Mine Town, and adjacent to Shijiir Alt North Dredge operations;
- Site SW-40 – Tuul River at Big Bend and upstream of Altan Dornod Mongol operations;
- Site SW-30 – Tuul River downstream of Ger community of Ninja miners known as "Persian Gulf", below Big Bend, but upstream of Monpolymet Concession;
- Site SW-20 – Tuul River at Monpolyment concession;
- Site SW-10 – Tuul River at the northern section of Monpolymet Concession; and
- Site SW-200 – Hailaast Valley spring.


SW-10
SW-20
SW-30
SW-40
SW-200
SW-50
SW-60
MINING
WM Mining Company, LLC
AATA INTERNATIONAL, INC.
Denver, Colorado, USA
Social and Environmental Impact Assesment
Big Bend Placer Gold Mining Project, Mongolia
FIGURE III.6-3
2002 Water Sampling Locations
Source: Google Image, 2008
Drawn by: EJS
Issued/Revised: 10.22.08
0 600 1,200 2,400 Km
Legend
Surface Water Sample Location
Big Bend License Area

6.2.1.3 Methods and Materials – December 2002 Baseline Study

Field water quality measurements were taken at the water sample locations. The field water quality measurements included water temperature, pH, conductivity, dissolved oxygen, alkalinity, and turbidity. The following equipment was utilized to determine in-situ field measurements.

- pH was measured with a portable Fischer Scientific Accumet AP61 pH meter. Calibration was performed each day to standard buffer solutions of pH 4 and pH 10.
- Water temperature, dissolved oxygen, and conductivity were measured with a portable YSI Model 85 meter. The dissolved oxygen sensor was calibrated in saturated air several times each day. The conductivity sensor was calibrated in the laboratory using a standard solution.
- Alkalinity measurements were determined in the field by titration to a colorimetric end point corresponding to a specific pH using a Hach alkalinity test kit. Titrations were performed with a digital titrator with 1.6N sulfuric acid (H_2SO_4) as the titrating agent, a 100 mL sample volume, and phenolphthalein and bromocresol green-methyl red indicators (pH 8.3 and 4.8 endpoints, respectively).
- Turbidity was measured with a Hach 2100P portable turbidity meter.

Water samples were collected for laboratory chemical analysis according to the US Environmental Protection Agency (USEPA, 1982) protocols. Water samples were obtained beneath the ice cover on the Tuul River by using a portable, hand ice auger with an 8-inch diameter blade, or by using existing holes in the ice where the current was fast enough to maintain an opening. A clean, inert, 2-liter plastic beaker with handle was used to collect the water sample after rinsing several times with sample water. Water samples collected in the beaker were poured into a new, clean, labeled, 1-gallon cubitainers (rinsed twice with sample water) and placed in a cooler.

Water from the cubitainers was transferred to sample containers provided by ACZ Analytical Laboratories, Inc. (ACZ). For dissolved analyses, water was pumped through a Geotech 0.45 µm disposable filter into a clean, labeled bottle with a hand pump. For raw water analyses (unfiltered), water was poured from the cubitainer into the properly labeled sample bottle. A total of seven ACZ water sample bottles were prepared and properly labeled for each sample site where water was collected:

- 500 ml high-density polyethylene (HDPE) plastic bottle: raw water sample for general parameters, total dissolved solids, total suspended solids, cations and anions;
- 50 ml plastic tube: raw water sample for conductivity;

- 250 ml HDPE plastic bottle: filtered water sample for chloride (Cl), sulfate (SO_4), ortho-phosphate, nitrate/nitrate, etc.
- 250 ml HDPE plastic bottle: raw water sample preserved with nitric acid (HNO_3) for total metals analysis;
- 125 ml HDPE plastic bottle: filtered water sample preserved with HNO_3 for dissolved metals analysis;
- 250 ml glass bottle: filtered water sample preserved with H_2SO_4 for dissolved organic carbon (DOC) analysis; and
- 250 ml glass bottle: raw water sample preserved with H_2SO_4 for total organic carbon (TOC), ammonia (NH_3), and total phosphorus analysis.

The samples were kept cold in a refrigerator until ready for shipment. Samples were transferred to coolers with ice and sent via air courier to ACZ Laboratories, Inc. (Steamboat Springs, Colorado, USA) from Ulaanbaatar, Mongolia with completed chain-of-custody forms.

Parameters analyzed from each water sample are shown in **Table III.6-9.**

Table III.6-9 Water Sample Parameters

Field measurements	Lab analysis
pH	Hardness
Dissolved oxygen	Major cations and anions
Conductivity	Total Suspended Solids
Temperature	Total Dissolved Solids
Alkalinity	Total and Dissolved Organic Carbon (TOC, DOC)
Turbidity	Chemical Oxygen Demand (COD)
	Nutrients
	Total and dissolved metals

Original documentation on the water chemistry lab reports is contained in **Appendix E**.

Placer mining activities had ceased for the winter in the Zaamar region except for local artisanal mining and the two dredges operating in dredge ponds (floodplain of the river, not the river) in the Shijiir Alt concession. Ice, snow cover and frozen soils limited the transport of sediment into the river during the winter. Analysis of these samples provided unique wintertime water quality that represents as close as possible background water quality conditions without the influence of mining (except for artisanal mining). **Table III.6-10** summarizes the sampling locations (**Figure III.6-3**) and results from measurement of field water quality parameters in the Tuul River and a Hailaast Valley spring.

Tuul River water temperatures underneath the ice cover were below 1 ºC. The pH was slightly alkaline, and ranged from 7.22 at SW-10 to 7.47 at SW-50 among the Tuul River sites. Conductivity was moderate and ranged from 306 µS/cm at SW-40 to 469 µS/cm at SW-60. Total field alkalinity in the Tuul River was moderate and ranged from 190 mg/L as calcium carbonate ($CaCO_3$) at SW-30 to 214 mg/L $CaCO_3$ at SW-10. Alkalinity is important in buffering pH changes due to photosynthesis, respiration and decomposition.

Dissolved oxygen in the river was generally high and ranged from 7.7 mg/L at SW-60 to 10.4 mg/L at SW-50. Dissolved oxygen was slightly below the Mongolian standard for Class 2 water at SW-40 and SW-60 (**Table III.6-10**). Turbidity was low and was below 3 NTUs at all Tuul River sites except for SW-30 where a measurement of 7.86 NTUs was obtained. Site SW-30 was about 250 meters downstream of where several artisanal miners were washing sand and gravels in the river to recover gold. A noticeable brown plume of elevates suspended sediments was observed in the water where the washing took place through the hole that the miners had chopped through the ice. This area was at the Ger community known as the "Persian Gulf".

6.2.1.4 Results – December 2002 Baseline Study

General Parameters (December 2002)

Table III.6-11 summarizes the laboratory analytical results of the samples performed by ACZ Laboratory, Inc., of Steamboat Springs, Colorado. Major ion analysis indicates that the Tuul River is a calcium – sodium – bicarbonate dominated system. Sulfate concentrations exceeded the Mongolian standard for Class 2 water at SW-50 and SW-60.

The Tuul River has moderately hard to hard waters with a range from 133 mg/L $CaCO_3$ to 304 mg/L $CaCO_3$. Water hardness is principally the result of the concentrations of calcium and magnesium (Mg) ions. Hardness is an important water quality constituent in ameliorating metal toxicity to aquatic life by Ca and Mg ions competing with dissolved metals for binding sites. Note that dissolved metal concentrations are very low (discussed below) and metals are not expected to mobilize due to alkaline pH and high hardness of the Tuul River.

Total suspended solids were low and less than detection (5 mg/L) for all river sampling sites except for SW-10 and SW-20 which had 14 mg/L and 20 mg/L TSS, respectively. The concentration of TSS is a key water quality parameter as high concentrations negatively impact aquatic life (Pentz and Kostaschuk, 1999).

Measured total dissolved solids were moderate and ranged from 320 to 540 mg/L. TDS consists of inorganic salts, small amounts of organic material, and dissolved materials. TDS exceeded the Mongolian Class 2 standard of 300 mg/L.

Table III.6-10 Field Water Quality Summary Results for Surface Water Samples Collected During the December 2002 Baseline Studies

Site	Description	Date (MM-DD-YYYY)	Time	GPS Coordinates	Water Temp. (°C)	pH	Conductivity (µS/cm)	Alkalinity (mg/L)	Dissolved Oxygen (mg/L)	Turbidity (NTU)
SW-10	Tuul River north of Monpolymet camp	12/12/2002	1330	N 48º 27' 58.1" E 104º 32' 41.7"	0	7.22	367.6	214	8.7	1.41
SW-20	Tuul River west of Main Monpolymet camp	12/12/2002	1545	N 48° 25' 14.1" E 104° 32' 24.9"	0.1	7.40	323	194	8.25	2.56
SW-30	Tuul River just down-stream of "Persian Gulf"	12/13/2002	1410	N 48° 23' 29.1" E 104° 30' 34.1"	0.2	7.40	326	190	9.1	7.86
SW-40	Tuul River near down-stream end of "Big Bend"	12/13/2002	1500	N 48° 20' 55.1" E 104° 28' 33.3"	0.3	7.33	306	199	7.8	2.23
SW-50	Tuul River just north of mine camp bridge at water intake for Shijiir Alt north dredge near west bank	12/14/2002	1005	N 48° 14' 21.1" E 104° 27' 05.5"	0.2	7.47	469	210	10.4	2.57
SW-60	Tuul River just north of public highway bridge	12/14/2002	1150	N 48° 11' 50.1" E 104° 25' 47.3"	0.6	7.44	444	219	7.7	2.37
SW-200	Hailaast Valley Spring	12/13/2002	1145	N 48° 19' 32.2" E 104° 32' 57.8"	2.2	7.71	292	186	10.55	0.85
Mongolian Class 2 surface water standard					—	6.5-8.5	—	—	8.0	—

Highlighted numbers represent values that exceeded the surface water standard
"—" indicates that there is no standard

Total organic carbon was relatively low and ranged between three and four mg/L. DOC was less than detection (two mg/L) at all sites. DOC of arid and semi-arid regions like the Tuul River typically average around 3 mg/L, but there is substantial range in DOC in any given stream as well as wide differences from one drainage to another (Hem, 1989). Organic carbon in aqueous systems is important in forming complexes that affect metal solubility (hence bioavailability and toxicity); they also participate in redox reactions, serve as nutrients for microbiota that mediate chemical processes, and influence both physical and chemical properties of solid-liquid or liquid-gas interfaces (Hem, 1989).

Nutrients (December 2002)

Nutrient concentrations were low in the Tuul River in the Zaamar region. Nitrate and nitrite concentrations ranged from 0.44 mg/L to 0.82 mg/L. Ammonia concentrations were less than detection for the three downstream sampling points (SW-10, SW-20 and SW-30), and slightly above detection (0.2 to 0.3 mg/L) at the upstream sites (SW-40, SW-50, and SW-60). Total Kjeldahl nitrogen, which is the sum of organic and ammonia nitrogen, was low and ranged from 0.2 to 0.6 mg/L in the Tuul River. Slightly higher concentrations were measured in the upstream stations.

Dissolved ortho-phosphorus concentrations were low at 0.01 mg/L or below detection limits. Total phosphorus ranged from 0.01 to 0.04 mg/L in the river, with the highest concentrations at the upstream stations of SW-50 and SW-60.

In general, there is a very slight increase in nutrients attributed to the upstream stations. The Shijiir Alt mine camp discharged treated wastewater in the vicinity of SW-50, but could not account for the slight nutrient increase at the upstream site SW-60.

Metals (December 2002)

The metals analysis of the Tuul River samples indicates extremely low levels of dissolved metals; most metals were at very low concentrations, usually at or below detection limits at all Tuul River sampling sites (antimony, arsenic, cadmium, chromium, copper, iron, lead, mercury, molybdenum, nickel, selenium, silver, zinc). Dissolved metals were analyzed by inductively coupled plasma mass spectrometry (ICP-MS) technology that provides extremely sensitive, low-level detection limits. Mercury was not detected (less than 0.2 µg/L) using low detection limit Cold Vapor Atomic Absorption analysis. Dissolved metal concentrations in the Tuul River are well below US EPA acute and chronic aquatic life criteria (US EPA, 2006).

Table III.6-11 Laboratory Results for Surface Water Samples Collected During the December 2002 Baseline Studies

Sample Site / Date sample collected / ANALYTE	UNITS	SW-10 12-Dec Result	SW-20 12-Dec Result	SW-30 13-Dec Result	SW-40 13-Dec Result	SW-50 14-Dec Result	SW-60 14-Dec Result	SW-200 13-Dec Result	Mongolian Class 2 Surface Water Standard	USEPA Water Qual. Criteria CMC	USEPA Water Qual. Criteria CCC
General Parameters											
pH (lab)	units	7.7	7.8	7.7	7.8	7.7	7.8	7.9	6.5 – 8.5	—	—
Hardness as $CaCO_3$	mg/L	275	133	260	228	304	282	251	—	—	—
Conductivity @25 °C	µmhos/cm	630	417	616	581	895	830	522	—	—	—
Bicarbonate as $CaCO_3$	mg/L	205	133	203	206	230	247	200	—	—	—
Carbonate as $CaCO_3$	mg/L	<2	<2	4	5	5	5	4	—	—	—
Hydroxide as $CaCO_3$	mg/L	<2	<2	<2	<2	<2	<2	<2	—	—	—
Total Alkalinity (lab)	mg/L	205	133	203	206	230	247	200	—	—	—
Calcium, dissolved	mg/L	67.1	35.1	67	60.2	74.1	69.7	67.9	90	—	—
Potassium, dissolved	mg/L	2.8	1.4	2.9	2	2.2	2.3	1.7	—	—	—
Magnesium, dissolved	mg/L	26.1	11.1	22.6	18.9	29	26.3	19.8	30	—	—
Sodium, dissolved	mg/L	56	20.2	43	37.3	70.8	66.7	23.6	—	—	—
Chloride	mg/L	22	25	24	21	53	46	15	150	—	—
Sulfate	mg/L	70	80	80	60	170	120	50	100	—	—
Sum of Anions	meq/L	6.1	5	6.4	5.9	9.6	8.7	5.4	—	—	—
Sum of Cations	meq/L	8	3.5	7.1	6.2	9.3	8.6	6.1	—	—	—
Cation-Anion Balance	percent	13.5	-17.6	5.2	2.5	-1.6	-0.6	6.1	—	—	—
Carbon, dissolved organic (DOC)	mg/L	ND	ND	3	3	4	4	3	—	—	—
Carbon, total organic (TOC)	mg/L	ND	ND	<2	<2	<2	<2	<2	—	—	—
TDS (calculated)	mg/L	367	253	361	323	538	480	298	—	—	—
TDS (ratio - measured/calculated	mg/L	0.87	1.3	1	1.02	1	1	1.04	—	—	—
Residue, Filterable (TDS) @180 °C	mg/L	320	330	360	330	540	480	310	300	—	—
Residue, Non-Filterable (TSS)	mg/L	14	20	<5	<5	<5	<5	<5	20	—	—

Sample Site Date sample collected ANALYTE	UNITS	SW-10 12-Dec Result	SW-20 12-Dec Result	SW-30 13-Dec Result	SW-40 13-Dec Result	SW-50 14-Dec Result	SW-60 14-Dec Result	SW-200 13-Dec Result	Mongolian Class 2 Surface Water Standard	USEPA Water Qual. Criteria CMC	 CCC
Sodium Absorption Ratio in Water		1.49	0.77	1.17	1.09	1.79	1.75	0.65	—	—	—
Nutrients											
Nitrate/Nitrite as N	mg/L	0.6	0.63	0.71	0.82	0.44	0.64	1.14	3	—	—
Nitrogen, ammonia	mg/L	<0.1	<0.1	<0.1	0.2	0.3	0.3	<0.1	—	—	—
Nitrogen, total Kjeldahl	mg/L	0.2	0.2	0.4	0.4	0.6	0.6	0.2	—	—	—
Phosphorus, ortho dissolved	mg/L	0.01	0.01	0.01	<0.01	0.01	0.01	0.03	0.05	—	—
Phosphorus, total	mg/L	0.02	0.01	0.02	0.02	0.03	0.04	0.04	0.1	—	—
Metals											
Aluminum, dissolved	µg/L	2	< 1	2	4	1	1	1	—	750	87
Aluminum, total	µg/L	50	80	100	40	50	70	< 30	—	—	—
Antimony, dissolved	µg/L	< 0.2	< 0.2	0.2	< 0.2	< 0.2	< 0.2	< 0.2	—	—	—
Antimony, total	µg/L	< 20	< 20	< 20	< 20	< 20	< 20	< 20	—	—	—
Arsenic, dissolved	µg/L	2.2	1.2	3	2.5	2.4	2.8	2.8	—	340	150
Arsenic, total	µg/L	< 40	< 40	< 40	< 40	< 40	< 40	< 40	10	—	—
Cadmium, dissolved	µg/L	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	—	2	0.25
Cadmium, total	µg/L	< 5	< 5	< 5	< 5	< 5	< 5	< 5	5	—	—
Chromium, dissolved	µg/L	0.7	0.2	0.4	0.3	0.1	0.3	0.6	**	570/16[1]	74/11
Chromium, total	µg/L	< 10	< 10	< 10	< 10	< 10	< 10	< 10	**	—	—
Copper, dissolved	µg/L	1.1	0.7	0.9	0.8	1.2	1.1	0.7	—	13	9
Copper, total	µg/L	< 10	< 10	< 10	< 10	< 10	< 10	< 10	50	—	—
Iron, dissolved	µg/L	< 10	< 10	< 10	< 10	< 10	< 10	< 10	—	1000	—
Iron, total	µg/L	20	50	90	30	110	130	< 10	500	—	—
Lead, dissolved	µg/L	0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	—	65	2.5
Lead, total	µg/L	< 40	< 40	< 40	< 40	< 40	< 40	< 40	50	—	—
Manganese, dissolved	µg/L	58.8	25.7	62.8	74.7	368	261	7.3	—	1000	—
Manganese, total	µg/L	62	49	81	81	411	308	9	100	—	—

Sample Site / Date sample collected / ANALYTE	UNITS	SW-10 12-Dec Result	SW-20 12-Dec Result	SW-30 13-Dec Result	SW-40 13-Dec Result	SW-50 14-Dec Result	SW-60 14-Dec Result	SW-200 13-Dec Result	Mongolian Class 2 Surface Water Standard	USEPA Water Qual. Criteria CMC	CCC
Mercury, dissolved	µg/L	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	—	1.4	0
Mercury, total	µg/L	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	—	14	0.77
Molybdenum, dissolved	µg/L	5.7	3.2	7	7.3	4.9	6	3.4	—	—	—
Molybdenum, total	µg/L	< 10	< 10	< 10	< 10	< 10	< 10	< 10	100	—	—
Nickel, dissolved	µg/L	1.8	0.6	0.9	1	1.3	1.2	0.9	—	470	52
Nickel, total	µg/L	< 10	< 10	< 10	< 10	< 10	< 10	< 10	50	—	—
Selenium, dissolved	µg/L	2	< 2	< 2	< 2	< 2	< 2	< 2	—	—	5
Selenium, total	µg/L	< 40	< 40	< 40	< 40	< 40	< 40	< 40	100	—	—
Silver, dissolved	µg/L	0.07	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	—	3.2	—
Silver, total	µg/L	< 5	< 5	< 5	6	< 5	< 5	< 5	100	—	—
Zinc, dissolved	µg/L	12	6	8	8	9	9	8	—	120	120
Zinc, total	µg/L	< 10	< 10	< 10	< 10	< 10	< 10	< 10	100	—	—

[1]Chromium Cr3+ limit (µg/L) / Chromium Cr^{6+} limit (µg/L)

Highlighted numbers represent values that exceeded the following standard:

-Yellow: Mongolia Surface Water Class 2 Standard;

-Red: US EPA CMC; and

-Teal/Blue: US EPA CCC.

ND – means there is no data

"—" indicates that there is no standard.

An exception was total and dissolved manganese that was several times higher at SW-50 and SW-60 than the downstream Tuul River sites. Dissolved manganese was 368 and 261 µg/L at SW-50 and SW-60, respectively, compared to a range of 25.7 to 74.7 µg /L at the downstream sites (**Table III.6-11**). Manganese exceeded the Mongolian standard for Class 2 waters at site SW-50, SW-60.

Total metals were generally very low and reflected the pattern of dissolved metals. Antimony, arsenic, cadmium, chromium, copper, lead, mercury, molybdenum, nickel, selenium, silver and zinc were at or below detection limits for all Tuul River sites. Total manganese was several times higher at the upstream sites of SW-50 (0.411 mg/L) and SW-60 (0.308 mg/L) when compared with the downstream sites. Total iron was also slightly higher at the upstream sites.

The water quality results from AATA's winter baseline study indicate that water quality in the Tuul River is excellent during winter with low levels of TSS, turbidity, and metals. A few Mongolian Class 2 standards were exceeded, but these standards are quite stringent in order to protect the river.

Hailaast Valley Spring (December 2002)

A water sample (SW-200) was collected for analysis from a spring in the Hailaast Valley in December 2002. The field measured water quality parameters indicate that the spring is slightly alkaline, with moderate conductivity and alkalinity and low turbidity (**Table III.6-11**). The spring is a calcium bicarbonate dominated system, with low suspended solids, and low metals. Nutrients were low. Nitrate/nitrite was about 1.5 to 2 times higher than the Tuul River sites.

6.2.1.5 Tuul River – July 2008 Baseline Study

During the July 2008 baseline study, the AATA team collected water quality data at five sites along the Tuul River and one pit lake sample within the Project area during the baseline study. Sampling sites included (**Figure III.6-4**):

- Site S-110 – Tuul River upstream of Tuul River Bridge, upstream control point;
- Site S-120 – Tuul River Big Bend site upper sampling point;
- Site S-130 – Tuul River Big Bend site mid sampling point;
- Site S-140 – Tuul River Big Bend site lower sampling point;
- Site S-150 – Tuul River downstream control point; and
- Site L-125 – Lake sample in the middle of the Big Bend site.

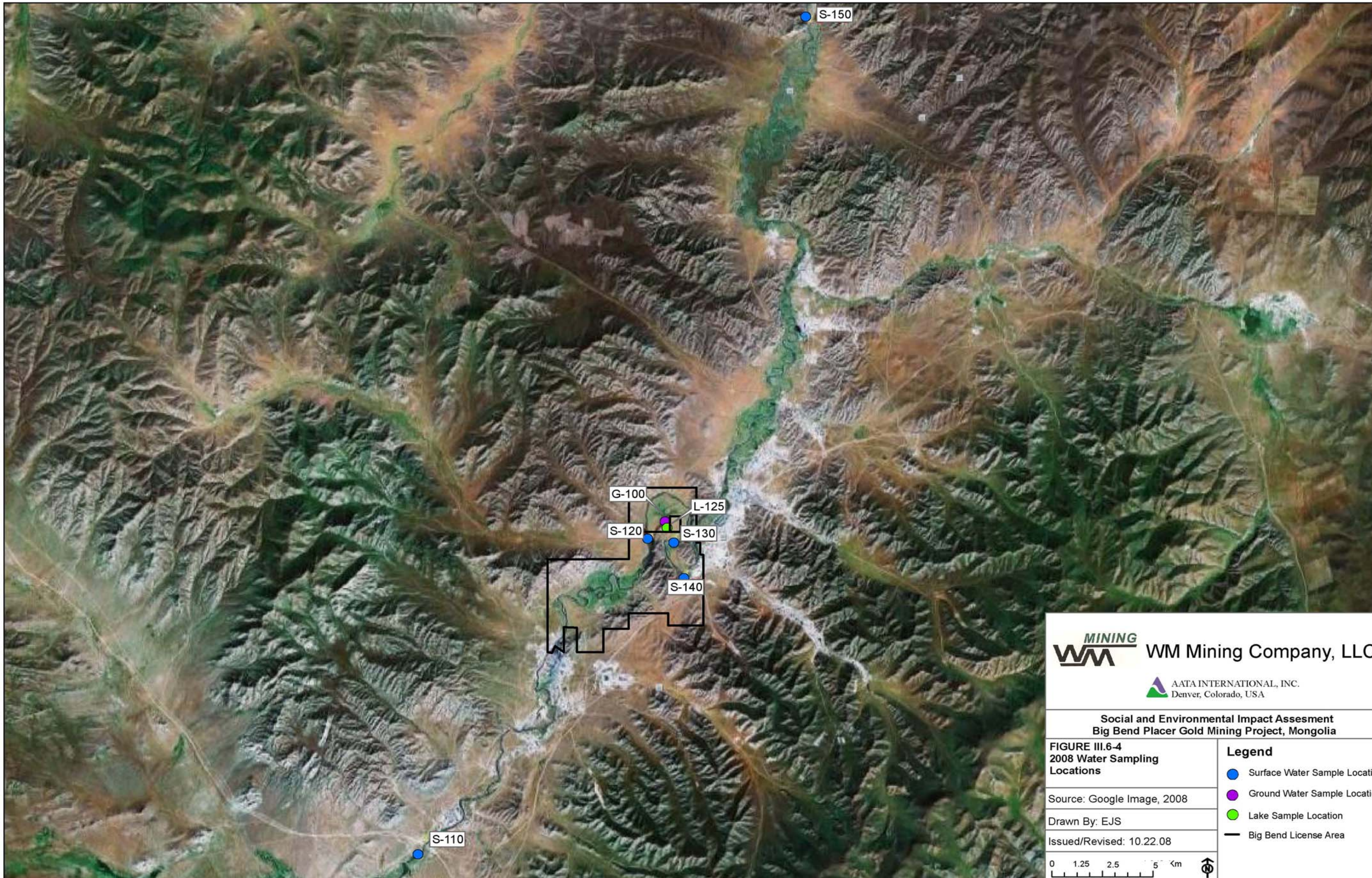


FIGURE III.6-4
2008 Water Sampling Locations

6.2.1.6 Methods and Materials – July 2008 Baseline Study

Field water quality measurements were taken at the water sample locations shown in **Figure III.6-4** above. The field water quality measurements included water temperature, pH, conductivity, dissolved oxygen, alkalinity, and turbidity. The following equipment was utilized to determine in-situ field measurements.

- pH was measured with a portable Fischer Scientific Accumet AP61 pH meter. Calibration was performed each day to standard buffer solutions of pH 4 and pH 10.
- Water temperature, dissolved oxygen, and conductivity were measured with a portable YSI Model 85 meter. The dissolved oxygen sensor was calibrated in saturated air several times each day. The conductivity sensor was calibrated in the laboratory using a standard solution.
- Alkalinity measurements were determined in the field by titration to a colorimetric end point corresponding to a specific pH using a Hach alkalinity test kit. Titrations were performed with a digital titrator with 1.6N H_2SO_4 as the titrating agent, a 100 mL sample volume, and phenolphthalein and bromocresol green-methyl red indicators (pH 8.3 and 4.8 endpoints, respectively).
- Turbidity was measured with a Hach 2100P portable turbidity meter.

Water samples were collected for laboratory chemical analysis in bottles provided by Energy Laboratories (Casper, Wyoming). All sample bottles were triple rinsed with the sample prior to sample collection.

For dissolved analyses, water was pumped through a Geotech 0.45 μm disposable filter into a clean, labeled bottle with a hand pump. For raw water analyses (unfiltered), water collected directly in the sample bottle. A total of seven Energy Laboratories water sample bottles were prepared and properly labeled for each sample site where water was collected:

- 500 mL HDPE plastic bottle: raw water sample for general parameters, TDS, TSS, cations and anions;
- 50 mL plastic tube: raw water sample for conductivity;
- 250 mL HDPE plastic bottle: filtered water sample for chloride, sulfate, ortho-phosphate, nitrate/nitrate, etc.
- 250 mL HDPE plastic bottle: raw water sample preserved with HNO_3 for total metals analysis;
- 125 mL HDPE plastic bottle: filtered water sample preserved with HNO_3 for dissolved metals analysis;
- 250 mL glass bottle: filtered water sample preserved with H_2SO_4 for DOC analysis;
- 250 mL glass bottle: raw water sample preserved with H_2SO_4 for TOC, ammonia, and total phosphorus analysis.

Samples were kept cool in coolers with ice and hand delivered to Activation Laboratories, Ltd. (ACTLABS) in Ulaanbaatar, Mongolia with completed chain-of-custody forms. ACTLABS then shipped the samples to their Ontario, Canada office.

Parameters analyzed from each water sample are shown in **Table III.6-9.** Initial field measurements indicated that the lake and groundwater well had contrasting physical parameters (**Table III.6-12**). The lake water was alkaline with a pH of 9.9, while the groundwater well had a neutral pH of 7.4. The lake water temperature of 26.8 °C was much warmer than the groundwater well temperature of 7.9 °C. The lake water had a turbidity of 7.9 NTU and a conductivity value of 584 μS/cm. The groundwater well sample had a lower turbidity value of 2.9 NTU and a corresponding lower conductivity value (372 μS/cm).

6.2.1.7 Results – July 2008 Baseline Study

Water quality samples were collected from the Tuul River and the on-site pit lake on July 14 to 15, 2008. Sites were sequentially numbered from upstream (S-110) to downstream (S-150). The July 2008 samples were collected following a period of heavy precipitation, while discharge was high and the Tuul River carried a large suspended sediment load. These conditions contrast sharply with those present during the December 2002 baseline study when the river was frozen and carried little suspended sediment.

Tuul River General Parameters (July 2008)

Table III.6-13 summarizes the laboratory results for the July 2008 surface water samples, which were analyzed by ACTLABS. Major ion analysis indicates that the Tuul River is a calcium-sodium-bicarbonate dominated system. Samples showed hard water with hardness as $CaCO_3$ ranging from 91.4 mg/L to 105 mg/L. Hardness as $CaCO_3$ exceeded the Mongolian Class 2 surface water standard (Mongolian Class 2 standard) of 15 mg/L for total hardness. Water hardness is principally the result of the concentrations of calcium and magnesium ions. Hardness is an important water quality constituent in ameliorating metal toxicity to aquatic life because positively charged calcium and magnesium ions compete with dissolved metals for binding sites. Metals are not expected to become mobilized due to alkaline pH (**Table III.6-12** and **Table III.6-13**) and hardness of the Tuul River.

Total magnesium at the Tuul River sampling sites was 11.0 to 23.4 mg/L, which is less than the Mongolian Class 2 standard of 30 mg/L. Fluoride concentrations approached the Mongolian Class 2 standard of 0.5 mg/L at the four upstream sites (0.46 to 0.48 mg/L) and slightly exceeded the standard at the downstream site (0.51 mg/L).

Table III.6-12 Field Water Quality Summary Results for Surface Water Samples Collected During the July 2008 Baseline Studies

Site	Description	Date (MM/DD /YYYY)	Time	GPS Coordinates	Water Temp. (˚C)	pH	Conductivity (µS/cm)	Alkalinity (mg/L)	Dissolved Oxygen (mg/L)	Turbidity (NTU)
S-110	Tuul River upstream of Tuul River Bridge, upstream control point	7/14/2008	1100	N 48º 14' 02.3" E 104º 19' 40"	21.6	8.07	334	58	5.4	147
S-120	Tuul River Big Bend site upper sampling point	7/14/2008	1630	N 48° 21' 31.8" E 104° 27' 42.9"	23.2	8.01	343	90.3	5.44	407.5
S-130	Tuul River Big Bend site mid sampling point	7/14/2008	615	N 48° 21' 27.2" E 104° 28' 33.1"	20.7	8.01	282	65	5.6	729
S-140	Tuul River Big Bend site lower sampling point	7/14/2008	1445	N 48° 20' 33.3" E 104° 28' 56.1"	22.5	7.67	328	96	5.92	263
S-150	Tuul River downstream control point	7/15/2008	1200	N 48° 34' 14.7" E 104° 33' 26.9"	23.2	8.02	363	112	7.33	248
L-125	Lake sample in the middle of the Big Bend site	7/15/08	1600	N 48° 21' 49.9" E 104° 28' 22.3"	26.8	9.9	584	172	11.3	7.9
Mongolian Class 2 surface water standard					—	6.5-8.5	—	—	8.0	—

Highlighted numbers represent values that exceeded the surface water standard
"—" indicates that there is no standard

Total dissolved solids (TDS) were moderate, and ranged from 230 to 253 mg/L, which is less than the Mongolian Class 2 standard of 300 mg/L. TDS consists of inorganic salts, small amounts of organic material, and dissolved materials. Due to prior precipitation and high flow in the Tuul River, total suspended solids (TSS) ranged from 208 to 1130 mg/L, which is greater than the Mongolian Class 2 standard of 20 mg/L, which applies only during periods of low flow. Since the Tuul River was at high flow during the July 2008 sampling event, the high TSS readings do not constitute an exceedence of the Mongolian Class 2 standard. TSS is a key water quality parameter, as high concentrations negatively impact aquatic life (Pentz and Kostaschuk, 1999). As a result of the elevated TSS concentrations, total solids (TSS plus TDS) was also high, ranging from 438 to 1364 mg/L.

Tuul River Nutrients (July 2008)

Nutrient concentrations were generally low at the Tuul River sampling sites. Nitrite concentrations were all less than the 0.01 mg/L detection limit, and probably lower than the Mongolian Class 2 standard of 0.05 mg/L. Nitrate concentrations ranged from 0.51 to 0.76, well below the Mongolian Class 2 standard of 3 mg/L. Ammonia concentrations exceeded the 0.05 mg/L Mongolian Class 2 standard at the two upstream sites (0.21 and 0.26 mg/L), but levels attenuated downstream and were at the detection limit of 0.02 mg/L at the three sites downstream. Similarly, phosphate concentrations were slightly greater than the 0.05 mg/L Mongolian Class 2 standard at the three upstream sites (0.06 mg/L), but less than the 0.02 mg/L detection limit at the two downstream sites.

Tuul River Metals (July 2008)

The analytical results indicate that several metals were present in concentrations greater than the relevant surface water standards at one or more sites on the Tuul River. These parameters include dissolved aluminum, total arsenic, total iron, total manganese, and dissolved mercury.

The concentrations of a number of metals were elevated in the July 2008 samples as compared to prior samples, most likely as a result of runoff from recent heavy rains. Metals concentrations were generally lowest at station S-110, the upstream control point above most existing mining activity. High metals concentrations were likely related to elevated TSS and turbidity.

Dissolved aluminum concentrations ranged from 93 to 184 μg/L at all sampling locations, which exceeds US EPA Criterion Continuous Concentration (CCC) of 87 μg/L. Total aluminum levels were also very high with levels from 7130 to greater than 20,000 μg/L, although there is no relevant water quality standard for this parameter. The high ratio of total aluminum to dissolved aluminum, combined with the comparatively lower concentrations of aluminum at the upstream control site, suggest that non-dissolved aluminum had been mobilized by the heavy rains that preceded the sampling event, particularly from the site of current mining activity.

Total arsenic exceeded the Mongolian Class 2 standard of 10 µg/L at sites S-120 and S-130 with concentrations of 13.5 and 16.5 µg/L, respectively. Total arsenic concentrations at the other sites were below the 10 µg/L standard, and dissolved arsenic concentration were relatively low at all stations (5.26 to 6.17 µg/L).

Total iron concentrations were very high at all stations (7,300 to 35,000 µg/L), greatly exceeding the Mongolian Class 2 standard of 500 µg/L. Dissolved iron concentrations were much lower (120 to 240 µg/L), and well within the US EPA Critical Maximum Concentration (CMC) of 1,000 µg/L in all samples.

Total manganese concentrations ranged from 290 to 1080 µg/L, exceeding the Mongolian standard for Class 2 waters (100 µg/L) at all sampling locations. However, dissolved manganese was far less than the US EPA CMC of 1,000 µg/L, with levels between 18.0 and 41.3 µg/L at the four upstream sites and 413 µg/L at site S-150.

Total mercury, analyzed using the ICP-MS methodology, was less than the detection limit of 0.2 µg/L in all samples. Cold Vapor Atomic Absorption analysis, with a detection limit of 0.006 µg/L, found dissolved mercury concentrations of 0.037 to 0.064 µg/L in the Tuul River samples. These dissolved mercury concentrations exceeded the Mongolian Class 2 standard and the US EPA CMC of 0.000 µg/L, but were well below the US EPA CCC of 1.4 µg/L.

Pit Lake (July 2008)

The sample collected from the groundwater-fed pit lake in the Project area, L-125, was basic with a pH of 9.5. This exceeded the Mongolian Class 2 standard, which has an upper limit of 8.5. The pit lake had hard water, with 104 mg/L hardness as $CaCO_3$, exceeding the Mongolian Class 2 standard of 15 mg/L for total hardness. Total alkalinity was 165 mg/L. Total dissolved solids was 349 mg/L, which exceeded the Mongolian Class 2 standard. Total suspended solids was less than the 4 mg/L detection limit, since solids settle out in an undisturbed environment.

Nutrient concentrations in the lake were low, and less the detection limit for nitrite, nitrate, and phosphate. Ammonia was detected at 0.03 mg/L, which is less than the 0.05 mg/L Mongolian Class 2 standard.

Analytical results for the pit lake showed that metals concentrations were below the US EPA CCC and CMC. Metals concentrations were generally very low, however total arsenic and total copper were elevated relative to the Mongolian Class 2 standard. Total arsenic was 22.8 µg/L, which exceeded the Mongolian Class 2 surface water standard of 10 µg/L, and total copper was 77 µg/L, somewhat higher than the Mongolian Class 2 standard of 50 µg/L.

Table III.6-13 Laboratory Results for Surface Water Quality Samples Collected during the July 2008 Baseline Study

Sample Site / Date sample collected / ANALYTE	UNITS	Detection Limit	Analysis Method	S110 14-Jul Result	S120 14-Jul Result	S130 14-Jul Result	S140 14-Jul Result	S150 15-Jul Result	L125 15-Jul Result	Mongolian Class 2 Standard*	USEPA Water Qual. Criteria	
											CMC	CCC
General Parameters												
pH (lab)	Units	0.1	pH	7.7	7.7	7.8	7.6	7.6	9.5	6.5 – 8.5	—	—
Hardness as $CaCO_3$	mg/L $CaCO_3$	0.2	ICP-OES	98.5	103	98	91.4	105	104	15	—	—
Conductivity @25°C	µS/cm	0.01	ISE	346	370	351	352	380	524	—	—	—
Bicarbonate	mg/L	1	TITR	109	131	120	114	125	84	—	—	—
Carbonate	mg/L	1	TITR	< 1	< 1	< 1	< 1	< 1	80	—	—	—
Total Alkalinity (lab)	mg/L $CaCO_3$	2	TITR	109	131	120	114	125	165	—	—	—
Calcium, total	mg/L	0.7	ICP-MS	31	46	71	35	36	11	90	—	—
Potassium, total	mg/L	0.03	ICP-MS	4.5	6.4	8.2	5.3	5.1	0.8	—	—	—
Magnesium, total	mg/L	0.001	ICP-MS	11.0	16.8	23.4	13.2	13.5	22.0	30	—	—
Sodium, total	mg/L	0.005	ICP-MS	33.6	30.3	26.5	28.5	34.2	81.8	—	—	—
Chloride	mg/L	0.03	IC	15.9	15.4	14.2	15.6	16.8	20.8	150	—	—
Bromide	mg/L	0.03	IC	0.09	< 0.03	< 0.03	< 0.03	0.09	0.23	—	—	—
Fluoride	mg/L	0.01	IC	0.46	0.48	0.48	0.47	0.51	1.91	0.5	—	—
Sulfate	mg/L	0.03	IC	39.4	39.3	35.8	38.8	42.5	79.2	100	—	—
Sulfur Trioxide (SO_3)	mg/L	0.4	IC	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	—	—	—
Non-Purgable Organic Carbon	mg/L	0.01	Analyzer	89.2	53.1	69.1	69.1	64.1	51.1	—	—	—
Total Dissolved Solids	mg/L		GRAV	230	246	234	234	253	349	300	—	—
Total Suspended Solids	mg/L	4	GRAV	208	620	1130	363	330	< 4	20[1]	—	—
Total Solids	mg/L		calculated	438	866	1364	597	583	> 349	—	—	—
Turbidity (lab)	NTU	0.1	Turbidimetric	101	355	730	210	206	5.6	—	—	—

Sample Site / Date sample collected / ANALYTE	UNITS	Detection Limit	Analysis Method	S110 14-Jul Result	S120 14-Jul Result	S130 14-Jul Result	S140 14-Jul Result	S150 15-Jul Result	L125 15-Jul Result	Mongolian Class 2 Standard*	USEPA Water Qual. Criteria	
											CMC	CCC
Nutrients												
Nitrite, NO_2 (as N)	mg/L	0.01	IC	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.005	—	—
Nitrate, NO_3 (as N)	mg/L	0.01	IC	0.58	0.74	0.76	0.56	0.51	< 0.01	3	—	—
Ammonia, NH_3	mg/L	0.02	ISE	0.21	0.26	0.02	0.02	0.02	0.03	0.05	—	—
Phosphate, PO_4 (as P)	mg/L	0.02	IC	0.06	0.06	0.06	< 0.02	< 0.02	< 0.02	0.05	—	—
Metals												
Aluminum, dissolved	µg/L	2	ICP-MS	93	172	171	106	184	14	—	750	87
Aluminum, total	µg/L	2	ICP-MS	7130	>20000	>20000	13400	11900	230	—	—	—
Antimony, dissolved	µg/L	0.01	ICP-MS	0.46	0.6	0.45	0.51	0.63	0.52	—	—	—
Antimony, total	µg/L	0.01	ICP-MS	0.3	0.3	0.4	0.4	0.3	0.3	—	—	—
Arsenic, dissolved	µg/L	0.03	ICP-MS	5.65	5.71	5.26	5.47	6.17	22.6	—	340	150
Arsenic, total	µg/L	0.03	ICP-MS	7.4	13.5	16.5	8.8	9.1	22.8	10	—	—
Cadmium, dissolved	µg/L	0.01	ICP-MS	0.03	0.03	0.02	0.03	0.02	0.03	—	2	0.25
Cadmium, total	µg/L	0.01	ICP-MS	< 0.1	0.2	0.3	0.1	0.1	< 0.1	5	—	—
Chromium, dissolved	µg/L	0.5	ICP-MS	<0.5	<0.5	<0.5	<0.5	<0.5	< 0.5	—	570/16[2]	74/11
Chromium, total	µg/L	0.5	ICP-MS	< 5	< 5	8	< 5	< 5	< 5	100/10[2]	—	—
Copper, dissolved	µg/L	0.2	ICP-MS	1.7	1.9	1.8	1.7	2	1.9	—	13	9
Copper, total	µg/L	0.2	ICP-MS	9	29	47	17	17	77	50	—	—
Iron, dissolved	µg/L	10	ICP-MS	120	190	180	140	240	20	—	1000	—
Iron, total	µg/L	10	ICP-MS	7300	21900	35000	14300	12700	200	500	—	—
Lead, dissolved	µg/L	0.01	ICP-MS	0.27	0.39	0.27	0.37	0.4	0.04	—	65	2.5
Lead, total	µg/L	0.01	ICP-MS	5.7	15.3	22.8	8.4	17.9	0.3	50	—	—
Manganese, dissolved	µg/L	0.1	ICP-MS	41.3	33.1	18.0	25.9	413	3.5	—	1000	—
Manganese, total	µg/L	0.1	ICP-MS	290	725	1080	435	419	5	100	—	—
Mercury, dissolved	µg/L	0.2	ICP-MS	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	—	—	—
Mercury, dissolved	µg/L	0.006	cold vapor	0.044	0.051	0.037	0.049	0.064	0.064	0	1.4	0

Sample Site / Date sample collected / ANALYTE	UNITS	Detection Limit	Analysis Method	S110 14-Jul Result	S120 14-Jul Result	S130 14-Jul Result	S140 14-Jul Result	S150 15-Jul Result	L125 15-Jul Result	Mongolian Class 2 Standard*	USEPA Water Qual. Criteria CMC	USEPA Water Qual. Criteria CCC
Mercury, total	µg/L	0.2	ICP-MS	< 2	< 2	< 2	< 2	< 2	< 2	—	14	0.77
Molybdenum, dissolved	µg/L	0.1	ICP-MS	13.5	12.6	9.8	11.5	13.2	20.7	—	—	—
Molybdenum, total	µg/L	0.1	ICP-MS	13	12	10	12	13	22	100	—	—
Nickel, dissolved	µg/L	0.3	ICP-MS	1.6	1.8	1.3	1.9	2.1	1.2	—	470	52
Nickel, total	µg/L	0.3	ICP-MS	12	26	44	16	16	< 3	50	—	—
Selenium, dissolved	µg/L	0.2	ICP-MS	0.8	0.7	0.7	1.0	0.9	1.2	—	—	5
Selenium, total	µg/L	0.2	ICP-MS	< 2	< 2	< 2	< 2	< 2	< 2	10	—	—
Silver, dissolved	µg/L	0.2	ICP-MS	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	—	3.2	—
Silver, total	µg/L	0.2	ICP-MS	< 2	< 2	6	< 2	< 2	< 2	10	—	—
Uranium, dissolved	µg/L	0.001	ICP-MS	9.30	7.70	6.08	7.78	9.25	19.80	—	—	—
Uranium, total	µg/L	0.001	ICP-MS	9.49	8.66	8.3	8.33	9.39	19.1	—	—	—
Zinc, dissolved	µg/L	0.5	ICP-MS	2.1	3.8	2.2	1.9	4.0	3.1	—	120	120
Zinc, total	µg/L	0.5	ICP-MS	79	65	105	48	45	203	1000	—	—

*Mongolian Class 2 Surface Water Standard

[1]Standard only applies during low flow. Since samples were collected during high flow, observed TSS values are not exceedences.

[2] Chromium Cr^{3+} limit (µg/L) / Chromium Cr^{6+} limit (µg/L)

Highlighted numbers represent values that exceeded the following standard:

- -Yellow: Mongolian Surface Water Class 2 Standard;
- -Red: US EPA CMC; and
- -Teal/Blue: US EPA CCC.

— indicates no regulatory standard

6.2.1.8 Turbidity Survey – July and August 2008

Water samples from the Tuul River were field-analyzed for turbidity using a portable digital turbidimeter during the July 14 to 15, 2008 baseline sampling event and an additional site visit on the August 18 to 19, 2008 (which included a site inspection by an OPIC representative) (**Table III.6-14**). Samples for laboratory analysis of turbidity were also collected during the baseline sampling. The July baseline measurements were made during a period of high river flow, while the measurements during the August OPIC inspection visit were made at lower flows. Comparison of turbidity under these different flow conditions allows a qualitative assessment of point vs. non-point source discharge of sediment to the Tuul River in the project vicinity.

Table III.6-14 Turbidity (NTU) Measurements Made During the July 2008 Baseline Sampling Event and the August 2008 OPIC Inspection

Station	S-110	S-120	S-130	S-140	S-150
July Turbidity (NTU)	145	408	730	263	279
August Turbidity (NTU)	27.2	43.4	54.2	53.8	37.6
Average Turbidity (NTU)	533.1	940.1	1346.9	488.8	742.0

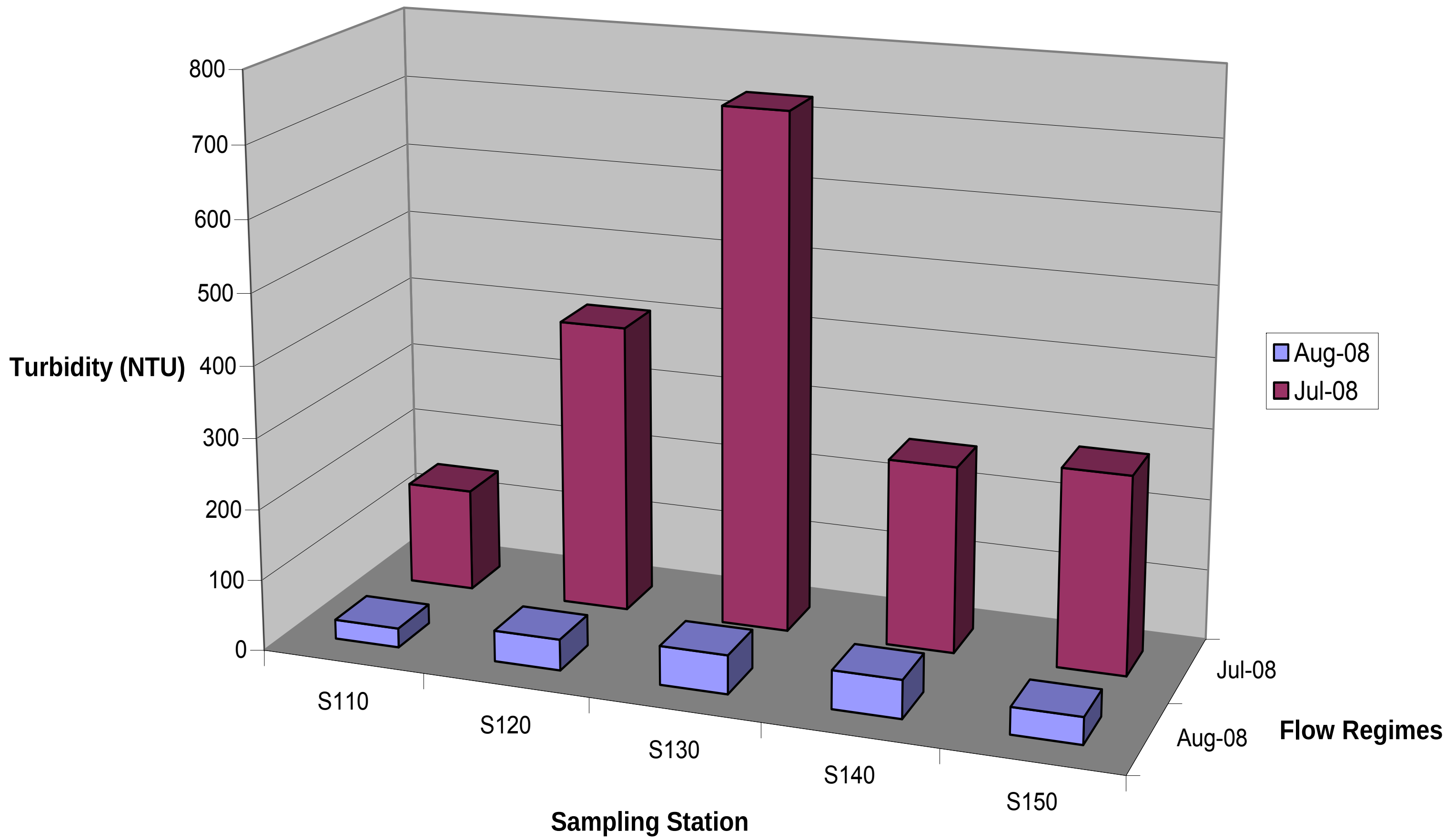
Turbidity of the Tuul River upstream of the Tuul River Bridge (S-110) is affected by some mining activities, and a large drainage area containing agriculture and grazing. During the baseline water quality sampling, local heavy rains had occurred recently and contemporaneously to the sampling so the Tuul River was at a relatively high stage. The stage of the river had decreased by approximately three feet between the July and August visits. The turbidity data show that the river was carrying a much higher suspended sediment load during the high flow period.

An assessment of point vs. non-point source contributions to turbidity can be made in general terms using these data. Comparison of dry period (August) turbidity at S-110 (upstream of most mining activity) with that at stations S-120 through S-140 (within the mining area) suggests that point source contributions of mining to the total suspended sediment load in the river is about 20 to 30 NTU. During the period of heavy rain (July), turbidity increased some 500 to 1,300 percent (5 to 13 times) compared to the low flow conditions in August (**Figure III.6-5**), suggesting that non–point source contributions dominate the suspended sediment load during wet periods. The observed increase in turbidity and, by inference, sediment load can be attributed to runoff from unreclaimed disturbance areas, mining, road traffic, construction, grazing, and agriculture. A specific apportionment among the different disturbances is not possible.

At low flow, the incoming Tuul River water (which does contain some mining contributions upstream of S-110) is about 27 NTU, doubling to 54 NTU before it departs the Big Bend area at S-140. The downstream control point shows a recovery (sedimentation) and decrease of 16 NTU to about 38 NTU leaving the area. A point source contribution of slightly more than 10 NTU is seen between S-110 and S-150.

The results indicate the need for much more management of non-point source sediment inputs (soil erosion and runoff) to limit sediment sources and contributions to the Tuul River.

Figure III.6-5 Turbidity (NTU) Measurements Made During the July 2008 Baseline Study and the August 2008 OPIC Visit



6.2.2 Groundwater

Very limited groundwater quality data has been collected during previous studies and/or monitoring in the Zaamar Goldfield. Several EIAs prepared for the area of interest and/or adjacent areas do not provide any data on groundwater quality.

Two groundwater quality studies were conducted within the Tuul River alluvial aquifer in the past. These two main sources for groundwater quality data have been analyzed for this report. It is important to note here that both sets of data were analyzed by the local Mongolian labs without appropriate Quality Assurance/Quality Control (QA/QC).

In addition to past studies, groundwater samples were taken from a groundwater drinking well (G-100) located in the Project area on July 15, 2008, as part of AATA baseline studies for this current SEIA (**Figure III.6-4**). This sample was taken with Western sampling protocol and proper QA/QC, prepared and preserved by ACTLABS in Ulaanbaatar, and shipped to the ACTLABS lab facility in Ontario, Canada for analyses.

All groundwater quality results in this section are compared to Mongolia Drinking Water Standards (MDWS). Recent groundwater quality analytical results are also compared to WHO drinking water standards.

6.2.2.1 Groundwater Quality Monitoring from 1986 to 1990 (USSR and Mongolia)

The first main historical source for groundwater quality data is from hydrogeologic investigations in the Tuul River alluvial aquifer conducted by the Soviet Geological Exploration Unit (USSR) in 1986 to 1988 and later by the Darkhan Geological Exploration Unit (Mongolia) in 1988 to 1990. Groundwater quality samples were collected upon the completion of pumping tests, which indicates that wells were sufficiently purged prior to sampling. Samples were collected at different times of the year, mostly during March, May, and October (**Table III.6-15**).

Groundwater quality results indicated neutral to slightly alkaline pH values, ranging from 6.75 to 8.40. Hardness ranged from 3.00 to 27.95 meq/L. Groundwater samples were calcium – sodium – bicarbonate and calcium – sodium – sulfate types. Ammonium concentrations ranged from below the detection limit (BD) to 0.40 mg/L. Nitrites were mostly below the detection limit, with three samples having trace concentrations (Tr.) and one sample having a concentration of 1.20 mg/L. Nitrates ranged from below the detection limit to 5.20 mg/L. Iron concentrations were all below the detection limit.

Total anions ranged from 245.66 to 2068.44 mg/L and total cations ranged from 79.21 to 911.99 mg/L. Cation concentrations were low in iron and ammonium and higher in magnesium (Mg) and potassium plus sodium. Anion concentrations were generally low in nitrogen ions and carbonate (CO_3) and high in sulfate and chloride (Cl).

According to these data, at the time of sampling groundwater quality data, groundwater analytical results from the wells 108-g, 88-g, 52-g, 72-g, and 104-g were in compliance with MDWS.

Water quality results from the other wells showed elevated cation (K^+ + Na^+, Ca^{2+}, and Mg^{2+}) and anion (Cl^-, SO_4^{2-}, and NO_2^-) concentrations that were not in compliance with MDWS. Concentrations of K^+ + Na^+ in wells 74-g, 142-g, and 1-c were 444.4, 385.5, and 423.9 mg/L, respectively; all of these exceeded the MDWS (200 mg/L). Magnesium concentrations ranged from 1.2 to 138.5 mg/L; four of these ten samples (74-g, 08-g, 142-g, and 76-g) exceeded the MDWS (30 mg/L). Chloride samples were generally low (10.3 to 59.2 mg/L); however, results from two samples (74-g and 142-g) had elevated chloride concentrations of 758.27 and 429.65, respectively. Groundwater quality results from these wells exceeded the MDWS for chloride (350 mg/L). Sulfate concentrations were mostly low, excluding sulfate concentrations in wells 74-g, 142-g, and 1-c (968.7, 528.4, and 860 mg/L, respectively) which all exceeded the MDWS (500 mg/L). Water quality results from well 74-g also showed elevated concentrations of calcium and nitrate (331.7 and 1.2 mg/L, respectively), which exceeded the MDWS for calcium and nitrite (100 and 1 mg/L, respectively).

6.2.2.2 Groundwater Quality Monitoring from 1997 to 1998 (Jadamba and Doloonbayar)

The second main historical source of groundwater quality data is from Jadamba and Doloonbayar who conducted an environmental study of the Zaamar Goldfield from 1997 to 1998. Groundwater quality samples were analyzed for anion-cation composition from a number of wells, boreholes, and seepage areas (**Table III.6-17** and **Table III.6-17**). In addition, five samples were analyzed for select metals and radium (**Table III.6-18**).

Groundwater quality data collected from wells and boreholes drilled at various properties in the Zaamar Goldfield are presented in **Table III.6-17**. The pH values at these sites were alkaline, ranging from 8.55 to 8.74. Hardness ranged from 3.55 to 4.90 meq/L. The major dominating ions were sodium – calcium – and bicarbonate. Ammonium concentrations mostly ranged from 0.02 to 0.12 mg/L with one exception where ammonium was 1.53 mg/L, measured at Darkhan-41 site. Nitrate values ranged from 0.09 to 1.82 mg/L. Silicon ranged from 3.4 to 5.8 mg/L. Total iron concentrations mostly ranged between 0.1 to 0.02 mg/L, except for the Darkhan-41 mine site which had an iron concentration of 0.09 mg/L.

Table III.6-15 Summary of Groundwater Quality Data from 1986 to1990 (USSR and Mongolia)

Well	Sampling Date	K^+ + Na^+ mg/L	NH_4^+ mg/L	Ca^{2+} mg/L	Mg^{2+} mg/L	Fe^{2+} + Fe^{3+} mg/L	Total cations mg/L	Cl^- mg/L	SO_4^{2-} mg/L	NO_2^- mg/L	NO_3^- mg/L	CO_3^{2-} mg/L	HCO_3^- mg/L	Total anions mg/L	Total ions mg/L	pH	H_2SiO_3 mg/L	Hardness meq/L
108-g	10-May-87	19.08	Tr.	40.08	20.05	BD	79.21	20.91	30.45	Tr.	0.7	4.5	189.1	245.66	324.87	8.4	3.83	3.65
88-g	6-Jun-87	23.21	Tr.	45.09	17.62	BD	85.92	17.37	35.39	BD	1.66	BD	210.45	264.87	350.79	7.1	4.08	3.7
52-g	11-May-87	90.12	BD	55.11	17.62	BD	162.85	59.2	104.5	BD	1.5	BD	259.3	424.54	587.39	7.35	3.51	4.2
72-g	24-Mar-88	72.87	Tr.	51.1	25.51	BD	149.48	56.01	100.4	BD	Tr.	BD	253.2	409.57	559.05	7.9	4.35	4.65
74-g	29-Oct-87	444.4	0.4	331.7	138.5	BD	911.99	758.3	968.7	1.2	1.66	BD	BD	338.64	2068.4	6.75	4.24	27.95
08-g	28-Mar-88	49.99	BD	54.11	32.81	BD	136.58	24.46	107.8	Tr.	1.62	BD	280.6	414.56	551.14	7.3	4.08	5.4
142-g	27-Mar-88	385.5	BD	92.18	92.34	BD	570.06	429.7	528.4	BD	BD	BD	356.9	1314.96	1885	7.5	3.12	12.2
76-g	5-Mar-89	23	BD	63	39.5	BD	115.5	10.3	51	BD	3.4	BD	33.6	410.7	516.4	7.7	3.2	5.9
104-g		80	BD	58	1.2	BD	139.2	13.8	51	BD	2.1	BD	30.5	371.9	511.1	7.6	4.6	3
1-c	27-May-87	423.9	Tr.	52.1	24.3	BD	500.3	24.81	860	Tr.	5.2	BD	265.4	1155.39	1655.7	7.8	4.68	4.6
Mongolia Drinking Water Standard		200	–	100	30	0.3	–	350	500	1	50	–	–	–	–	6.5 - 8.5	–	–

Based on results of hydrogeologic investigation by the Soviet Geological Exploration Unit, 1986-1988 and the Darkhan Geological Exploration Unit, 1988-1990)

All units are mg/L except pH (standard units) and hardness (meq/L)

Tr. – trace detected

BD –below th e detection limit

"–" means there is no standard

Highlighted numbers represent values that did not meet the MDWS water standard

Table III.6-16 Summary of Groundwater Quality Data from Wells and Boreholes (Jadamba and Doloonbayar, 1998)

Sample number/ observation number	Sampling Location	pH	SO_4	Cl	HCO_3	Ca	Mg	Hardness meq/L	Na+K	Sum of cations	NH_4	NO_3	Si	Fe
50/71	Borehole at Unet Metal Co's property	8.74	71	8.9	278.2	53	23	4.52	44.2	478.2	0.12	1.7	6	0
78/45	Borehole at Tsagaanbulag garden	8.7	97	22	283	63	22	4.9	59.2	545	0.02	1.82	3	0
80/46	Borehole at Tsagaanbulag center	8.64	33.5	6.7	263.5	57	14	4	30.2	404.9	0.07	1.22	5	0
43/66	Borehole at Darkhan-41 property	8.78	428	89	309.9	32	24	3.55	323.2	1205	1.53	0.09	5	0.1
68/37a	Borehole at Avdar Bayan property	8.55	29.8	2.8	263.5	58	13	3.92	27.5	393.9	0.04	0.98	4	0
80/46	Tsagaanbulag well at the center	8.64	33.5	6.7	263.5	57	14	4	30.2	404.9	0.07	1.22	5	0
68/37a	Well in Avdarbayan	8.55	29.8	2.8	263.5	58	13	3.92	27.5	393.9	0.04	0.98	4	0
Mongolia Drinking Water Standard		6.5 - 8.5	500	350	–	100	30	7	200	–	–	50	–	0.3

All units are mg/L except pH (standard units) and hardness (meq/L)
Highlighted represent values that did not meet the MDWS water standard
"–" means that there is no standard

According to these data, at the time of sampling groundwater quality, various properties within the Zaamar Goldfield were in compliance with MDWS except pH, which slightly exceeded the upper standard limit of 8.5. The higher pH values in these samples opposed to the USSR and Mongolia samples may be due to the fact that these wells were not sufficiently purged prior to sampling.

Groundwater quality data collected from open pit seepage are presented in **Table III.6-17**. The pH values from these sites were alkaline, ranging from 8.19 to 8.81. Hardness ranged from 1.28 to 7.40 meq/L. Groundwater samples were calcium – sodium – bicarbonate; calcium – sodium – chloride; and calcium – sodium – sulfate types. Ammonium concentrations ranged from 0.02 to 0.57 mg/L and nitrates ranged from 0.02 to 0.18 mg/L. Silica ranged from 0.5 to 5.7 mg/L. Total iron concentrations mostly ranged from not detected to between 0.12 mg/L.

According to these data, at the time of sampling, the groundwater that seeped from walls of operating open pit mines in the Zaamar Goldfield was mostly in compliance with MDWS. Values of pH from sample numbers 55, 74, 90, and 98 slightly exceeded the MDWS upper limit of 8.5. Sample number 7, a water quality sample collected from Zegsen company open pit, also showed some exceedances for sulfates, chlorides, and magnesium. This sample had elevated concentrations of cations that were over twice the sum of cations in other samples. High proportions of cations such as calcium, magnesium, sulfate and chloride can be an indication of agricultural influences on the groundwater (Theune, 2007). Sample number 98, seepage from Gan-Erden Company's open pit, showed a slightly elevated concentration of magnesium (48 mg/L) which exceeded the MDWS (30 mg/L).

Lastly, historical groundwater quality data analyzed for metals and radium are presented in **Table III.6-18.** Metal analysis of groundwater samples 51, 76, and 79 indicated very low metal concentrations for six parameters (copper, lead, nickel, manganese, molybdenum, and chromium). However, no samples were analyzed for mercury, which was historically used for gold recovery in the area. Groundwater samples were also analyzed for radium and uranium. Sample 26 was the only sample that had a discernible radium and uranium concentration. Radium and uranium in samples 10 and 51 were below detection limits.

Groundwater quality data indicate that, at the time of sampling, samples analyzed for metals and uranium in the Zaamar Goldfield were mostly in compliance with MDWS, except for the alkaline pH values which were all over the MDWS of 8.5 and ranged from 8.55 to 8.78. The concentration of molybdenum in Sample 10 was 15.1 μg/L, which exceeded the MDWS for molybdenum (7.0 μg/L). The concentration of uranium in sample 26 was 90 μg/L, which significantly exceeded the MDWS for uranium (30 μg/L). There is no MDWS for radium.

Table III.6-17 Summary of Groundwater Quality in Open Pit Seepages (Jadamba and Doloonbayar, 1998)

Sample number/ observation number	Sampling Location	pH	SO_4	Cl	HCO_3	Ca	Mg	Hardness	Na+K	Sum of cations	NH_4	NO_3	Si	Fe
7/8	Seepage in Gan-Erden Co's open pit	8.28	209.5	259	162.3	50	48	6.46	196.8	926	0.57	0.006	4.3	0.04
11/11	Seepage in open pit #5	8.19	5.4	9.6	80.5	19	4	1.28	10.5	129	0.36	0.018	4.1	0.12
55/74	Seepage in open pit #3 of Erdes Co.	8.81	121	27.6	312.3	70	6.1	4	110.5	647.6	0.14	0.004	5.2	0.01
74/43	Seepage in open pit of Khargui	8.68	56	9.6	236.7	52	12	3.58	43.5	402.6	0.02	0.002	5.3	0.01
90/50a	Seepage in open pit of Ikh Zagtsag Co.	8.56	98	19.5	241.6	55	16	4.06	62.2	492.2	0.14	0.004	5.7	ND[2]
98/57	Seepage in open pit of Zegsen Co.	8.77	935	411	262.3	61	53	7.4	699.2	2421.7	0.22	0.008	0.5	0.02
Mongolia Drinking Water Standard		6.5 - 8.5	500	350	–	100	30	–	–	–	–	50	–	0.3

All units are mg/L except pH (standard units) and hardness (meq/L)
Highlighted numbers represent values that did not meet the MDWS water standard
"–"indicated that there is no standard

Table III.6-18 Summary of Metals and Radionuclides in Groundwater (Jadamba and Doloonbayar, 1998)

Sample Number	Sampling Location	Copper, µg/L	Lead, µg/L	Nickel, µg/L	Manganese, µg/L	Molybdenum, µg/L	Chromium, µg/L	Uranium, µg/L	Radium, Bq/L
10	Open pit	3.1	0.2	0.5	5.7	15.1	4.1	BD	BD
51	Borehole # 2	0.6	1	0.8	0.5	3.8	BD	BD	BD
26	Format	BD	BD	BD	BD	BD	BD	90	1.1
76	Erdes open pit	BD	BD	BD	BD	BD	BD	<8	<0.1
79	Garden well at Tsagaan Bulag	BD	BD	BD	BD	BD	BD	<8	<0.1
Mongolia Drinking Water Standard		100	1	2	10	7	5	15	–

All units are µg/L except Ra (Bq/L)

Highlighted numbers represent values that did not meet the MDWS water standard

BD – values were below the detection limit

"–" means there is no standard

6.2.2.3 Groundwater Quality Testing (AATA, July 2008)

In addition to these previous groundwater studies, in July 2008, AATA collected a drinking water well groundwater quality sample (G-100) in the Project area as part of a baseline study for this SEIA (**Table III.6-7**). AATA sampling methods are as follows.

Methods and Materials

The well was pumped using a submersible electronic pump for 10 to 15 minutes until adequate purging was achieved. Field parameter measurements, including temperature, conductivity, pH, turbidity, and dissolved oxygen were measured during well purging and prior to sample collection. Purging was considered complete (upon which sampling could begin) when field water quality parameters stabilized.

After the well had been purged of at least three well volumes, the sample was collected from the pump spigot using pre-cleaned laboratory-certified bottles, which were then labeled providing information on sample identification, requested analysis, preservatives, filtering, date, and time.

The groundwater sample was collected for laboratory chemical analysis following the United States Environmental Protection Agency protocols. Clean, disposable, inert containers were used to collect groundwater samples. Sample containers were provided by ACTLABS in Ulaanbataar, Mongolia. For dissolved analyses, water was pumped through 0.45 μm disposable filters into clean, labeled bottles with a hand pump. For raw water analyses (unfiltered), water was poured from the cubitainer into the sample bottles. As required, preservative was added to the sample bottle. Preparation and preservation of water samples taken in July 2008, including the groundwater sample, are described in **Section 6.2.1**.

Results

Initial field measurements showed that the groundwater well sample had a neutral pH of 7.4 (**Table III.6-19**). The water temperature was 7.9 °C and the dissolved oxygen concentration was 8 mg/L. Other field measurements from the groundwater well sample showed a low turbidity value of 2.9 NTU and a corresponding low conductivity value of 372 μS/cm.

Laboratory results are summarized in **Table III.6-20**. Groundwater quality results were compared to Mongolian Drinking Water standards and World Health Organization (WHO) Guidelines for Drinking water standards. The WHO produces international norms on drinking-water quality for human health in the form of guidelines, which are used as the basis for regulation and standard setting in developing and developed countries worldwide (WHO, 2006b). The fundamental purpose of the WHO Guidelines for Drinking Water Quality is the protection of public health (WHO, 2006b). The guidelines provide the reasonable minimum requirements for the protection of consumer health and/or derive numerical “guideline values” for constituents of water or indicators of water quality (WHO, 2006b).

The lab pH for the groundwater well (G-100) was 8.0, which is slightly alkaline, but fell within the MDWS limits. The groundwater evidenced hard water with a hardness value of 198 mg/L (as $CaCO_3$). Analytical results for the groundwater well showed an elevated dissolved sodium concentration of greater than 35 mg/L; this exceeds the MDWS of 30 mg/L. Bromide was also elevated with a concentration of 0.18 mg/L, in comparison to the MDWS of 0.01 mg/L.

Nutrient concentrations in this sample were low. Nitrite and phosphate concentrations were below the detection limit (less than 0.01 and less than 0.02 mg/L), and nitrate and ammonia were also low (1.36 and 0.02 mg/L).

Metal concentrations were generally low, although analytical results showed elevated concentrations of potentially toxic metals such as arsenic, iron, and uranium. The dissolved arsenic concentration in G-100 was 15.2 µg/L, which exceeded the 10 µg/L WHO drinking water standard for arsenic, and total arsenic was 15.5 µg/L, which exceeded the 10 µg/L MDWS. The groundwater sample had an elevated total iron concentration of 400 µg/L, which exceeded the 300 µg/L MDWS. The uranium concentration in G-100 was 22.3 µg/L, which exceeded the 15 µg/L MDWS for uranium.

6.2.2.4 Summary

Limited data available for this review showed that many of the samples were in compliance of MDWS and suitable for domestic and agricultural use. Concentrations of some general parameters in groundwater including pH, sodium, magnesium, calcium, chloride, bromide, sulfate and nitrite exceeded the standards in one or more samples. However, groundwater quality samples did not show any pH exceedances when the well was sufficiently purged prior to sampling. One groundwater sample (sample 26, Format site) showed an elevated concentration of uranium that exceeded the MDWS. The July 2008 groundwater quality results showed elevated concentrations of arsenic, total iron, and total uranium.

Groundwater samples from the previous reports have very limited data on metal concentrations and no data for several parameters including mercury and petroleum products. The 2008 samples were analyzed for a full range of parameters, but these samples indicated the water quality at a single point and cannot be extrapolated to the entire aquifer. There were no accessible groundwater wells upgradient and downgradient of the Project area. Hence, future work will require installation of monitoring wells for further groundwater testing.

Table III.6-19 Field Groundwater Quality Summary Results for Samples Collected

Site	Description	Date	Time	GPS Coordinates	Water Temp. (˚C)	pH	Conductivity (µS/cm)	Alkalinity (mg/L)	Dissolved Oxygen (mg/L)	Turbidity (NTU)
G-100	Groundwater well sample site	7/15/08	1700	N 48° 21’ 58.5” E 104° 28’ 20”	7.9	7.4	372	221	8	2.9

Table III.6-20 Laboratory Results for the Groundwater Sample (G-100) Collected During the July 2008 Baseline Studies

Sample Site / Date sample collected / ANALYTE	UNITS	Detection Limit	Analysis Method	G100 15-July Result	Mongolian Drinking Water Standard	WHO Drinking Water Standard
General Parameters						
pH (lab)	units	0.1	pH	8.0	6.5 – 8.5	—
Hardness as $CaCO_3$	mg/L $CaCO_3$	0.2	ICP-OES	198	—	—
Conductivity @25°C	µS/cm	0.01	ISE	530	—	—
Bicarbonate as $CaCO_3$	mg/L	1	TITR	214	—	—
Carbonate as $CaCO_3$	mg/L	1	TITR	< 1	—	—
Total Alkalinity (lab)	mg/L $CaCO_3$	2	TITR	214	—	—
Calcium, dissolved	mg/L	700	ICP-MS	> 20	—	—
Potassium, dissolved	mg/L	30	ICP-MS	3.24	—	—
Magnesium, dissolved	mg/L	1	ICP-MS	19.4	—	—
Sodium, dissolved	mg/L	5	ICP-MS	> 35	30	—
Chloride	mg/L	5	ICP-MS	13.3	350	250
Bromide	mg/L	0.03	IC	0.18	0.01	—
Fluoride	mg/L	0.01	IC	1.0	0.7 – 1.5	1,500
Sulfate	mg/L	0.03	IC	42.2	500	—
Sulfur Trioxide (SO_3)	mg/L	0.4	IC	< 0.4	—	—
Non-Purgable Organic Carbon	mg/L	0.01	Analyzer	53.2	—	—
Filterable (TDS) @180°C	mg/L		GRAV	353	—	
Non-Filterable (TSS)	mg/L	4	GRAV	< 4	—	50
Total Solids	NTU			> 353	1000	
Turbidity (lab)	NTU	0.1	Turbidi-metric	1.2	—	—
Nutrients						
Nitrate/Nitrite as NO_2-N	mg/L	0.01	IC	< 0.01	1	3
Nitrate/Nitrate as NO_3-N	mg/L	0.01	IC	1.36	50	50
Nitrogen, ammonia as NH_3	mg/L	0.02	ISE	0.02	1.4	—
Phosphate, PO_4-P	mg/L	0.02	IC	< 0.02	3.5	—
Metals						
Aluminum, dissolved	µg/L	2	ICP-MS	3	—	200
Aluminum, total	µg/L	2	ICP-MS	300	500	—
Antimony, dissolved	µg/L	0.01	ICP-MS	0.17	—	20
Antimony, total	µg/L	0.01	ICP-MS	< 0.1	20	—
Arsenic, dissolved	µg/L	0.03	ICP-MS	15.2	—	10
Arsenic, total	µg/L	0.03	ICP-MS	15.5	10	—
Cadmium, dissolved	µg/L	0.01	ICP-MS	0.03	—	3
Cadmium, total	µg/L	0.01	ICP-MS	> 0.1	3	—

Sample Site Date sample collected ANALYTE	UNITS	Detection Limit	Analysis Method	G100 15-July Result	Mongolian Drinking Water Standard	WHO Drinking Water Standard
Chromium, dissolved	µg/L	0.5	ICP-MS	0.9	—	—
Chromium, total	µg/L	0.5	ICP-MS	< 5	50	50 (P)
Copper, dissolved	µg/L	0.2	ICP-MS	0.3	—	2,000
Copper, total	µg/L	0.2	ICP-MS	2	50	—
Iron, dissolved	µg/L	10	ICP-MS	10	—	—
Iron, total	µg/L	10	ICP-MS	400	300	—
Lead, dissolved	µg/L	0.01	ICP-MS	0.02	—	—
Lead, total	µg/L	0.01	ICP-MS	0.3	10	10
Manganese, dissolved	µg/L	0.1	ICP-MS	10.5	—	—
Manganese, total	µg/L	0.1	ICP-MS	15	100	400 (C)
Mercury, dissolved	µg/L	0.006	Cold vapor	0.048	—	—
Mercury, total	µg/L	0.2	ICP-MS	< 2	0.5	6
Molybdenum, dissolved	µg/L	0.1	ICP-MS	12.2	—	70
Molybdenum, total	µg/L	0.1	ICP-MS	13	70	—
Nickel, dissolved	µg/L	0.3	ICP-MS	0.4	—	70
Nickel, total	µg/L	0.3	ICP-MS	< 3	20	—
Selenium, dissolved	µg/L	0.2	ICP-MS	1.5	—	10
Selenium, total	µg/L	0.2	ICP-MS	< 2	10	—
Silver, dissolved	µg/L	0.2	ICP-MS	< 0.2	—	—
Silver, total	µg/L	0.2	ICP-MS	< 2	100	—
Uranium, dissolved	µg/L	0.001	ICP-MS	22.7	—	—
Uranium, total	µg/L	0.001	ICP-MS	22.3	15	—
Zinc, dissolved	µg/L	0.5	ICP-MS	3.4	—	—
Zinc, total	µg/L	0.5	ICP-MS	7	5000	—

Highlighted numbers represent values that did not meet the MDWS or the WHO drinking water standard:
"—" indicates that there is no standard
C = Concentrations of the substance at or below the health-based guideline value may affect the appearance, taste, or odor of the water, leading to consumer complaints
P = Provisional guideline value, as there is evidence of a hazard, but the available information on health effects is limited

6.3 Noise Levels

The Project area is situated in the Tuul River Valley, which has 10 to 13 mining operations, illegal artisanal mining, and supportive services. Dry and wet mining operations and motorized vehicle traffic contribute to the regional noise levels. No major roads, airports, or railroads are adjacent to or within the Project area, limiting the noise generated from vehicle traffic.

Noise levels from various sources were measured in July 2008. The ambient noise levels ranged from less than 40 to 88 dB (**Table III.6-21**).

Table III.6-21 Noise Levels near the Project Area

Source	Sound Level (dB)
Background	< 40 - 55
Birds	40 - 55
Cranes	50
Camp	68 - 78
Motorcycle	88
Activities	58 - 70
Drillers	60 - 68

6.4 Soil Chemisty

Soil chemistry, especially metal concentrations, vary significantly from place to place depending upon many factors, principally on the composition of parent materials (bedrock and, in this case, also river sediments). Chemical features of the four soil types seen in the Zaamar Goldfield region are summarized in **Table III.6-22**.

Table III.6-22 Chemical Features of the Soil Types

Feature	Stony Thin Dark Soil	Thin Dark Soil	Medium Thick Dark Soil	Meadow Dark-Black Soil
Humus Content	1.8 - 3.3 percent	4.7 - 5.3 percent	4.9 – 5.8 percent	6.8 – 9.8 percent
Phosphorus	0.2 mg/kg	0.2 – 0.3 mg/kg	0.2 – 0.3 mg/kg	0.4 –0.8 mg/kg
Mobile Nitrogen	0.3 – 0.4 mg / kg	0.5 – 0.6 mg/kg	0.4 – 0.6 mg/kg	0.9 – 1.2 mg/kg
Calcium	2.5-3.0 mg/kg	7.0 – 8.0 mg/kg	9.8 – 14.4 mg/kg	6.8 – 17.6 mg/kg
pH	Neutral near top, becomes weakly alkaline downward	Neutral in humus zone; weakly alkaline downward	Weakly acid near the top; to weakly alkaline near the bottom.	Weakly acid

Source: Khos Khas EIA, 2002

AATA collected 15 representative soil samples, 3 samples from a pit dug to observe the soil profile (Pit 1 A through C) and the rest from sites S-1 through S-12 within the floodplain during the baseline study in July 2008. Sampling locations are shown on **Figure III.2-19**. The soil samples were collected with new, clean hand trowels and placed in labeled, 1-gallon zip-locked plastic bags. The pit samples were collected from the A, B, and C horizons at a depth of 15 cm, 67 cm and, 110 cm bgs. The other 12 soil samples (S-1 through S-12) were collected from 15 to 20 cm bgs. The soil samples were placed in a second labeled bag for protection and kept in a cooler while in the field.

The soil samples were kept in a cooler while in the field and transferred to a refrigerator until they were ready for shipment to ACT Laboratories LTD (ACT), Ulaanbaatar, Mongolia. Samples were transferred to a cooler with ice with chain-of-custody information, and sent from Ulaanbaatar via air courier to ACT in Ancaster, Ontario, Canada. Soil samples were analyzed by ACT for total metals, organic content, and particle size.

Sample S-5 failed QA/QC in the initial analysis, so the results for soluble metals, conductivity, and nitrogen were rejected and reanalyzed. **Table III.6-23** summarizes the laboratory analytical results of the soil samples collected in the Project area. Original lab reports are presented in **Attachment 6** of **Appendix E**. For comparison purpose, the concentrations range of soil parameters found in surficial materials of the conterminous United States (Shacklette, H. T. 1984; Baudo et. al., 1990) are also presented in **Table III.6-23**.

The analytical results of the soil samples indicated that the soils in the Project area are weakly alkaline to alkaline with pH values ranging from 7.57 to 9.23. The alkalinity of the three soil samples collected from the pit increased with increasing depth with the A Horizon being weakly alkaline at 7.86. The pH of the B Horizon was 8.95 and the C Horizon was 9.25.

Total nitrogen was less than 0.01 percent for the B and C horizon samples collected from the pit, and ranged from 0.1 to 0.15 for the A Horizon samples. Potassium levels ranged from 0.22 percent to 0.62 percent. Phosphorous ranged from 0.045 percent to 0.079 percent. Sodium Absorption Ratio (SAR) ranged from 4 to 174 in the A Horizon samples and in the pit the SAR was 44 for the A horizon, 239 for the B Horizon, and 229 for the C Horizon. Soluble salts were all high in the soil with electric conductivities ranging from 105 µS/cm to 2,870 µS/cm for the A Horizon samples. The soluble salts in the pit were 107 µS/cm for the A Horizon sample; 2,830 µS/cm for the B Horizon sample; and 653 µS/cm for the C Horizon sample. Soluble boron ranged from 2.3 mg/L to 15.7 mg/L, soluble calcium ranged from 6.6 mg/L to 332 mg/L, soluble magnesium ranged from 7 mg/L to 141 mg/L, and soluble sodium ranged from 24.5 mg/L to 1,530 mg/L.

The soil sample results were compared to a range of element concentrations determined from over 1,300 soil samples collected throughout the conterminous US (USGS, 1984). For the purposes of this report, the range of element concentrations was defined as a normal range. As shown on **Table III.6-23,** most of the metals fall within the normal range, however, thirteen of the fifteen soil samples collected at the Project area have aluminum concentrations two to four times the upper boundary of the normal range. On the other hand, the antimony concentrations in the Big Bend soil samples are slightly lower than the normal range. The boron concentrations in all of the Big Bend soil samples are below, or at the low end of the normal range. Mercury concentrations in the Big Bend soil samples were also on the low concentration range with two of the samples having mercury concentrations below the normal range. Sodium concentrations were also on the low end of the range with one sample slightly below the normal range. A major contributor to the differences in soil chemical composition is believed to be the differences in surface geology.

Table III.6-23 Soil Analysis Results

Parameter	Unit	Pit 1 A Horizon	Pit 1 B Horizon	Pit 1 C Horizon	S-1	S-2	S-3	S-4	S-5	S-6	S-7	S-8	S-9	S-10	S-11	S-12	Normal Range
Aluminum, total (AR-MS)	percent	2.45	2.1	2.05	2.61	3.34	2.37	2.83	0.68	2.2	2.28	1.22	2.83	3.49	3.49	3.03	0.07–1 (percent)**
Antimony, total (AR-MS)	mg/kg	0.49	0.48	0.42	0.44	0.43	0.39	0.37	0.13	0.38	0.34	0.46	0.32	0.45	0.46	0.47	1–8.8 (mg/kg)**
Arsenic, total (AR-MS)	mg/kg	13.9	12	10.7	8.5	7.7	6.8	7	3.9	6	5.9	3.6	5.6	7.6	7.5	7.8	<0.1–97 (mg/kg)**
Barium, total (AR-MS)	mg/kg	124	96.9	85.9	148	180	132	156	201	118	133	118	181	170	172	147	10–5,000 (mg/kg)**
Beryllium, total (AR-MS)	mg/kg	0.8	0.6	0.5	0.9	1.1	0.7	0.9	0.2	0.7	0.8	0.4	0.9	1.1	1.1	0.9	<1–15 (mg/kg)**
Boron, total (AR-MS)	mg/kg	6	20	27	50	10	22	14	33	19	34	39	36	11	11	10	<20–300 (mg/kg)**
Cadmium, total (AR-MS)	mg/kg	0.08	0.07	0.09	0.15	0.12	0.08	0.08	0.16	0.09	0.16	0.1	0.13	0.11	0.13	0.14	0.01-2 (mg/kg)*
Calcium (AR-MS)	percent	0.52	9.18	13	6.15	0.72	4.17	0.47	18.5	3.25	4.7	17.9	4.14	0.56	0.55	3.14	0.01–32 (percent)**
Chromium, total (AR-MS)	mg/kg	51.5	32.4	38.9	30.6	46.2	34.6	40.1	11.4	30.7	36.8	15.3	37.8	50.8	49.5	43.7	1–2,000 (mg/kg)**
Copper, total (AR-MS)	mg/kg	22.1	25.4	22.1	32.1	26.4	25	23.3	7.3	21.4	20	10.5	80	36.6	37	27.7	<1–700 (mg/kg)**
Iron, total (AR-MS)	percent	2.9	2.21	2.12	2.59	3.5	2.81	3.06	0.93	2.4	2.28	1.27	3.08	3.81	3.78	3.49	0.01-10 (percent)**

Parameter	Unit	Pit 1 A Horizon	Pit 1 B Horizon	Pit 1 C Horizon	S-1	S-2	S-3	S-4	S-5	S-6	S-7	S-8	S-9	S-10	S-11	S-12	Normal Range
Lead, total (AR-MS)	mg/kg	10.2	8.03	6.54	8.04	17	8.73	11.1	3.0	8.27	7.84	4.83	9.73	13.9	13.7	12.2	<10–700 (mg/kg)**
Manganese, total (AR-MS)	mg/kg	601	295	284	565	786	443	569	1330	430	467	407	594	848	824	686	<2–7,000 (mg/kg)**
Magnesium (AR-MS)	percent	0.9	1.35	1.47	3.28	0.93	1.39	0.87	0.78	0.99	2.21	1.42	1.25	1.17	1.14	1.01	0.005–10 (percent)**
Mercury, total (FIMS)	ppb	8	< 5	11	15	14	13	16	17	12	21	14	16	17	17	23	10–4,600 (ppb)**
Nickel, total (AR-MS)	mg/kg	28.7	27.1	24.6	54.4	36.4	46.5	31.6	9.3	25.1	21	14.6	177	57.3	58	37.2	5–700 (mg/kg)**
Potassium (AR-MS)	percent	0.36	0.22	0.24	0.62	0.51	0.37	0.47	0.07	0.31	0.52	0.19	0.57	0.61	0.6	0.51	0.005–6.6 (percent)**
Selenium, total (AR-MS)	mg/kg	0.7	0.8	0.8	1.3	0.6	0.6	0.5	0.5	0.6	1	1.7	1.4	0.6	0.7	0.6	<0.1–4.3 (mg/kg)**
Sodium (AR-MS)	percent	0.088	0.256	0.164	0.316	0.056	0.251	0.236	0.071	0.319	0.186	0.25	0.524	0.13	0.13	0.04	0.05–10 (percent)**
Silver, total (AR-MS)	mg/kg	0.066	0.022	0.026	0.053	0.061	0.04	0.118	0.026	0.044	0.04	0.025	0.068	0.10	0.10	0.07	0.01-8 (mg/kg)*
Thallium, total (AR-MS)	mg/kg	0.14	0.1	0.1	0.13	0.17	0.11	0.14	0.04	0.11	0.1	0.06	0.17	0.17	0.17	0.14	
Zinc, total (AR-MS)	mg/kg	59.7	41.1	40.2	57.9	77	49.9	65.5	19.1	52.9	56.4	31.1	63.2	83.2	83.7	72.8	<5-2,900 (mg/kg)**
Total Nitrogen (Analyzer)	percent	0.1	< 0.01	< 0.01	0.13	0.12	0.04	0.09	1.23	0.05	0.11	0.49	0.05	0.09	0.15	0.14	
Nitrate (IC)	mg/L	3.75	< 0.2	0.09	2.09	4.39	15.3	10.6	23.8	290	0.13	0.5	12.6	0.23	3.74	4.29	

Parameter	Unit	Pit 1 A Horizon	Pit 1 B Horizon	Pit 1 C Horizon	S-1	S-2	S-3	S-4	S-5	S-6	S-7	S-8	S-9	S-10	S-11	S-12	Normal Range
Nitrite (IC)	mg/L	0.1	< 0.2	0.18	2.71	0.07	0.23	0.24	50.8	4.11	0.4	0.82	0.59	< 0.2	<0.0 6	0.3	
Phosphorus, total (AR-ICP)	percent	0.046	0.045	0.047	0.051	0.052	0.047	0.045	0.057	0.062	0.05	0.055	0.07	0.07	0.068	0.08	
Organic Matter (GRAV)	percent	4.17	2.56	2.03	6.63	5.71	3.73	4.65	27.01	3.47	6.41	11.33	4.05	6.81	6.28	6.16	2 – 5 (percent)*
pH	pH units	7.86	8.95	9.25	9.21	7.64	9.23	8.67	8.05	9.03	9.07	8.23	9.35	9.06	7.57	7.96	6.5-7.5*
Conductivity (ISE)	µS/cm	107	2830	653	1080	105	1000	735	–	1880	697	2870	1990	1810	652	233	
Sodium Absorption Ratio (ICP-OES)		44	239	229	83	12	87	115	17	174	42	102	142	129	99	4	
Boron , soluble (ICP-OES)	mg/L	2.4	2.6	5.3	10.3	2.3	7.7	9.4	<0.5	5.4	4.6	1.6	15.7	9.1	3	1.4	
Calcium, soluble (ICP-OES)	mg/L	36.1	22.9	6.6	154	26.6	161	66.2	169	136	206	332	233	175	27.9	116	
Magnesium, soluble(ICP-OES)	mg/L	17.6	141	10	122	7	58	56.8	21.8	18.6	113	278	29.9	25.5	23.7	9	
Sodium, soluble (ICP-OES)	mg/L	159	1530	466	686	34.7	644	635	119	1090	371	1260	1150	914	356	24.5	
Chlorine (INAA)	percent	< 0.01	0.06	0.01	0.02	0.01	0.03	< 0.01	0.03	0.03	0.02	0.06	0.02	0.03	0.02	0.02	

"– " values not presented for QA/QC purposes

7.0 Archaeological, Historical, and Cultural Resources

Archaeological finds have demonstrated that nearly all of Mongolia was settled in prehistoric times (Montsame, 2008). Human traces from the middle and later Paleolithic periods have been evidenced throughout Mongolia, including the Tuul River Valley. Archaeological evidence indicates that what is now Mongolia may have been populated as early as 500,000 years ago.

Mongolia became politically significant with the introduction of iron weapons around the 3rd century BC. Similar to other areas within the vast nomadic steppe, Mongolia was inhabited by tribes of nomads that periodically united in confederations of varying sizes. These nomads typically practiced animal husbandry and traded with nearby tribes and communities, occasionally raiding each other and agricultural peoples. From time to time, large united confederations of nomads threatened bordering societies and, during certain periods, occupied much of Eurasia.

Today, Mongolia has a unique and durable traditional culture, centered around herding. Herders remain semi-nomadic, moving their animals with the seasons as they have for centuries. Many urban Mongolians retain strong links to the land, both literally and sentimentally, and the country's performing and visual arts often celebrate the landscape and the animals that are central to Mongolian life.

The Law on Culture of Mongolia (1996), State Policy on Culture (1996) and, most importantly, the Law on the Protection of the Cultural Heritage (2001) provide for the protection of tangible and intangible forms of cultural heritage, placing authority at the national, aimag and soum level for protecting cultural heritage properties classified as “common”, “valuable” or “unique and valuable”. The emphasis of the legislation is on intangible forms of culture in need of protection, such as:

- mother language, script, and associated culture;
- oral literature;
- folk songs (urtiin duu and bogino duu) and epics, and the techniques of singing or narrating these;
- work and labor-related songs and chants; and
- khuumii (diaphonic singing): whistling, clicking of the lips and palate, and other non-vocal musical forms created with the mouth and speech organs; etc.

Although the legislation does include physical areas of cultural heritage, the emphasis is on intangible culture. Such physical areas include burial sites, places of particular historical or cultural interest such as shamanistic sites, and places of particular natural beauty.

As part of the AATA baseline study in July of 2008, 13 archaeological sites were recorded within and near the Project area. Detailed records of these sites are provided in **Attachment 2** of **Appendix E**. Effort will be made to minimize or eliminate any potential impacts to these archaeological sites. Should the Project disturb these areas, the appropriate regulators and/or institutes will be contacted in order to implement mitigation measures in accordance with local and national regulations.