

APPROVED.

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BOROO GOLD LLC
“HEAP LEACH PROJECT” DETAILED ENVIRONMENTAL
IMPACT ASSESSMENT ADDENDUM

Executed company;

“ GLOBAL ENVIRON “ LLC, Executive Director;Davaasuren.Ch /signed and stamped/

Project Proponent;

“BOROO GOLD “ LLC, President and Executive Director;John Kazakoff /signed and stamped/

CHAPTER ONE. BACKGROUND

The main purpose of detailed environmental impact assessment is to define and assess potential social, environmental and health impacts of a specific project implemented by a citizen or an entity in a certain area, and to define measures to prevent from and mitigate the impacts.

Within the framework of a detailed environmental impact assessment of Heap leach project implemented at Boroo mine site of Boroo Gold LLC, our specialists conducted assessment of prevention and mitigation measures taken on potential social, environmental and health impacts. Moreover, they have worked with aim to define further potential impacts, ways of impact mitigation, as well as provided professional and methodical recommendations to project implementors on environment and landscaping.

TETRE TECH company of Colorado (USA), MOORE WATSON company of Scotland (Great Britain) and "Gan kharsh" LLC (Mongolia) have been conducted the construction design of the project in 2008 that has been approved by state expertise and the construction has been handed over to the State commission. The Mining Institute of the University of Science and Technology developed the Feasibility Study Report of the project that has been approved by specialized committee of Mineral resources in April, 2009. The mine was approved with an act of State commission.

On December 14 2013, Addendum for Feasibility study report of Boroo gold open-pit mine operation and heap leach project situated within Bayangol and Mandal soums of Selenge aimag prepared by Mining Institute has been discussed and approved by Mineral resources specialized committee of MRAM.

The purpose of the project is to recover 4407 kg of gold through processing 9.8 tons of low-grade ore with heap leaching method, as processing low-grade ore through Boroo Gold processing plant is economically insufficient.

Research on processing Boroo mine low-grade ore by heap leaching method started from 2005. Samples were sent to Australia and the USA for roll and column tests; moreover, pilot test has been started at Boroo mine site. Due to satisfactory results of the tests, separate low-grade ore stockpiles have been created from the end of 2005. Heap leach facility construction work has been conducted in 2007-2008. Permission for pilot heap leach ore processing has been granted in April 2008, and the pilot operation has been commenced in June 2008 and completed in May 2009. The main purpose of heap leach pilot operation was to define whether recovery can reach the planned amount and to ensure that production can go on regular basis, especially in winter time. Despite the pilot operation brought good results, heap leach stockpile and gold bearing cyanide solution have been rinsed with clear water due to delay of issuance of permission to use the technology. These measures have been taken in order to protect the environment, as well as to sustain further normal operation preventing pipeline damages and freezing.

In order to perform a detailed environmental impact assessment in accordance with appendix 2 of order A-11 "Environmental impact assessment guidelines" issued by Minister of Environment and Green Development on January 2014, project documents and specifics, feasibility study report,

design parameters and layouts of the project has been studied in detail. Topographic map of the project area and its vicinity, air and satellite images has been prepared in accordance with general environmental impact assessment summary; moreover, location of the project, project implementation area and other objects are shown on above mentioned maps and images. Scope and features of Boroo mine heap leach techniques and technology, economic efficiency and primary and supporting activities have been defined. Moreover, environmental analysis has been conducted and main and potential impacts have been defined.

Vital part of the environmental impact assessment is to define environmental components under impact of project activities, as well as to define potential impacts on local residents, their social status, cultural and historical heritage and ecosystem components, introduce the project and the detailed environmental impact assessment to Citizens' Representatives' Meeting of Bag and plan project operation by integrating it with feedbacks of local authority and residents.

Main impacts caused by project operation include 33 ha area disturbed during development of heap leach pad, dust generated from use of heavy duty equipment at heap leach, content of cyanide and other chemical substances that may evaporate in air or infiltrate into soil from the heap leach stockpile, pollution of soil and vegetation caused by leakage of oil products and lubricants, noise pollution and fire caused by careless action.

Details for estimation of dust impact caused by project operation are included in chapter 4, and mitigation measures are included in chapters 5 and 7.

In order to perform detailed environmental impact assessment, meeting has been held with local authority, soum and bag governors, the chairman of the Bag's citizens' representatives together with the project implementer and the project has been discussed with Bag's citizens' representatives hural in accordance with the order of ensuring public participation in environmental impact assessment.

Davaasuren.Ch, a senior teacher of Physics from University of Science and Technology's Applied Science School, Dr. Dorjgotov, a chemist, a senior teacher from University of Science and Technology, Munkhbat.G, a soil scientist, Tungalag.J, a botanist, a teacher from National University of Mongolia (NUM) and Jargalsaikhan, a zoologist, a teacher from NUM are participated in detailed environmental impact assessment conducting fieldwork studies, measurement and sampling and defined environmental baseline condition and prepared the environmental impact assessment report.

CHAPTER II. SCOPE OF OPERATION

Below are environmental legislative documents related with actions reflected in DEIA and Heap leach project activities of Boroo Gold LLC implemented within the Bayangol soum territory of Selenge aimag.

Following legislation and regulations should be followed.

2.1. LAWS OF MONGOLIA

Law on Environmental protection, 1995

Article 1. Purpose of this law

The purpose of this law is to regulate relations between the State, citizens, business entities and organizations in order to guarantee the human right to live in a healthy and safe environment, an ecologically balanced social and economic development, the protection of the environment for present and future generations, the proper use of natural resources and the restoration of available resources.

Articles and provisions related to project activities	Background
CHAPTER TWO.	
ENVIRONMENTAL ASSESSMENTS, DATABANKS AND RESEARCH	
Article 7. Environmental assessments	
<p>1. Natural resource assessments and environmental impact assessments shall be conducted in order to preserve the natural state of the environment, to develop and carry out activities aimed at sustaining environmental balance, and to regulate the use of natural resources.</p>	
Article 9. Environmental impact assessments	
<p>1. <i>(This paragraph has been annulled by the law of January 22 1998)</i></p>	Within the framework of entire project
<p>2. Issues related with environmental impact assessment shall be regulated by law. <i>(This paragraph has been amended by law of January 22 1998)</i></p>	
<p>3. The body requesting the assessment shall meet the costs of it.</p>	
<p>4. Citizens, business entities and organizations implementing proposals, shall comply with the requirements determined by the impact assessment. <i>(This paragraph was amended by the Law of January 22 1998)</i></p>	
Article 10¹. Environmental auditing	
<p>1. Environmental auditing shall be conducted by business entity and organization engaged in industry and services using natural resources once in two years, conclusion and recommendations shall be issued and the report shall be sent to aimag and city environmental agency within the period</p>	

indicated in recommendation.

2. Business entity and organization is in charge of costs of planned environmental auditing; however, if Governor or state central administration body in charge of environmental issues consider that unplanned auditing is required, costs shall be paid by the requester.

Article 4. Environmental protection

4.2.1. to comply with environmental protection legislation

Article 31 Duties of business entities and organizations

Business entities and organizations shall have the following duties in respect of environmental protection:

- 1) to comply with environmental legislation, decisions by the Government, local self-governing organizations and Governors, and the requirements of State inspectors and rangers;
- 2) to comply with environmental standards, limits, legislation and procedures approved by authorized organizations and to supervise their implementation within their internal organization;
- 3) to keep records on toxic substances, adverse impacts and wastes discharged into the environment while engaged in production or services and to write reports and collect data on the measures taken to reduce or eliminate toxic chemicals, adverse impacts and wastes, as well as on any monitoring equipment and its operation and to submit these to the relevant organization on time;
- 4) if engaged in environmentally adverse production and services, to include and implement in their annual budget the amounts necessary to restore soil erosion, purify polluted soil and water, and reintroduce plants and animals;
- 5) in accordance with contracts and punctually, to reforest, cultivate plants, breed animals, improve water sources, maintain land, and obtain approval of Soum and Duureg Governors;
- 6) to keep the ecological passport of the area in accordance with procedures approved by the central State administrative body.

Article 32. Participation of non-Governmental organizations in environmental protection

1. Non-Governmental organizations whose purpose is the protection of the environment and its natural resources may conduct the following environmental protection activities:

- 1) to conduct public supervision and inspection of implementation of environmental protection legislation, to demand the rectification of breaches and to submit matters to authorized organizations for decision;
- 2) to submit proposals on environmental protection to the central State administrative body and relevant Hural and Governors;
- 3) to organize ecological training and education independently or in cooperation with other concerned organizations;
- 4) to develop proposals, recommendations, and methodologies for environmental protection and restoration and submit them to the relevant organization for decision.

2. The Government of Mongolia may delegate special functions of the State executive body for environmental protection by way of contract to non-Governmental organizations whose purpose is environmental protection and shall fund their implementation.

Law on Environmental impact assessment

Article 1. Purpose of this law

The purpose of this Law is to implement paragraph 2 of Article 16 of Constitution of Mongolia, to protect the environment, prevent ecological imbalance, ensure minimal adverse impacts on the environment from the use of natural resources, and regulate relations that may arise in connection with the assessment of environmental impacts of and approval decisions on regional and sectorial policies, development programs and plans and projects.

Articles and provisions related to project activities	Background
<p>Article 9. Environmental Management Plan</p> <p>9.8 The entity that has performed the general environmental impact assessment shall receive the project implementer’s report on the implementation of the environmental management plan within twelve months from the start of the year as well as approving the next year’s plan and associated budget.</p> <p>9.9 The project implementer other than those specified in article 9.10 of the law shall deposit, as a guarantee, a sum in the amount of no less than 50 percent of the total budget of the annual environmental protection management plan in the designated account opened by the local soum or district governor’s office for centralizing local environmental protection and restoration funds and shall annually report on the implementation of the plan.</p> <p>9.12 Local rangers, state environmental inspectors, governors of all levels, the relevant state central administrative organization and non-governmental organizations shall monitor the implementation of the environmental management plan and the mine closure management plan.</p> <p>9.13 If necessary, the entity that has performed the general environmental impact assessment may require that an independent review be commissioned at the expense of the project implementer to review the project’s performance in the implementation of environmental management plan and restoration measures and based on the findings of the monitoring referred to in Article 9.12.</p> <p>Article 14. Obligations of the project implementer</p> <p>14.1 The organizations proposing a program and plan that is subject to a strategic assessment and all project implementers shall have the following obligations:</p> <p>14.1.1 To furnish documents for the strategic assessment and environmental impact assessment of the proposed project, as may required by authorized agencies and officials;</p> <p>14.1.2 To report, within the established deadline, the implementation status of the environmental management plan to the local community, local authority, affected parties and the relevant state central organization;</p>	<p>During the DEIA report and its implementation process</p>

14.1.3 Petroleum and mining projects shall be required to submit, at least three years prior to the project or activity closure, a restoration plan and closure plan to the state central administrative organization in charge of nature and environment after having duly incorporated the comments of the state central administrative organization for the sector.

Article 18. Public participation in the process of environmental impact assessments

18.1 The state central administrative organization in charge of nature and environment shall make public via its website information regarding the development programs and plans that are subject to a strategic assessment and the projects that have undergone an environmental impact assessment.

18.2 Public comments may be invited during the process of strategic assessments of national and regional policies that the government plans to adopt and development programs and plans to be implemented.

18.3 The members of public may comment in writing and verbally and shall do so within not more than 30 working days.

18.4 It is the responsibility of the legal entity performing the detailed environmental impact assessment to organize, at the report preparation stage, consultations with and formally seek comments from the local authority, the community that is likely to be affected by the project and local residents living in the area where the proposed project is going to be implemented.

18.5 Public participation may be regulated by a procedure which shall be approved the Minister of Nature and Environment.

Article 20 Compensation for damages

20.1 Damages to the environment from projects implemented without an environmental impact assessment or non-compliance with the requirements of the environmental impact assessment shall be estimated in accordance with the methods approved by the state central administrative organization and the losses compensated by the guilty party.

20.2 Damages to the environment from an improper conduct of a detailed environmental impact assessment shall be compensated by the licensed entity performing the assessment.

Law on water 2012

Article 1. Purpose of this law

The purpose of the present law is to regulate the protection, effective use and restoration of water and its basin.

Articles and provisions related to project activities	Background
<p>24.1. It is prohibited to litter, store radioactive and toxic chemical substances, pathogen of infectious diseases and to wash vehicles and dirty things in the area of water basin.</p> <p>24.2. Basin administration shall issue permission to those engaged in waste water removers that waste water, exceeding 500m³ per day or waste water containing contaminative substances, specified in 10.1.12 of the present law and the governors of soum and district shall issue permission to those waste water removers that waste water per day not exceeding 50 m³.</p> <p>24.3. If the water contaminator has to throw the waste water without treatment because of accident then he will immediately inform the basin administration and governors of all levels and shall bear all expenses concerning the mitigation of contamination and rehabilitation of environment.</p> <p>24.4. Water user citizens, economic entities and organizations have to furnish their domestic waste water removal points with water separator in accordance to procedure defined by the Cabinet member in charge of health and environment.</p> <p>24.5. Permission for removal of waste water shall be registered in water database.</p> <p>24.6. Removal of waste water exceeding the norms, specified in the permission or removal of waste water, exceeding the standard repeatedly shall become the justification for cancellation of right to use water.</p> <p>24.7. Sample of the permission for waste water removal, set out in 24.2 of the present law shall be approved by the state administrative central organizations of environment, and city and dwelling water supply, sewage treatment authorities.</p>	<p style="text-align: center;">For exploitation of abyssal wells during the project activities</p>
<p>Article 25. Payment and compensation for water pollution and depletion</p> <p>25.1. Water contaminator shall be responsible to supervise the volume and composition of waste water and to remove the waste water after meeting the standard requirement and to be liable to pay water contamination fee.</p> <p>25.2. Environment inspector shall impose water pollution compensation on the basis of the conclusion of the professional institution in case of the water contaminator removes waste water not meeting standard requirement and the inspector shall oversee the settlement of payment and compensation for water pollution could be increased by three times for each of polluting substances on the basis of ecology-economic evaluation.</p>	

25.3. Water pollution compensation shall be paid to environment protection fund by citizens, economic entities and organizations.

25.4. Citizens, economic entities and organizations shall be liable to pay fee for water depletion according to size of building, asphalt road in their possession and utilization in cities and dwellings.

25.5. Water pollution and water depletion fee shall be determined by law.

25.6. Settlement of compensation, set out in 25.2 of the present law by the guilty legal person shall not be ground for excuse to face criminal or administrative liability in accordance to the relevant legislations.

Article 26. Purpose and type of water utilization

26.1. Citizens, economic entities, organizations, foreign legal person shall exercise the right to use water for concert purpose and period on the basis of water use permission and contract in conformity with legislations.

26.2. Citizens, economic entities and organizations shall be classified as follows in accordance to water use and purpose of utilization:

26.2.1. water user

26.2.2. water consumer

Article 27. Permission to be issued to water user

27.1. Aimag, capital city environment author shall issue permission to water user for drilling holes and wells, and digging channel and canal on the basis of volume and quality of the water.

27.2. Water user shall submit an application for obtaining permission to aimag, capital city environment authority which shall include the following information:

27.2.1. Purpose and volume of water use;

27.2.2. Copy of the title for land ownership, possession and use;

27.2.3. Information regarding the wells.

27.3. Aimag, capital city environment authority shall register the wells and holes of the water use in the water database and issue wells passport.

27.4. It is prohibited to change the purpose of use, to drill holes and wells and digging channels and canals without permission.

Article 28. Permission to be issued to water user

28.1. Citizens, economic entities and organizations shall submit their request for use of water to legal person, specified in 28.4 of the present law.

28.8. Water use permission for citizens, economic entities and organizations shall be granted for 10 years and the right to use water shall be prolonged for another 5 subsequent years if the water user fulfills its contract obligation satisfactorily.

28.10. Land title of citizens, economic entities and organization shall not represent the right to use water in the land of their procession.

28.11. With the issuance of title for water use, on the basis of permission, specified in 28.6 of the present law and the conclusion of contract, the right to use water shall enter into force for citizens, economic entities and organizations.

28.12. Citizens, economic entities and organizations may use water resource jointly on the basis of contract.

28.14. Water resource determined by the economic entity by its own capital and its guaranteed quantity of usable water resource is to ensure the profitable performance during the period of the implementation of the project of relevant entity then no water use right shall be issued overlapping that particular water resource to other entity.

28.18. It is prohibited to use water without conclusion on water use and relevant permission and arbitrarily digging holes.

28.19. It is prohibited to bring out conclusion on water use for industries and services with technology of negative impact on environment.

Article 29. Conclusion and termination of contract on water use

29.1. Contract shall be concluded with the centralized water supply resource water user by the water supplying organization and with those water users of non-centralized water supply by basin administration, aimag and capital city environment authority and governors of soum and districts.

29.2. The following shall be included in the water utilization contract:

29.2.1. decision on water use;

29.2.2. purpose of the use of water, quantity of per day use, water quality and composition;

29.2.3. location of water resource, design and project of water facilities;

29.2.4. quantity of waste water, standard requirement, removal point, location, permission for removal of waste water;

29.2.5. unit price of water use;

29.2.6. amount of payment per unit polluting substance contained in waste water;

29.2.7. measures to be taken to protect water resource and prevent water depletion and pollution and amount of capital to be spent for these purposes;

29.2.8. rights and obligations of contract parties;

29.2.9. other required materials.

29.3. Contract concluded with citizens, economic entities and organizations may be terminated before its expiry by the initiative of the permission issuer under the following circumstances:

29.3.1. failure to fulfill duty and contract obligation by the water user;

29.3.2. violation of provisions of environment protection and water legislations;

29.3.3. failure to settle payment for water use and pollution in due time;

29.3.4. polluting the water resource;

29.3.5. no installation of water meter and adjustment equipment or false calculation of used water;

29.3.6. by the decision of the basin administration.

Article 30. Duty of water users and requirements to meet

30.1. Water user shall have the following duties:

30.1.1. to use water according to the amount specified in water use permission and contract;

30.1.2. in accordance to 31.7 of the Environment protection law, the water user of over 50 m³ water per day shall have internal control point, equipments and instruments and to employ water utilization manager in charge of water consumption;

30.1.3. to obtain permission for removal of waste water, to purify polluted water, generated during the process of utilization, up to the requirement of standard and to circulate to centralized sewage network or remove directly;

30.1.4. to install meter at water distribution points, underground water holes and pipes;

30.1.5. to settle payments for water and mineral water consumption;

30.2.2. to construct and use treatment facility for waste water and mineral water, generated in the process of utilization or to remove directly;

30.3. Waste water treatment facilities of industries, economic entities and organizations, engaged in production using radioactive substance shall be equipped with special technology capable for complete purification;

30.4. Industrial purpose water resource and pipes shall be separated from water resource and pipes of centralized drinking and domestic water supply in cities and dwellings;

Article 31. Water use Fees

31.1. An individual, economic entity or an organization, using water and mineral waters shall be subject to a fee.

31.2. Fee for water exceeding the permitted quantity shall be calculated by escalated rate up to 50 percent and the procedure for escalated rate estimation will be developed by the state administrative central organizations in charge of nature, environment and approved by the Government.

31.3. Fees for water use shall be set by law.

Article 33. Liabilities for Violations of the Legislation on Water

33.1. A judge or an inspector for environmental protection shall charge violators of the legislations on water with the following administrative punishments, with reimbursement of damage to nature, if the violation is not of criminal nature:

33.1.5. Violation of 17.1.9 of the present law: a fine for officials shall be fifteen to twenty five times of monthly minimum wage and reimbursement of damage caused;

33.1.6. Violation of 22.2.1 of the present law: a fine for individuals shall be twenty to forty times of monthly minimum wage, for entities and organizations shall be forty to fifty times of monthly minimum wage and reimbursement of damage caused;

33.1.7. Violation of 22.6, 22.15 of the present law: a fine for individuals shall be twenty five to forty times of monthly minimum wage, for entities and organizations shall be thirty to fifty times of monthly minimum wage and reimbursement of damage caused;

33.1.8. Violation of 22.11, 22.12, 22.13 of the present law: a fine for individuals shall be ten to twenty times of monthly minimum wage, for entities and organizations shall be thirty to fifty times of monthly minimum wage and reimbursement of damage caused;

33.1.9. Violation of 22.8, 22.17, 24.1, 24.4, 27.4, 28.18, 30.3, 30.5, 30.6 of the present law: a fine for individuals shall be five to ten times of monthly minimum wage, for entities and organizations shall be twenty to fifty times of monthly minimum wage and reimbursement of damage caused;

33.1.10. Violation of Article 30 of the present law, regarding the failure to fulfill the obligation and requirement: a fine for individuals shall be ten to twenty times of monthly minimum wage, for entities and organizations shall be forty to fifty times of monthly minimum wage and reimbursement of damage caused;

33.1.11. Violation of 28.7, 28.19 of the present law: a fine for officials shall be twenty to forty times of monthly minimum wage, for entities and organizations shall be forty to fifty times of monthly minimum wage;

33.1.12. A fine for officials shall be five to fifteen times of monthly minimum wage for failure to timely deliver registration and accurate statement and information of water use and waste water;

33.1.13. In case of the use of water for different purpose rather than specified in the contract or use of water without permission, or hushing up the excessive use water than specified in the contract or evading to pay for excessive amount of water used, a fine for violation shall be for individuals ten to twenty times of monthly minimum wage, for entities and organizations twenty to forty times of monthly minimum wage and with confiscation of illegally accumulated income and termination of the right to use water;

33.1.14. Failure to pay water use and water pollution fee in due time, a fine shall be for water user twenty to thirty times of monthly minimum wage;

33.1.15. A fine for water user who sold or transferred water use permission to others shall be fifteen to thirty times of monthly minimum wage;

33.1.16. In case of non-compliance with the obligation of water and mineral water use, to terminate or suspend the right to use water until the breach is eliminated and the measures of termination, limit or cease of water use right shall not remit the guilty person from other legal liabilities.

Law on natural reserve usage fees 2012

Article 1. The purpose of the law

1.1 The purpose of this law is to regulate matters pertaining to the imposition of natural reserve usage fees on citizens, business entities and organizations, incorporation of them into the budget, reporting thereon, and the determination of the percentage and amount of the funds to be spent from the proceeds of natural reserve usage fees for the environmental protection and natural reserve restoration measures.

Articles and provisions related to project activities	Background
<p>Article 6. Items subject to water and mineral water reserve usage fee imposition</p> <p>6.1 Fees shall be imposed for using water, mineral water and the surrounding area thereof for the following purposes;</p> <p>6.1.1 Water used for the population’s drinking and household purposes as well as manufacturing and service purposes;</p> <p>6.1.2 Water used for mining industrial purposes;</p> <p>13.3 A percentage and amount of parts of proceeds from fees for mineral reserve usage and environmental contamination and pollution to be spent for environmental protection and natural reserve restoration measures shall be regulated pursuant to the relevant legislation</p> <p>Article 15. The percentage and amount of water and mineral water usage fees</p> <p>7. Per cubic metre of water used for mining industry</p> <p>/ Minimum rate of underground water usage shall be 20% of ecologic and economic value and maximum shall be 60% (1 m³ – 794 tugrik, minimum)</p> <p>Article 20. Exemption from and discount of water reserve usage fees</p> <p>20.1 Fee payers who used water for the following purposes shall be exempt from fees:</p> <p>20.1.3 reused water for manufacturing technological needs</p>	<p>Pursuant to contract conducted with authorized organization</p>

Law on air 2012

Article 1. Purpose of this Law

The purpose of this law is to regulate the actions related to the protection of ambient air, prevention from air pollution, and reduction and monitoring of emissions of air pollutants.

Articles and provisions related to project activities	Background
<p>Article 9. Rights and obligations of economic entities, organizations, and</p>	<p>Air polluters</p>

individuals

used in mill operation

9.1. Economic entities, organizations, and individuals have the following rights and obligations:

9.1.1. Comply with the legislation on air and requirements and decisions for self-governing and public organizations, governors and state inspectors;

9.1.2. Comply with the air protection regulations, procedures, and standards and limit the emission of air pollutants;

9.1.3. Equip facilities with controlling and measuring devices when running a major production and service stationary facilities that emit air pollutants;

9.1.4. Economic entities and organizations shall run their internal monitoring in accordance with their environmental monitoring action plans as contained in their detailed environmental impact assessment reports;

9.1.5. Economic entities and organizations shall present their internal monitoring and other relevant reports on air pollution sources to respective local branches of the professional/specialized agency as stated in clause 12.5 of this Law;

9.1.6. Obtain the necessary assistance and advice with regard to air protection from the professional agency;

9.1.7. Comply with the legislation on air pollution reduction;

9.1.8. Not use or burn raw coal and other air polluting materials in the air quality improvement zones;

9.1.9. Use techniques and technologies addressed at air pollution reduction including liquefied petroleum fuels and other cleaner fuel sources;

9.1.10. Individuals, economic entities, and organizations may demand, inform, and complain, and notify the respective institutions if air pollution caused by businesses and service operations has become a concern and has shown adverse impact on human health;

9.1.11. Exercise other powers defined in the law;

Article 13. Actions to reduce air pollution and their main principles

13.2.3. Ensure the implementation of actions and measures for air pollution reduction through joint efforts of the public, economic entities, organizations, and individuals;

Article 21 Air protection requirements during construction, production, and services

21.1. Standards for permissible limits on air polluting substances and negative physical impacts shall serve as the basis for selection of a site, design and construction, start of operations, expansion or renovation of equipment and technology for any building for industrial, service or other purposes.

21.2. An environmental impact assessment shall be done prior to the construction of an economic entity or organization engaged in activities which result in the discharge of air polluting substances.

21.5. Introduction and use of non-standard techniques, technologies, materials, substances, products, equipment and devices in terms of air protection shall be prohibited.

Article 31. Liabilities for Violation of the Legislation on Air

31.1.3. To use facilities and equipment and introduce techniques and technologies that do not meet air protection requirements, citizens shall be subject to a fine of 4-5 times the adjusted amount of the minimum monthly salary rate and economic entities and organizations shall be subject to a fine of 8-9 times the adjusted amount of the minimum monthly salary rate;

31.1.4. For exceeding limits and breaching the requirements and terms stated in a permit on air polluting substances and negative physical impacts, or failure to follow procedures for the use of instruments, equipment, and technology to reduce, clean or control air polluting substances and negative physical impacts, citizens, shall be subject to a fine of 3-5 times the increased amounts of the minimum monthly salary rate and economic entities and organizations shall be a subject to a fine of 6-8 times the adjusted amount of the minimum monthly salary rate;

31.1.5. For air pollution and negative physical impacts on residential areas and human health caused by stationary sources or running production and services by using stationary sources emitting air pollution and negative physical impacts without a permit from an authorized organization, or illegal industrial use of air by packing it, the illegal income shall be confiscated and a fine equal to the amount of the illegal income shall be applied.

31.2. Officials, who fail or inadequately fulfill their legal powers and obligations specified in the legislation on air protection, shall be subject to sanctions stated in the Mongolian Law on Public Service.

31.3. Offenders, who pollute the air and cause serious impact on the environment and human health through infringement of this Law, shall be subject to sanctions as defined in the Criminal Law or compensation of all the damages incurred.

Law on air pollution fee 2010

Article 1. Purpose of the law

The purpose of this law is to regulate actions related with imposition and payment of fee by a party responsible for air pollution.

Articles and provisions related to project activities	Background
<p>Article 7. Rates of fees</p> <p>7.3. 7.3. Fees payable for CO2 emissions from vehicles shall be set at the following rates subject to vehicle types:</p>	<p>Vehicle used for mill operation</p>

Vehicle type	CO2 emissions (g/km)	Annual fee /MNT/
	121-180	1800
	181-250	2100
	251-350	3500
	351-500	5000
	501-750	7500
	Above 751	9500

7.4. Rates of fees payable for air pollutants generated by waste from large fixed sources of air pollution shall be set by the government within the limits of MNT 1-10 per kg.

Law on waste 2012

Article 1. Purpose of this law

The purpose of this Law is to regulate relations related to mitigation, collection, transportation, storage, and landfill of household and industrial waste and re-using of waste as source of raw materials to prevent from and eliminate hazardous impact of household and industrial wastes on public health and environment.

Articles and provisions related to project activities	Background
<p>Article 9. Common Rights and Responsibilities of Individuals, Business Entities and Organizations</p> <p>9.1 Individuals shall have following rights and responsibilities;</p> <p>9.1.1 exercise public control pursuant to the procedure prescribed by this law and demand relevant authorities to impose liability on persons who breach legislation on waste;</p> <p>9.1.2 report to the state and local administrative bodies the produced hazardous waste and its sources;</p> <p>9.1.3 not to dispose waste in places other than designated waste disposal sites;</p> <p>9.1.4 sort and dispose the produced waste at temporary waste storage sites;</p> <p>9.1.5 clean litter around the living area, participate in public clean-up activity</p> <p>9.1.6 not to burn waste in open area</p> <p>9.1.7 dispose hazardous material at centralized hazardous waste facility or</p>	<p>In storage and disposal of industrial and household waste</p>

dispose at designated site

9.1.8 other rights and responsibilities as provided in law

9.2 Business entities and organizations shall have the following rights and responsibilities:

9.2.1 receive technical assistance and advice on waste management from specialized institutions

9.2.2 introduce waste recycling technologies

9.2.3 classify waste depending on the type of own production or services and discharge the sorted waste at designated temporary waste storage sites; correctly report to the state and local administrative bodies the industrial waste generated from their activities;

9.2.4 observe relevant rules, procedures and standards on waste;

9.2.5 provide relevant knowledge to their staff on waste sorting and comply with safety standards in their operation;

9.2.6 enter into contracts with individuals, business entities and organizations holding permit for collection and transportation of waste and ensure the performance of contractual obligations

9.2.7 not to transport hazardous waste with other type of waste

9.2.8 put waste in specified container and dispose at designated site

9.2.9 not to burn waste in open area

9.2.10 dispose hazardous material at centralized hazardous waste facility or dispose at designated site, and

9.2.11 such other rights and responsibilities as provided in law.

9.3 Individuals, business entities and organizations shall be obliged to participate in the public waste cleaning activities.

9.4 Individuals, business entities and organizations when constructing, dismantling or repairing buildings in their ownership or possession, shall in advance enter into agreements for collection and transportation of waste and pay relevant fees transfer the waste to be produced to individuals, business entities or organizations holding permit for collection, transportation and land-filling of waste.

Article 11. Waste Disposal

11.1 Individuals, business entities and organizations residing in cities, villages and other urban areas shall dispose their waste in the following procedures:

11.1.1 residents living in apartments with special waste disposal facility shall dispose their waste in such facility;

11.1.2 individuals living in ger districts and housing without special waste disposal facility and business entities and organizations other than those specified in 11.3 of this law shall dispose their waste in temporary waste disposal sites defined by soum or district governors at specified times.

Article 20. Fees for Producing Waste

20.1 Business entities, organizations and individuals shall pay fees for producing waste.

20.2 Revenue from waste fees shall be accumulated in the waste service fund of the Capital city and soums.

Article 21. Promotion

21.1. Citizens, business entities and organizations engaged in activities to reduce, collect, transport, store, recycle, re-use and dispose waste and who introduced waste-free technology shall be disseminated and granted with incentives.

Article 23. Liabilities for Violation of the Legislation

23.1.1. For disposing waste in non-designated places a fine of monthly minimum wage on an individual and monthly minimum wage multiplied by 3-4 times on a business entity with compensation of the damage caused;

23.1.2. For breach of 24.1 of this Law, a fine of monthly minimum wage multiplied 2 times on an individual and monthly minimum wage multiplied by 3-4 times on a business entity;

23.1.3. For breach of 9.1.6 and 9.2.9 of this Law, a fine of monthly minimum wage on an individual monthly minimum wage multiplied by 3-4 times on a business entity;

Article 24. Reprise the harm

24.1. Losses caused to human health, environment, livestock, animals and property shall be remedied by an offender who caused loss due unlawful action which infringes laws and legislation on waste

24.2. The state central administrative body in charge of specialized inspection issues shall terminate operation of waste facilities and cause remedy of losses by offenders provided that location of waste facility is not included in the urban development and land management plans, technologies and activities to dispose waste causes adverse impact on human health, environment or do not meet requirements specified in the respective laws and legislations.

Law on labor safety and hygiene 2008

Article 1. Purpose of law

The purpose of this law is to define state policy and basic principles on labor safety and hygiene and to regulate the relations with respect to maintain safety and hygiene requirements and standards of management of state organizations, inspection structure and work place, develop the condition for the citizen for working in healthy and safe environment.

Articles and provisions related to project activities	Background
<p>Article 7. Requirements on industrial buildings and facilities</p> <p>7.1. Activities, such as to build and extend industrial buildings and facilities, installing machinery and equipments, doing maintenance, are shall meet labour safety and hygiene requirements.</p> <p>Article 9. Requirements on machinery and equipments</p> <p>9.1. Following requirements shall be maintained for machinery and equipments that are purposed for industrial use and that may harm human health:</p> <p>9.1.1. structure, model, moveable parts, controlling, alarm system and other parts (labour facility, exits, steps, barrier and protective equipments etc) of machinery and equipments shall be met safety requirements;</p> <p>9.1.2. shall have operation and safety instruction, technical documentation to operate and service machinery and equipments;</p> <p>9.1.3 shall get it controlled by professional organization and get certificate, before using machinery and equipments after installation and maintenance;</p> <p>9.1.4 Make servicing, maintenance and adjucement to the machinery and equipments within the period indicated in technical documentation.</p> <p>9.2. Shall have transferred the machinery and equipments to others together with technical documentation and certificate.</p> <p>9.3. Electrical equipments shall be equipped with control, alarm, cover and barrier in order to prevent from possible hazards.</p> <p>9.4. Electrical equipments shall be installed as indicated in drawings, equipped with groundings and the grounding capacity is approved by the professional organization to meet power safety requirements.</p> <p>9.5. It is prohibited to use machinery and equipments that doesn't meet the requirements indicated in articles 9.1-9.4.</p> <p>Article 10. Requirements on lifting, carrying and transporting mechanisms</p> <p>10.1. Entire technical completeness of the lifting, carrying and transporting mechanisms shall be maintained.</p> <p>10.2. Technical inspection to the lifting, carrying and transporting mechanism shall be made by professional organization and the permission to use is obtained.</p> <p>10.3. Service, maintenance and adjustments shall be done as indicated in technical documentation and within the period set by authorities.</p> <p>Article 11. Requirements on pressure containers and pipelines</p> <p>11.1. Pressure containers and pipelines shall meet following requirements:</p> <p>11.1.1. pressure containers and pipelines shall be adjusted and certified according to relevant regulation and technical integrity is maintained and user</p>	<p>During mill operation</p>

license obtained;

11.1.2. shall have usage procedure for safe usage and storing for long period of time;

11.1.3. Shall be equipped with proper signs, alarm system and protective equipments.

Article 12. Requirements on handling with toxic and hazardous substances, blasting elements and equipment, radio and bio active substances

12.1. Employer shall take activities to protect and prevent employee’s life and health from toxic and hazardous substances, blasting elements and equipment, radio and bio active substances and its influences.

12.2. Employer shall keep records about usage of toxic and hazardous substances, blasting elements and equipment, radio and bio active substances in the course of operation and inform labour control and other relevant professional organization as indicated in regulation approved by relevant authority.

12.3. An employee who handles with toxic and hazardous substances, blasting elements and equipment, radio and bio active substances shall have the knowledge about substance handling and its influences.

Article 13. Requirements on fire safety

13.1. An element indicated in article 4.1 of this law shall have the right to prevent fire hazard and maintain regulation, procedure and standard on fire extinguishing.

13.2. Fire alarm, fire fighting set and fire escape map shall be illustrated in every work place where fire hazard is essential and employee who works in that facilities shall have the knowledge how to use these equipments.

Article 14. Medical check

14.1. Employer shall include employee in pre-employment and scheduled medical check in accordance with regulation approved by state authority in charge of health issues.

Article 15. Supply employee with special work uniform and personal protective equipments

15.1. Employer shall provide employee with special uniform and PPE in accordance to employee work place and work condition, without any charge

Article 17. Requirements on labour safety and hygiene professional training

17.1. A labourer, an employee and an employer shall attend in short term labour safety and hygiene trainings, that is approved by state authority in charge of labour issues and gained knowledge and practice on it.

Article 18. Rights and responsibilities of citizen and employee

18.2.1. to strictly obey labour safety and hygiene requirements, standard, regulation and technological procedure;

18.2.8. to follow requirements on labour safety and hygiene that is required by employer.

Article 27. Committee and officer in charge of labour safety and hygiene of business entities and hygiene

27.1. Director /owner/ or employer of business entities and organizations shall be directly responsible for maintaining labour safety, strengthening of labour condition, implementation of legislation and controlling.

27.3. Employer shall employ trained and experienced personnel as labour safety and hygiene officer and the officer shall work under direct supervision of employer and fully responsible for his/her duties.

Article 28. Employer’s right and responsibilities on labour safety and hygiene

28.1.2. immediately eliminate the negative and hazardous situation that may harm human life and health that may possibly arise during the course of industrial process;

28.1.4. to make risk assessment in order to eliminate and control possible work place hazard;

28.1.6. to work out regulation, procedure and instruction that fits to work place characteristics and get it implemented;

28.1.11. to keep the numerical record on industrial accident, poisoning and occupational disease and inform relevant organizations;

28.1.13. to activities to eliminate the violations and deficiencies found during the inspections according to authorities written notification and report the implementation back to relevant authorities;

28.1.15. to pay the reimbursement to employees who lost their working abilities because of industrial accident, poisoning and occupational disease according to relevant legislation;

28.1.16. The element indicated in 4.1.2, 4.1.3, 4.1.6 of this law shall maintain safe and healthy working condition to their employees.

Article 29. Activities to take during the occurrence of industrial accident and poisoning

29.1. Employer shall take actions to transport to the hospital, to cover the expenses for necessary medical checks for the employee who suffered from industrial accident and poisoning, to eliminate the hazard within 24 hour after occurrence.

29.8. It is prohibited to employer to hide industrial accident and poisoning.

Article 35. Internal control of business entities and organizations

35.1. Employer shall maintain internal control on fulfillment of activities taken to implement labour safety and hygiene legislations, common requirements and standard and according to result of risk assessment in every work place.

35.2. Employer shall be responsible for elimination of violations found during

the internal control.

35.3. Employee representative and employee can be participated in internal control activities.

Article 36. Responsibilities to be imposed for the violators of labour safety and hygiene legislations

36.1. State inspector on labour control shall fine by 350.000-500.000 tugrugs ,if industrial accident or poisoning occurred because of employers fault.

36.2. Judge and state inspector on labour control shall fine officials by 1.000.000-2.000.000 organization by 1.500.000-3.000.000 tugrugs, if industrial accident poisoning occurred two and over times.

36.3. Judge or state inspector on labour control shall fine officials by 1.000.000-2.000.000 organization by 2.000.000-2.500.000 tugrugs, if to hide industrial accident, occupational disease and poisoning occurrence.

36.4. Both judge and state inspector on labour control shall fine the organization by 200.000-250.000 tugrugs, if does not maintain labour safety and hygiene requirements; by 500.000-1.000.000 tugrugs, if jointly owned industrial building and facilities without following the requirements indicated in article 8 of this law.

36.5. Both judge and state inspector on labour control shall fine the officials by 300.000-6000.000 and the organization by 600.000-750.000 tugrugs, if does not let the state inspection organization to control, make conclusion about the requirements to build and extend industrial building and facilities, to install equipments, pressure container and pipeline and did not take the permission.

36.6. Judge shall fine by 25.000-50.000 tugrugs, if the member of health and labour accreditation commission failed to determine the reason for loss of work ability and disability percentage.

Article 37. To settle a dispute

37.1. The dispute arises between employer and employee about labour safety and hygiene issues shall be settled according to law.

Law in fire safety 1999

Article 1. Purpose of the Law

The purpose of the Law shall be to ensure fire safety, to establish the legal basis of the authority in charge of fire safety monitoring, to define the rights and duties of local administrative bodies, business entities and citizens for ensuring fire safety and to govern relationships connected with the exercise of such rights and duties.

Articles and provisions related to project activities	Background
Article 16. Rights and Duties of Business Entities and Organizations With	International standards for

Respect To Ensuring Fire Safety

mill operation

16.1. Business entities and organizations shall have the following duties with respect to ensuring fire safety.

16.1.1. to strictly abide by the fire safety legislation;

16.1.2. to ensure the given business entity or organization’s fire safety;

16.1.3. to observe the fire prevention and extinguishing regulations, norms and standards;

16.1.4. to obtain permission from the fire fighting authority when building, expanding and changing designs, structures of buildings, or changing or repairing electricity source networks;

16.1.5. to train employees in fire fighting skills, develop and implement steps to enhance their knowledge;

16.1.6. to provide immediate support and assistance in fire extinguishing actions;

16.1.7. to obtain specialized conclusion of the fire fighting authority when placing and using fire extinguishing equipment and primary tools, substances and materials in the course of constructing of new buildings.

6.2. Business entities and organizations shall have the following rights in ensuring fire safety:

16.2.1. to obtain methodological assistance, instructions and advice from the specialized agencies with the purpose to ensure fire safety;

16.2.2. to hire a contract fire extinguishing unit with the purpose to prevent from fires.

Article 17. Contract Fire Fighting Unit

17.1. Business entities, organizations and citizens may hire contract fire units with the purpose to protect their property from danger of fire.

Article 18. General Requirements for Ensuring Fire Safety

18.1. Structure and design of buildings and construction objects shall ensure the safety of the population in the case of possible fire and shall provide possibilities to extinguish fires with minimal damage.

Article 19. Fire Safety Norms and Standards

19.1. Officials and citizens shall be obliged to observe in their activities norms and standards defining fire safety requirements and other technical normatives.

Law on standardization and conformity assessment

Article 1. Purpose of the law

The purpose of the law is to define legal grounds for standardization and conformity assessment and to regulate relations between the government, citizens, business entities and organizations occurred in the implementation process thereof.

Articles and provisions related to project activities	Background
<p>Article 9. Application of standards</p> <p>99.1. Business entities and organizations shall apply upon registration of them with the central Standardization body, international, regional or foreign advanced standards, which are not contradictory to the legislation and the rights of consumers or producers, and which are not harmful to the human health, the environment and the security of nations.</p> <p>9.2. The central standardization body shall provide temporary permissions /up to one year/ to business entities and organizations, which possess a new technology or products, to apply standards, methodologies and instructions other than those specified to be used in Mongolia.</p> <p>9.3. It is prohibited to copy and duplicate the national standards, to apply other standards than those specified in 6.5 and 9.1 and 9.2 article of the present law, and to use abbreviated marks to the product which are not compliant with the requirements.</p> <p>9.4. If the standards specified in Article 6.3 of the present law are referred in government resolutions and technical regulations, they shall serve as mandatory standards.</p>	<p>International standards for mill operation</p>

Law on minerals 2006

Article 1. Purpose of the law

The purpose of this law is to regulate relations within the territory of Mongolia with respect to prospecting, exploration and mining of minerals.

Articles and provisions related to project activities	Background
<p>Article 7. General requirements of a License holder and for conducting mineral exploration and mining operation.</p> <p>7.1 Mineral exploration and mining license shall be granted to a legal person duly formed and operating under the laws of Mongolia and a Mongolian taxpayer.</p> <p>7.2 A license holder shall meet the requirements set forth in Article 7.1 of this law for the entire duration of a valid license.</p> <p>7.3 Conducting exploration or mining without a valid license is prohibited.</p> <p>7.4 One license may be granted to one legal person only.</p> <p>Article 12. Full power of local administrative and self governing</p>	

agencies

12.1 Local administrative and self governing bodies shall implement the following with regard to mineral issues:

12.1.1 ensure implementation of this law and regulations of higher administrative bodies in its respective territories;

12.1.2 permit use of the license area for the purposes set forth in the licenses and halting any violations

12.1.3 monitor compliance by license holders of its obligations with respect to environmental reclamation, health and safety regulations for workers and local residents and payment of its obligations to the treasuries of local administrative bodies;

12.1.4 adopt resolutions on establishing local special purpose territory as set forth in grounds and regulations provided by the Land Law.

12.1.5. 16.1.11-
11.1.23-

Article 27. Rights and obligations of mining license holders

27.1 A mining license holder shall have the following rights and obligations:

27.1.1 the right to engage in mining of minerals other than radioactive mineral within the mining claim as set forth in the provisions of this law;

27.1.3 to fulfill obligations set forth in Chapter 6 of this law;

27.1.4 the right to sell mineral products and minerals other than radioactive minerals extracted from the mining claim at international market prices on foreign markets;

27.1.6 the right to transfer and pledge all or part of the mining License other than of radioactive license as set forth in provisions of this law;

27.1.7 the right to extend the term of the mining license two times for a period of twenty (20) years each depending on the reserve of the mineral;

27.1.8 the right to enter and pass through the mining area, construct necessary structures and use the mining area in order to carry out mining activities;

27.1.8 rights to pass through, build and use required construction and facilities for mine operation purposes;

27.1.11 the right to use land and water in compliance with applicable laws

27.1.12. 27.1.12. To specify clearly in the feasibility study referred to in Article 48.6.1 of this law things such as how products from the given mine will be transported, how the infrastructure will be constructed and what amount of funds will be required for mine reclamation and closure;

27.1.13. To have an employee with duty to update the state central administrative agency in charge of geology and mining regularly on environmental reclamation and mine closure matters

Article 35. General obligations of a license holder

35.1. While carrying out its activities a license holder shall comply with the general obligations set forth in this Article. Failure to comply with the general obligations will subject the license holder to the penalties set forth by Article 66.1.4 of this law.

35.2. An exploration license holder shall keep the following documents at the actual site of the exploration work:

35.2.1. certified copy of the exploration license;

35.2.2 environmental protection plan and report;

35.2.3 exploration work plan reviewed by the State administrative agency and professional inspection agency.

35.3. A mining license holder shall keep the following documents at the mine:

35.3.1. certified copy of the mining license;

35.3.2. feasibility study on mineral mining and a mining plan reviewed by the relevant organization;

35.3.3. environmental impact assessment; 35.3.4. environmental protection plan;

35.3.5. property leases and product sales agreements;

35.3.6. records establishing and marking the boundary of the mining area;

35.3.7. agreements on land and water use.

35.4 A mining license holder shall commence its mining activities after it has been accepted by a commission appointed by the State central administrative agency in charge of geology and mining.

35.5 The mining license holder shall exhaust all the mineral reserves. It is prohibited to mine selecting the high grade areas.

35.6. Mining license-holders and artisanal gold miners shall sell their mined gold within a given fiscal year.

35.7. If the license-holder discovers methane during its coal mining operations, it shall notify the state administrative agency in charge of oil affairs.

35.8. If the license-holder intends to use methane specified in Paragraph 35.6 of this law, it may conduct extraction operations in compliance with the Oil Law.

35.9. When procuring the required goods, work and services and selecting contractors for its operations, the license-holder shall give priority to businesses, which can supply goods, perform work and provide services that meet standard requirements and which are registered and pay taxes in Mongolia.

35.10. If the mining license-holder's operations are stopped due to an industrial accident, technical interruption, an event of force majeure, a court verdict or a state inspector's act, or when the mining license-holder has to stop its mine development and process plant operations for any other

reasons, the license-holder shall notify the state administrative agency in charge of geology and mining affairs.

35.11. Mined, concentrated and semi-processed products shall be supplied on a priority basis to a process plant operating in the territory of Mongolia at market prices.

35.12. A license-holder shall inform the state administrative agency within 14 days if it changes its residential address, e-mail address and telephone and facsimile numbers.

Article 37. Environmental protection

37.1. Exploration and mining license holders shall comply with the laws and legislations on environmental protection and Articles 38 and 39 of this law.

37.2. A license holder may not commence prospecting and exploration operations without first obtaining written approval from relevant environmental agency or commence mining operations without a commission act set forth in Article 35.4 of this law. In case of a dispute arising out of these matters, the complaint may be lodged with the professional inspection agency.

Article 39. Environmental protection obligations of mining license holders

39.1 A mining license holder shall have the following obligations with regard to environmental protection:

39.1.1 an environmental impact assessment and an environmental protection plan shall be prepared by a person set forth in Article 24.1 of this law before obtaining a mining license and by a person who obtained a mining license through tender; 39.1.2 the environmental impact assessment shall identify the possible adverse environmental impacts from the proposed mining operations regarding public health and environment and shall include preventive measures that avoid and minimize such adverse impacts;

39.1.3. the environmental protection plan shall contain measures to ensure that mining operations are conducted in the least damaging way to the environment. The plan shall also identify preventive measures to protect air and water, humans, animals and plants from the adverse effects of mining operations;

39.1.4. apart from Article 39.1.3 of this law, an environmental protection plan must include the following:

39.1.4.1. storage and control of toxic and potentially toxic substances and materials;

39.1.4.2. protection, utilization and conservation of the surface and underground water;

39.1.4.3. construction of tailings dams and ensuring the mine area safety;

39.1.4.4. reclamation measures set forth in Article 38.1.2 of this law;

35.1.4.5. other measures as may be appropriate for the particular type of a mining operation.

39.1.5. The environmental impact assessment and environmental protection

plan shall be submitted to the State central administrative agency in charge of the environment.

39.1.6. Immediately following the approval of the environmental impact assessment and environmental protection plan the license holder shall deliver a copy of the documents to the Governor of the aimag, soum or district and local environmental inspection agency of the area where the mineral deposit is located.

39.1.7. Mining license holders shall record all instances of adverse environmental impact resulting from mining activity, prepare and send a copy of its annual reports on the implementation of the environment protection plan to the State central administrative agency in charge of environment, the Governor of relevant aimag, soum or district and the professional inspection agency. The report shall contain the following:

39.1.7.1. information on measures taken to protect the environment

39.1.7.2. new machinery and technology utilized

39.1.7.3. proposed amendments to the environmental impact assessment and environmental protection plan with regard to possible adverse impacts on environment due to expansion of mining operations.

39.1.8. A mining license holder shall provide officials of local and State administrative bodies in charge of monitoring implementation of legislation on environmental protection with an opportunity to enter the mining claim area and to conduct inspection activities on the site.

39.1.9. To ensure the discharge of its responsibilities with respect to environmental protection, a mining license holder shall deposit funds equal to 50% of its environmental protection budget for the particular year into a special bank account established by the State central administrative agency in charge of the environment.

39.2. The State central administrative agency in charge of the environment shall review the documents set forth in Articles 39.1.5 and 39.1.7.3 and notify the license holder of its decision within thirty (30) days after receiving the documents.

39.3. If a mining license holder fails to fully implement the measures of environmental reclamation, the State central administrative agency in charge of the environment shall use the deposited funds set forth in Article 39.1.9 of this law to implement reclamation work and the license holder shall provide any additional funds required without dispute.

39.4. If the license holder complies with all the obligations of the environmental protection plan, the deposited funds set forth in Article 38.1.9 of this law shall be returned to the license holder.

39.5. Within one (1) month following the commencement of mining activities of that year, the deposited funds set forth in Article 39.3 of this law shall be transferred and the State central administrative agency in charge of the environment shall notify the Governor of the relevant soum or district of the transfer.

39.6. If license holder fails to transfer the deposited funds set forth in Article 39.1.9 of this law within the period required by Article 39.5 of this law, the soum or district Governor shall have the right to halt mining activities for the year.

39.7. In case of a failure to complete reclamation activities for the year, the Governor of the relevant soum or district and the professional inspection agency jointly hold the right to prevent the commencement of mining activities for the next year.

39.8. The procedures of monitoring the transactions of special accounts set forth in Articles 38.1.8 and 39.1.9 shall be approved by the member of the cabinet in charge of the environment.

39.9. The State central administrative agency in charge of the environment shall require the license holder to provide amendments to the environmental protection plan and environmental impact assessment if new circumstances arise which have adverse impacts on environment due to introduction of new equipment and technology during the valid license term.

Article 40. Review of environmental protection plan in connection with extensions of licenses

40.2. Mining license holders applying for a license extension shall submit its revised environmental impact assessment and environmental protection plan to the State central administrative agency in charge of the environment for approval.

40.3. The assessment and plan set forth in Articles 40.1 and 40.2 of this law shall be approved as set forth in the Articles 38.2 and 39.2 of the law.

45.1.2. take preventive measures if the mine claim is dangerous for public use;

45.1.3. remove all machinery, equipment and other property from the mining area except as permitted by local administrative bodies or the professional inspection agency.

45.2. Mining license holders shall prepare a detailed map of an appropriate scale showing dangerous or potentially dangerous areas created by mining operations by placing necessary warnings and markings in the vicinity of the mining claim and shall submit the map to the professional inspection agency and the local Governor.

Article 47. Royalties

47.1. A mining license holder shall pay royalties to the treasuries of the central and local administrative bodies on the sales value of all products extracted from the mining claim that are sold, shipped for sale, or used.

47.3. The royalty rates shall be as follows:

47.3.1. royalties for domestically sold coal for energy and common mineral recourses shall be two and one-half (2.5) per cent of the sales value of all products extracted from the mining claim which are sold, shipped for sale, or used;

47.3.2. royalties for extracted products other than those set forth in Article

47.3.1 shall be five (5.0) per cent of the sales value of all products extracted from the mining claim that are sold, shipped for sale, or used.

47.4. An exploration license holders shall pay royalties on minerals extracted during the exploration for surveying purposes which are to be sold after registering the type and quantity of the mineral with the professional inspection agency.

#	Product	UOM	Product with comparative evaluation	Market price (USD)	Rate to add to main rate based on processing level		
1	Iron	ton	Iron ore	0-60	0.00	0.00	0.00
				60-70	1.00	0.70	0.40
				70-80	2.00	1.40	0.80
				80-90	3.00	2.10	1.20
				90-100	4.00	2.80	1.60
				100 and above	5.00	3.50	2.00

Law on toxic and hazardous chemicals 2006

Article 1. Purpose of this Law

The objective of this Law is to regulate relations concerning the export, import and transportation of toxic chemicals across the borders of Mongolia and production, storage, trade, transport, use, removal and control on thereof.

Articles and provisions related to project activities	Background
<p>Article 12. Basic requirement for transportation of hazardous and toxic chemicals</p> <p>12.1. Hazardous and toxic chemicals shall be transported in accordance with the procedures adopted by the provisions of the article 6.1.2 of this law by transport means comply with the technical and safety requirements and attention and safety warning sign shall be applied to those transport means.</p> <p>12.2. After transportation of hazardous and toxic chemicals the transport means used shall be disinfected and rendered non-toxic.</p> <p>12.3. It shall be prohibited to transport hazardous and toxic chemicals together with people, animals and goods and products.</p> <p>12.4. It shall be prohibited to post, transport in public and common transport means the hazardous and toxic chemicals.</p> <p>Article 13. Basic requirements for the use of hazardous and toxic chemicals</p> <p>13.1. Activities related to the use of hazardous and toxic chemicals shall be maintained in premises and places that comply with labor protection and safety</p>	

conditions and requirements.

13.2. It shall be prohibited during the utilization process of hazardous and toxic chemicals to exceed their admissible level set by the authorities in the premises and environment.

13.3. Businesses and organizations that use hazardous and toxic chemicals shall draft safety rules and adhere to them upon approval by the local inspector for the environment and sanitation.

13.4. Persons with proper professional knowledge and experience reached 18 years old are allowed to work with hazardous and toxic chemicals.

13.5. It is prohibited to employ pregnant women and breeding mothers for the positions related to hazardous and toxic chemicals.

13.6. Businesses and organizations shall organize on own expenses the training on safety work and prevention from potential accidents and risks and on providing the first aid assistance for the personnel engaged in operations with hazardous and toxic chemicals.

13.7. Individuals, businesses and organizations shall register the utilization and consumption of hazardous and toxic chemicals used for industrial purposes and submit the reports to soum and district governors within 15 November every year and to the state central administrative agency within the end of January of the next year.

13.8. It is prohibited to use hazardous and toxic chemicals with unclear name, characteristics and use instructions in the case if the professional authorities did not provide sufficient conclusions.

13.9. Individuals, businesses and organizations shall comply with procedures adopted with respect to the provisions of the article 6.1.2 of this law.

Article 14. Basic requirements for deposition of hazardous and toxic chemicals

14.1. The waste of hazardous and toxic chemicals shall be deposited on the basis of conclusion of the related professional organization to the place determined by the soum or district governor in compliance with the procedures set by in the provisions of the article 6.1.2 of this law by means that don't endanger or intoxicate human health, the environment, domestic animals and wildlife, and the commission consisted of the local environment and sanitation inspector and officer, specialist in emergency situations, shall be engaged in this operation.

14.2. The commission stated in the provisions of the article 14.1 of this law shall sign the act on deposition of hazardous and toxic chemicals and deliver it to the soum, or district governor.

Article 17. Estimation of risks

17.1. Individuals, businesses and organizations engaged in activities to produce, store, use the hazardous and toxic chemicals shall be obliged to estimate the risks of those chemicals as set forth by in the law on Estimation of factors that impact the environment.

17.2. The estimation shall include issues on determination of toxic and dangerous nature of that chemical, potential risks, measures of the prevention, neutralization of waste and its deposition.

2.2. GOVERNMENT RESOLUTIONS AND MINISTER DECREES

If a project operator uses eco-friendly technology and recycles waste during its production operations, it will be eligible for the following benefits:

1. Regulation for Granting Benefits to Citizens, Business Entities and Organizations Undertaking Activities in Reducing Air Pollution and Heat Loss and Energy Saving (Attachment 2 to Resolution No. 309 of 2011 of the Government of Mongolia)
2. “Water Use Fee Discount Rates” (Attachment 2 to Resolution No. 326 of September 21, 2013 of the Mongolian Government)
3. “Some Measures for Improving Waste Management” (Resolution No. 256 of 2001 of the Mongolian Government)
4. “Ecological and Economic Evaluation of Water” applicable for quantitative and qualitative evaluation of water resources and assessment of damage to water resources (Attachment 1 to Resolution No. 302 of October 26, 2011 of the Mongolian Government)
5. Regulation for Maintaining the State Registry of Waste and Reporting (Decree #A-116 of April 9, 2014 of the Minister of Environment and Tourism)
6. Regulation for Preparation, Review, Acceptance and Approval of Environmental Protection Plan and Environmental Management Program and Report (Decree of the Minister of Environment and Tourism, dated February 16, 2011 regarding approval of regulation)
7. Regime for protective and hygienic zones of population drinking and household water sources (Attachment 1 to Joint Decree No. 167/335/ /171 of 1995 of the Minister of Environment, the Minister of Infrastructure and Development and the Minister of Health)
8. “Regulation for Preparation, Review, Approval and Reporting of Environmental Management Plan to be implemented by citizens, business entities and organizations in a given year”(Decree #A-05 of January 6, 2014 of the Minister of Environment and Green Development)

Mongolia is located in a region with an extremely dry and cold climate, fragile ecosystems and limited natural regeneration ability. These features make the country more prone to climate change and direct and indirect impacts of human activities that are changing the natural conditions in the country. In addition, operations should be compliant with international environmental agreements and conventions to which Mongolia is a signatory.

Therefore, it is critical for a project operator to comply with environmental laws and standards and reflect them in its operations to some extent.

CHAPTER THREE. PROJECT SPECIFICATIONS

3.1. GENERAL INFORMATION ON THE PROJECT

Project Number: E/049

Project title: Heap Leach

Project purpose: The purpose of this project is to process 9.8 million tonnes of low-grade ore through heap leaching method and produce 4407 kg of gold that cannot be currently processed through the processing plant of Boroo Gold LLC.

Significance: Processing of the low-grade ore will extend the Boroo gold mine life for 6 years. Tax revenue to the state and local budgets will also increase for the same period.

Project implementer’s name and address:

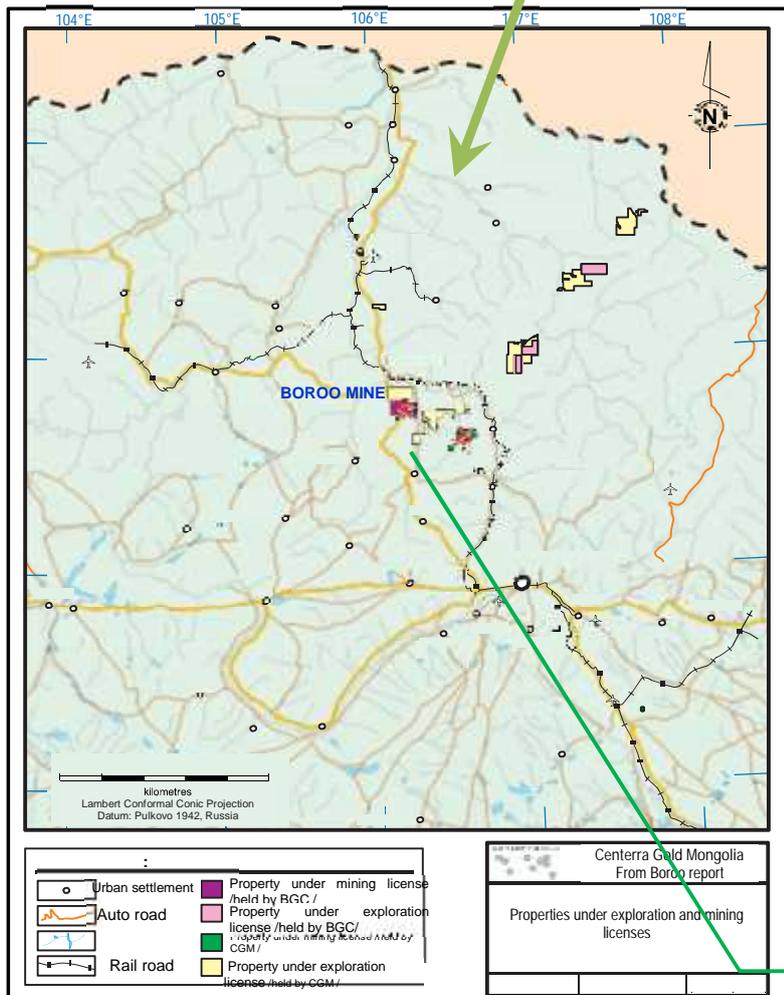
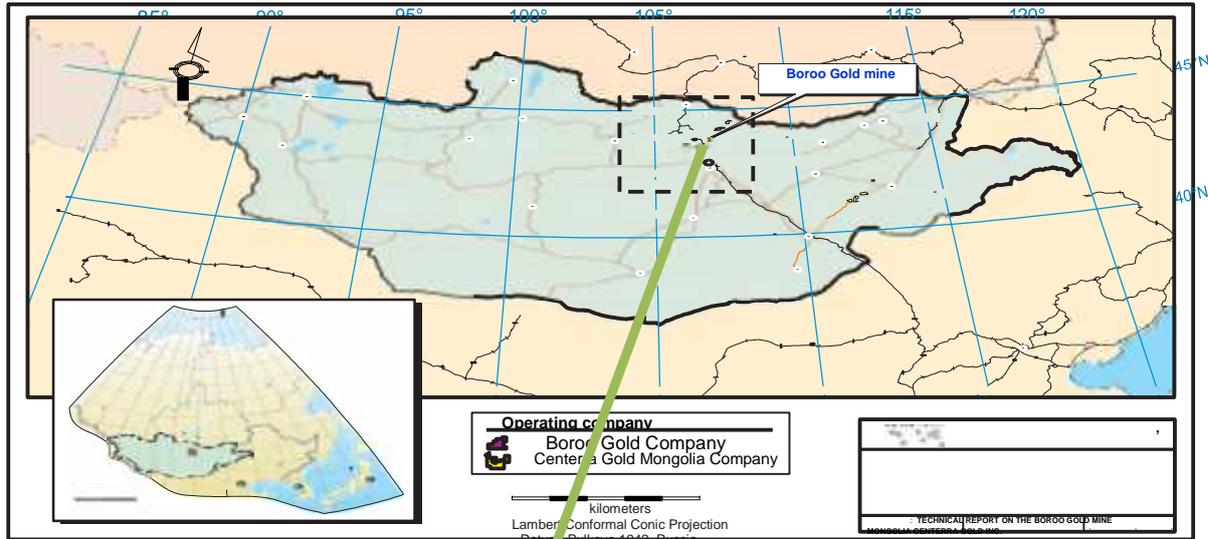
“Boroo Gold” LLC
 State Registration number – 9019011029
 Registration number - 2094533
Address: Ulaanbaatar city, Chingeltei District
 Khoroo 1, Sukhbaatar Street,
 Bodi tower, level 11 and 12

Project location, layout map of the project site area

The project is located in the licensed property under a mining license held by BGC within the Bayangol soum territory in 140 km from Ulaanbaatar city, 10 km from Ulaanbaatar-Darkhan-Selenge highway, 19 km from Baruunkharaa, Bayangol soum center, 25 km from Zuunkharaa, Mandal soum center, 3 km from the processing plant, and 5 km from Boroo River.

Table 1. Heap Leach pad coordinates

	Longitude (EST)	Latitude (NS)
1	106 ⁰ 13.27',48"	48 ⁰ 45.32',04"
2	106 ⁰ 13.33',96"	48 ⁰ 45.18',36"
3	106 ⁰ 14.15',72"	48 ⁰ 45.27',36"
4	106 ⁰ 14.07',08"	48 ⁰ 45.46',08"
5	106 ⁰ 13.07',08"	48 ⁰ 45.55',08"
6	106 ⁰ 13.55',92"	48 ⁰ 45.57',24"



Heap Leach area

: Licences information from Centerra Gold Mongolia LLC, as of October 31, 2009.

Image.3.1,3.2. Location of Boroo mine and heap leach pad

3.2. PROJECT CAPACITY AND TECHNOLOGY

3.2.1. Introduction of Boroo Gold Company operations

The Joint Mongolia-German expedition conducted a detailed exploration at the Boroo gold deposit in Bayangol soum, Selenge aimag in 1982-1989, and as a result, 43 tons of gold of B and C1 category has been approved with the Resolution #08 of the State Mineral Reserves Commission of the People's Republic of Mongolia on March 20, 1992 (soil stripping coefficient - 3,8 m³/tn, average gold grade - 2,7 g/tn, cut-off grade 0,8 g/tn, the minimum thickness of the ore body 2,0 m). Based on results of explorations conducted by Boroo Gold LLC in 1999-2000 and the previous Mongolian-German exploration expedition, the geological reserve of the deposit has been estimated by geostatistical method as 42.56 tons.

Pursuant to the Minerals Law of Mongolia, BGC updated the registration of the mining license at the Boroo hard-rock gold deposit in Bayangol soum, Selenge aimag under license #198 on July 14, 1997.

After an investment of USD 74 million to the Boroo gold mill, it was commissioned by the end of 2003 and started operating at its full capacity in 2004. It currently employs over 350 employees. Boroo Gold LLC is a subsidiary company of Canadian Centerra Gold Inc. (Image 1.1 and 1.2.)

Taxes and fees paid to the state and local budgets in 2004-2013 are as follows:

- In 2004 - 7 billion
- In 2005 - 11 billion
- In 2006 - 18 billion
- In 2007 - 44 billion
- In 2008 - 42 billion
- In 2009 - 41 billion
- In 2010 - 47 billion
- In 2011 - 20 billion
- In 2012 - 25 billion
- In 2013 - 43 billion

Total 298 billion

BGC was selected as the Best Tax Payer of Mongolia in 2007, 2008, 2009, 2010 and 2013.

As a result of additional exploration works conducted at the Boroo mine in 2007, the mine ore reserves has been increased by 13.9 million tons. The Boroo hard-rock gold reserves has been accepted and registered under Decree #426 of the Chairman of the Mineral Resources and Petroleum Authority issued on August 21 2008. (Image 1.2.)

The Specialized Minerals Council of the Mineral Resources Authority reviewed and approved the report on the Addendum Feasibility Study to conduct mine works at the Boroo hard-rock gold deposit open pit mine and apply heap leach processing prepared by the Mining Design Research Center on December 14, 2013.

Currently, after the approval of Boroo mine project, additional improved amendments has been introduced such as operational conditions of hard-rock gold deposit, ore extraction and processing and disposal of technological waste. The company considers that these amendments are economically beneficial and moreover, provides proper use of natural resources.

3.2.2. Deposit reserves

Initial reserve of the Boroo hard-rock gold deposit has been defined by exploration works of G.Dorj and G.Chorn conducted within the scope of Mongolian-German joint geological expedition in 1982-1989. Parameters of 282 drilled columns and data of excavation works conducted to confirm the parameters has been used to estimate the reserve. The reserve assessment used geological blocking method and maximum high-grade limit has not been evaluated. 40x40 m net has been drilled to define B category reserves and 40x80 m net to define C1 category reserves based on 80x80 m net and excavation data. Balance reserve of Boroo deposit has been estimated as 43021 kg of gold in 1380 thousand tons of ore by edge grade of 0.8 g/ton and average of 3.1 gr/ton by B+C1 category. This reserve has been approved by the Resolution #08 of the Mineral Reserves Commission of the People's Republic of Mongolia on March 20, 1992.

During its open pit mine operations at the Boroo hard-rock deposit, Boroo Gold LLC conducted operational exploration by conducting total of 86.5 thousand t.m drill works with 30-60 m intervals between boreholes. These works has been conducted to confirm the defined reserve, defined final ore body and increase the reserves. The Boroo reserve assessment is conducted in connection with the exploration results and fluctuation of prices of gold and other products.

Based on the conclusion #30-01 approved by the meeting of Specialized Minerals Council of Mineral Resources Authority and Ministry of Industry and Trade on July 23 2008, certain and actual reserve (A+B) of Boroo hard-rock gold deposit is 13039 kg and inferred reserve (C) is 24453 kg. On the meeting, decision was made to exclude this reserve from the state registry of the mineral reserves that was approved in 1992. As a result of reviewed assessment, ore specifics has been re-studied to update the database, as well as mill plant recovery has been estimated at 75-95% and heap leach – at 55-85%. Block modeling method using GEMCOM mining software has been used for deposit reserve assessment (Table 3.2.)

Table 3.2 Reserve classification

Processing type	Reserve classification	Ore quantity	Grade	Gold reserves	
		thous.tn	g/t	kg	thous.oz
Heap Leach	Inferred reserves in pits	7719	0.74	5712	183
	Inferred reserves in stockpiles	6467	0.70	4535	145
Total Heap Leach reserves	Total Inferred reserves ()	14186	0.72	10247	328

Remaining reserves of the Boroo gold mine, description

The Boroo hard-rock gold deposit reserve has been registered by the State Mineral Reserves Commission in 1992 and the reserve has been mined by Boroo Gold LLC since 2003. Update of reserve has been made in 2008 and 2013. The Boroo gold mine extracted and processed through the processing plant 14309 thousand tons of ore containing 27205 kg of gold in 2003-2006 and 31577 kg of gold in 2007-2012, and recovered 2015 kg of gold by heap leach project in 2007-2012. Total of 60797 kg of gold has been extracted from the Boroo hard-rock gold deposit.

Majority of the reserve estimated as of January 1 2013 is stored in stockpiles stacked dumped mining operations and total reserve of gold in stockpiles and heap leach pad is 9127 kg. Economic study of remaining resources of the deposit at USD 1350 per ounce, ore containing 307 kg of gold in the east wall of Pit 3 is considered as economically beneficial and included in reserve as additional inferred (C) category reserve. This part of the reserve is considered as situated within the area undisturbed by extraction.

The total remaining reserve of Boroo deposit as of January 1 2013, categorized by processing technology is below:

Table 3.3. Revised reserves of Boroo hard-rock gold deposit

Processing type	Reserve category	Ore quantity, thous.tn	Gold grade, g/tn	Gold reserves, kg
Mill reserve (stockpile)		4680	0.84	3931
Total mill reserve		4680	0.84	3931
Heap leach (stockpile)		2577	0.71	1830
Heap leach (leach pad)		7162	0.47	3366
Total heap leach reserves		9739	0,53	5196
Total reserves		14420	0,63	9127

Table 3.4. Additional reserves of Boroo hard-rock gold deposit

Processing type	Reserve category	Ore quantity, thous.tn	Gold grade, g/tn	Gold reserves, kg
Mill reserve (pits)		108	2.06	222
Heap leach (pits)		113	0.75	85
Total reserve			1.39	307

Ore stockpile

Ore extracted from the pits is divided into main ore and low-grade ore. Main ore has been extracted and piled at the processing plant and has been processed in 2003-2012. Low-grade ore stockpiles are formed near Pits 2, 3, 5 and 6.

From 2008, after approval of Heap Leach Feasibility Study, low-grade ore has been hauled to the heap leach pad and the mill plant for processing. As of January 1 2007, the heap leach reserve has been approved as 14962 thousand tons of ore and 10.1 tons of gold. However, as of January 1 2008, the Project reserve has been revised as 16,645 thousand tons of ore and 12.0 tons of gold.

In 2013 supplementary report of Boroo hard-rock gold deposit, low-grade ore has been classified and approved as mill reserve and heap leach reserve. Mill reserve is 4,680 thousand tons and the heap leach reserve is 9,739 thousand tons of ore.

Through heap leach operation carried out in 2008-2013, total of 9.8 million tons of ore has been stacked on the heap leach pad. As of January 1 2013, low-grade ore stockpiles 1, 3, 5, 6 and 7 piled since the Boroo gold mine operations commenced are the low-grade ore reserve processed heap leach project.

Total reserve estimated to process through heap leach project is shown in table below. (Table 3.5).

Table 3.5. Final reserve of Heap Leach project as of September 1, 2012

Stockpile #	Ore, tons	Average grade, g/tn	Gold reserves, kg
Stockpile 1	62,333	0.86	53.6
Stockpile 3	733,472	0.67	494.3
Stockpile 5	130,069	0.72	93.6
Stockpile 6	649,652	0.77	500.7
Stockpile 7	1,001,476	0.686	687.7
Total	2,577,001	0.71	1830

The Feasibility Study to produce gold from low-grade ore of the Boroo hard-rock gold deposit with heap leaching method has been accepted with the Decree #136 of the Minister of Mineral Resources and Energy, dated July 6, 2012, and the mill has been commissioned and permitted to commence operations with an act #12/26 of the State Commission to accept the mine for commissioning, dated August 16, 2013.

3.2.3. Project implementation plan

The Boroo hard-rock gold deposit mine operation includes the processing plant to process the gold ore stacked in the stockpiles, and other operations related to heap leach processing method.

The minimum gold recovery of Heap Leach project reaches its minimum by the end of 2015 and in terms of timing, the operations will end in cold season. However, this will result in freezing of the solution being used in leaching and difficulties in detoxification process, thus it is planned to keep the solution in cycle until middle of 2016, i.e. warmer season. On the other hand, it ensures full recovery of gold from the leach solution.

Table 3.6. Implementation plan

Specification	Start date	Completion date
---------------	------------	-----------------

1. Heap leaching		
Heap leaching	January 2009	December 2016
2. Reclamation, closure		
Ore stockpile reclamation	January 2016	January 2018
Environmental monitoring	January 2017	December 2019

3.3. PRODUCTION TECHNOLOGY

3.3.2. Ore preparation

Immobilized crushing equipment has been used to prepare ore for heap leaching. Hydro-Cone HMC-440 type cone crusher and 1100mm x 800mm STJ joint toggle jaw crusher are used for crushing 80% of total fed ore to grains of less than 100 mm. In order to maintain pH of the solution required for leaching at 10.5 on average, burnt lime is added to the crushed ore. Normal capacity of crushing and stockpiling is 8220 t/day. Heap Leach crushing flowchart is shown in Image.3.3.

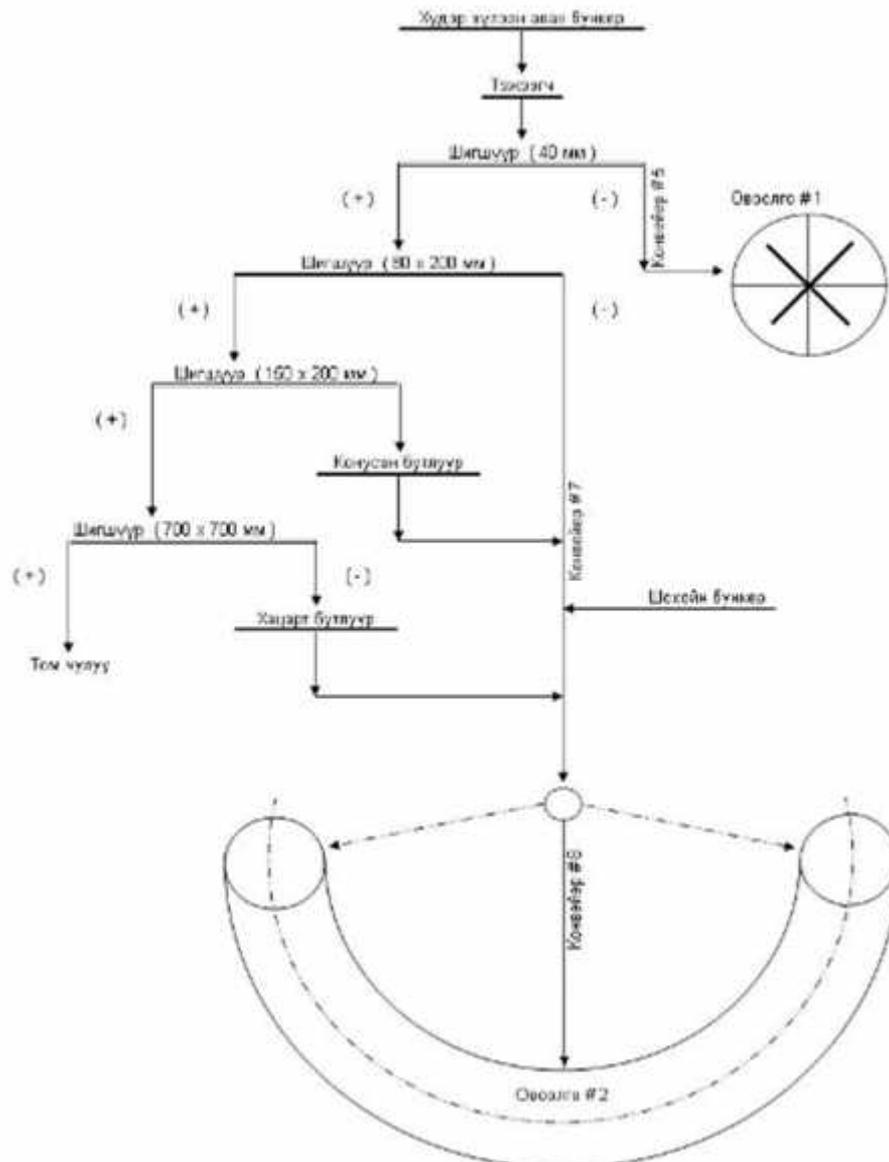


Image.3.3. Heap Leach Crushing cycle flowchart

Haulage of prepared ore

988 Loader is used to haul crushed ore to the heap leach pad. Average distance to heap leach pad from crusher area is 0.6 km and crushed ore is hauled to the heap leach pad by two CAT 773 dump trucks.

3.3.3. Ore heaping, stacking and loosening processes

The size of leach pad is about 600m 500m. Ore is stacked on the pad in 10 m high layers on average with 5 m protection berms. Slope of the stockpile is 1:1.5 and the total height of the stockpile is 51 m. The total average slope of the stockpile is 1:2 (comparison of vertical with horizontal).

Currently total of 9.8 million tons of ore is stacked on the heap leach pad. The heap leach stockpile consists of 4 cells.

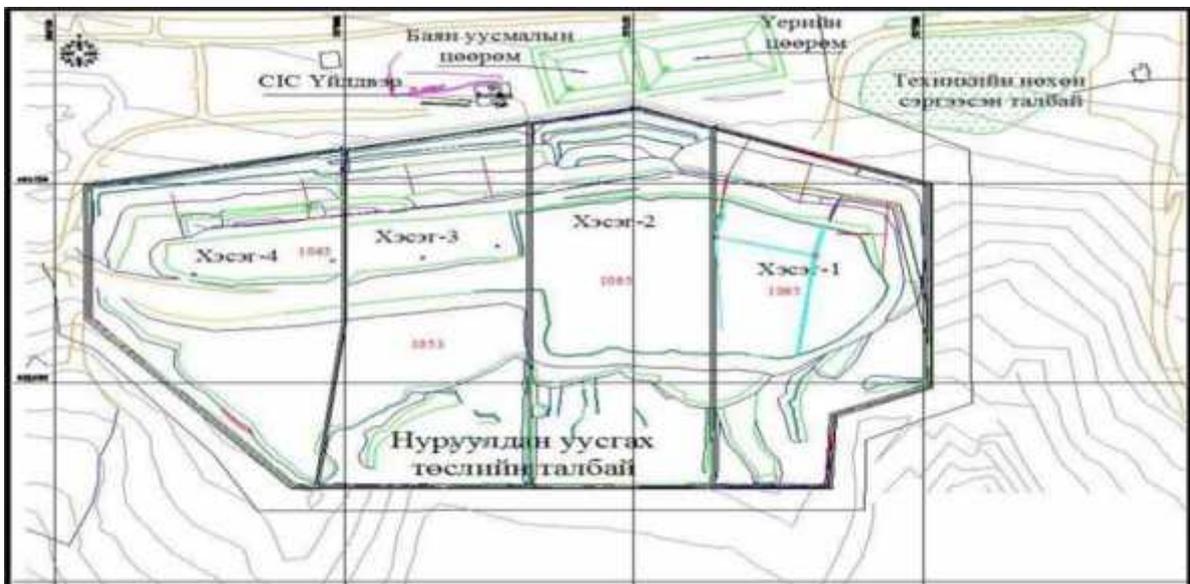


Image.3.4. Current view of heap leach pad

The heap leach pad covers total of 24.9 ha area. The pad height is 51 m at the highest parts of the stockpile and 5 m in the lowest.

3.3.4. Selection of the heap leach technology of the Boroo hard-rock gold deposit and completed activities

Studies to process the Boroo mine low-grade ore with heap leaching method started in 2005. Ore samples has been sent to Australia and USA for roll and column tests as well as pilot operations were conducted at the Boroo mine site. Due to satisfactory results of the tests, separate low-grade ore stockpiles have been created from the end of 2005. Construction of the heap leach facilities was carried out in 2007-2008, permits for pilot operations to process the ore with heap leaching method has been obtained in April 2008 and heap leaching activities were ready to start in June 2008. Pilot operations continued until May 2009. The purpose of the pilot operations was to determine whether recovery can reach the planned amounts as this

technology was used in Mongolia for the first time, especially to test whether operations could be continued during winter. Although pilot operations brought good results, due to delay in operational permits the leaching process has been completely stopped and actions are taken to rinse the gold-bearing cyanide solution accumulated in the leach stockpile and pad with clean water. These actions were undertaken with the purpose to protect the environment as well as to maintain normal operations and prevent the pipelines from damages and freezing.

Pilot operation results: During the pilot operations, total of 4,0 million tons of oxide and semi-oxide ore with gold grade of 0,65 g/t was put through leaching and re-leaching and the average recovery was 42%. The recovery was 60-70% in the first 30 days and after 3 stockpile was leached for 60 days, the leaching reached its maximum and the recovery basically stabilized. The average low recovery, i.e. 42%, has been related to suspension of leaching in June and July due to storm water, and emergence of channels in some parts of the stockpile due to loss of leach solution caused by pressure as a result of powder carbon blocking the drip holes of the pipes within the insulation stockpile in February and March. The recovery reached 60-80% during normal operations. The pilot operation results showed the possibility to have a recovery from oxide and semi-oxide ore at planned rates.

It was difficult to recover gold with heap leach technology during winter, and in order to eliminate such difficulty, special methods were used such as additional insulation stockpile, solution heat exchanger and heater cables which proved that normal leaching could be continued.

One of the most common risks that may arise during heap leach process is the abnormal and irregular operations of the plant and facilities and incompleteness of the leach pad liners. During pilot operations, there were no such risks arisen.

In 10 months of pilot operations, there were cases of harsh weather conditions (down to -45 degrees), strong blizzard and storms that may have affected the leaching, but as a result of necessary actions taken, the pilot operation results showed it is possible to recover gold from the low-grade ore through heap leach technology.

3.3.5. Heap Leach pad

The leach pad occupies approximately 600m x 500m area. Maximum capacity of the pad is 18.5 million tons of ore. Capacity of stockpile was estimated by average density of stacked ore to be 2 t/m³ and stockpile height from the pad liner to be 60 m high. The leach pad consists of 300 mm compacted clay base, 1.5 mm thick linear low density polyethylene synthetic liner (LLDPE) and 600 mm layer of crushed rock cover.

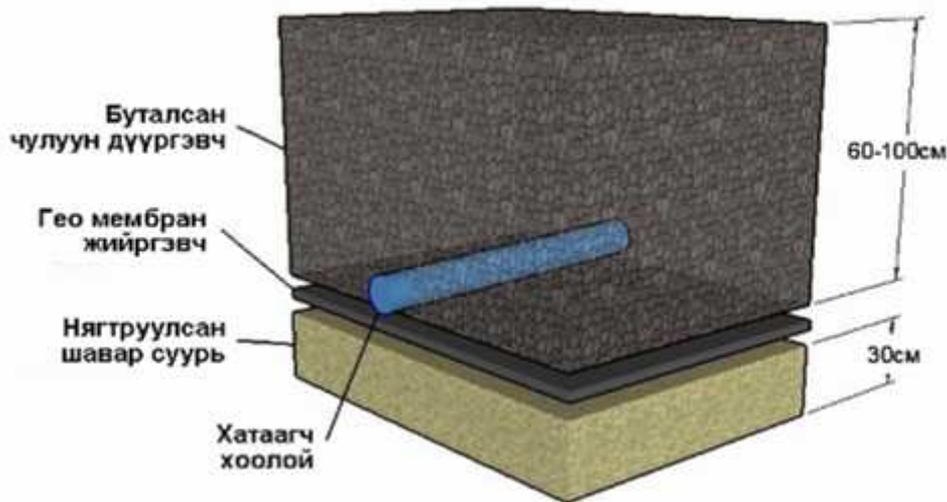


Image.3.5. Leach pad preparation chart

Pregnant leach solution (PLS) pond has a capacity of 14,274 m³ below the overflow level and the storm water pond 28,701 m³ below the overflow level. The difference between the overflow level and the top edge of the separating berm between the PLS pond and the storm water pond is 0.75 m which adds up the capacity of 10,533 m³.

In the event of power outage or pump failure, or strong storm or heavy rain, the solution in the PLS pond will flow by its own weight into the storm water pond next to the PLS pond.

The leach pad consists of 300 mm compacted soil base, 1.5 mm thick LLDPE, geonet layer to detect leaks and 2 mm thick HDPE liner. The base of the storm water pond consists of 300 mm compacted soil base and main layer of 2 mm thick HDPE liner. Water that runs into the leach stockpile from the top will be disposed through the diversion channels built around the facility.

Table 3.7. Solution pond dimensions

	Solution pond	UOM	Pregnant leach solution pond	Storm water pond
1	Base width	m	55.0	70.00
2	Base length	m	30.00	30.00
3	Top width	m	75.0	90.0
4	Top length	m	50.00	50.00
5	Pond depth	m	4.00	4.00
6	Pond capacity	m ²	10,517	12,899
7	Pond base area	m ²	1,650.00	2,100.00
8	Pond top area	m ²	3,750.00	4,500.00



Image.3.6. Leach pad pond¹

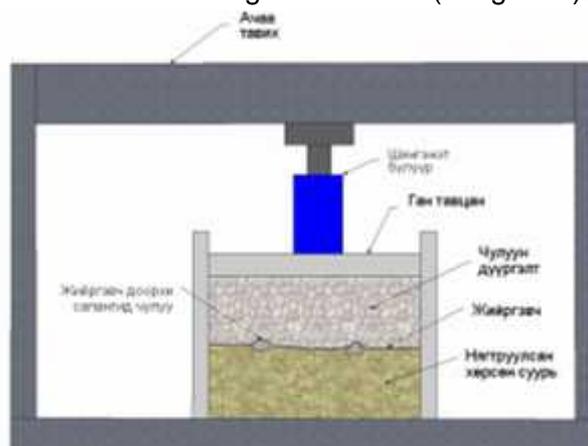
Solution is applied to the ore at the rate of approximately 0.2 l/min/m². In short period of time this can be increased by 30%. Gold-bearing pregnant solution flows by its own flow and is collected in the PLS pond.

Attenuated solution is transferred to the sprinkler system through 300 mm diameter pipes from the processing unit.

Solution is applied to the ore through solution sprinkler pipes installed in the depth of 1.5-2 m from the heap surface.

The leach pad consists of 300 mm compacted soil base, 1.5 mm thick linear low density polyethylene synthetic liner (LLDPE) and 600 mm layer of crushed liner cover (Image.3.7). Local clayey soil is used in the 300 mm soil base.

The liner tolerance has been tested with the method of applying pressure based on real conditions to cause potential crack or damage to the liner (Image.3.7).



¹ - Updated FS to mine the Boroo hard-rock gold deposit, 2013



Image 3.7. Tests on liner quality

Solution collection system consists of pipes installed through liner cover layer of 600 mm. Main solution collector consists of 75 mm pierced pipes distributed throughout the stockpile pad base with intervals of 10 m. 75 mm pipes are connected to collector pipes with larger diameter which take the pregnant solution to the pregnant leach solution (PLS) pond.

3.3.7. Gold leaching process

In order to have normal leaching in summer time, solution pipes are placed over the stockpile with 4 forking pipes with drippers apply solution. Active leaching range will be in approximately 15000-28000 m² area. In order to provide an opportunity to place additional percolation pipes during summer, the ore stacking period (30 days) will be twice shorter than leaching period (30-60 days) in each range. Solution distribution pipes are equipped with valves to change direction of solution application when required.

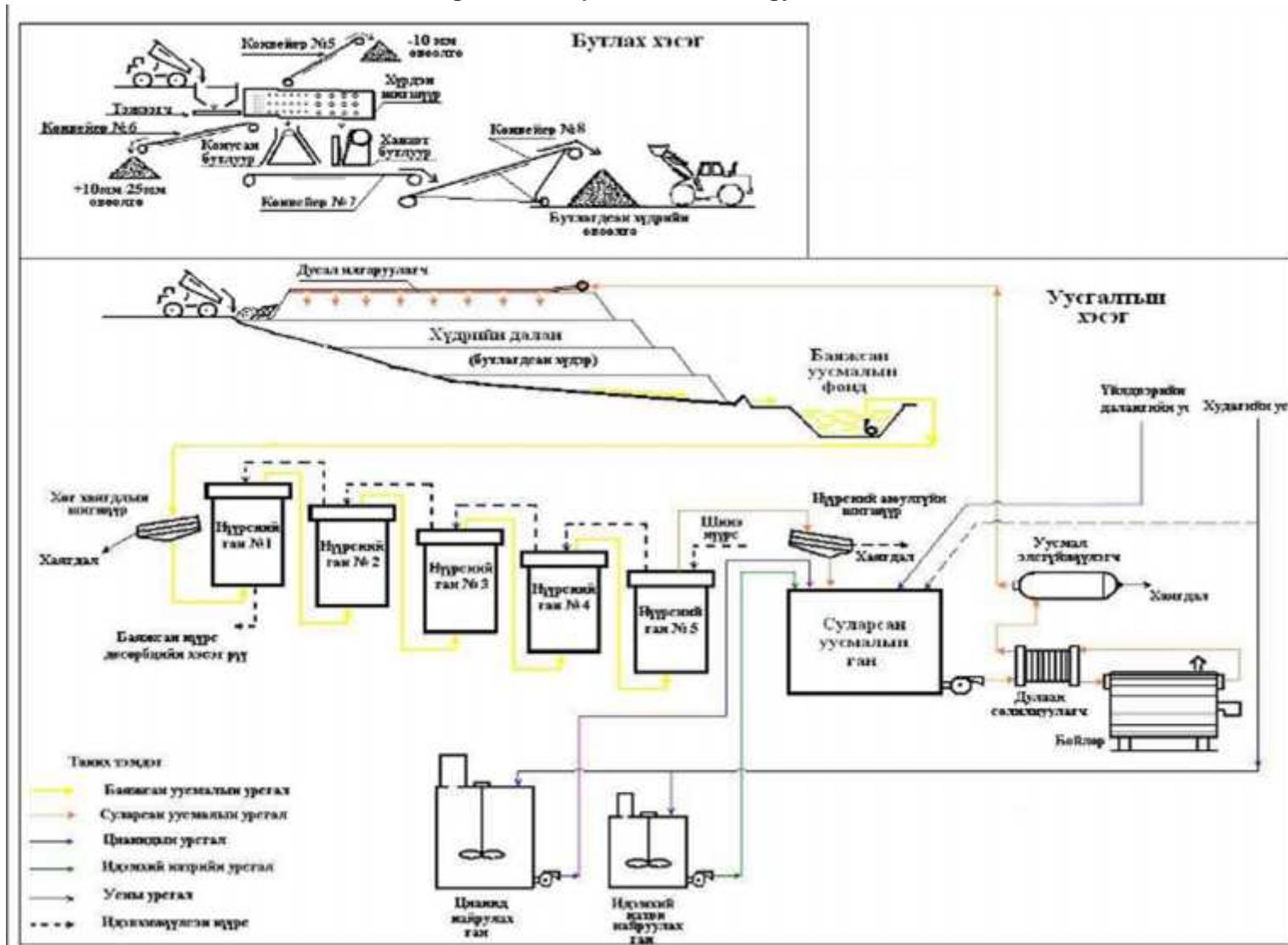
In order to coordinate winter conditions, the action plan reflects various methods to continue heap leaching in cold weather conditions. It includes sufficient number of vehicles to be used in collection only in summer time, insulated attenuated leach solution tanks and pipes, attenuated solution heater, reserve power source, sprinkler pipes to be installed in crushed ore in the depth of up to 2 m. Prior restarting leaching in spring preventive measures are undertaken such as to loosen frozen ore in advance, to sprinkle water from top for some time in order to melt ice layers that might be in the stockpile, to empty pipes prior stopping and to use protection from freezing at PLS pond.

0.05-0.1% sodium cyanide (NaCN) solution will be applied to stacked ore through sprinkler pipes at the rate of 0.2 l/min/m² throughout 30-60 days of leaching cycle for one work block of 484,500 tons of ore. This solution percolates through ore body, leaches the gold in the ore, flows by its own weight and is collected in the PLS pond. The solution is then pumped from the pond to carbon columns. Through attenuated leach solution columns the gold is absorbed in activated carbon (adsorption) creating attenuated leach solution. Gold is separated from gold-bearing carbon (desorption) and infused solution is prepared; carbon with no gold is re-used. The gold is recovered by electro-winning (cathode, anode) method from infused solution with high gold grade. Attenuated leach solution is heated and pumped for re-use at the heap leaching process.

Image.3.9. Ore leaching duration planning, year by year

Жил	Хийгдэх ажил	Хүдэр уусгалтын хугацаа, сараар											
		1-р улирал			2-р улирал			3-р улирал			4-р улирал		
		1 сар	2 сар	3 сар	4 сар	5 сар	6 сар	7 сар	8 сар	9 сар	10 сар	11 сар	12 сар
		31	28	31	30	31	30	31	31	30	31	30	31
2013 он	Анхдагч уусгалт	1,521,508			1,082,546			802,564			670,000		
	1-р циклийн -уусгалт явна	817,238			342,546			425,000			230,000		
	2-р циклийн -уусгалт явна		550,000			380,000			285,000			220,000	
	3-р циклийн -уусгалт явна			154,270			360,000			92,564			220,000
2014 он	Анхдагч уусгалт	670,000			730,000			36,963					
	1-р циклийн -уусгалт явна	220,000			230,000			36,963					
	2-р циклийн -уусгалт явна		220,000			250,000							
	3-р циклийн -уусгалт явна			230,000			250,000						
2014 он	Дахин уусгалт	487,507						1,451,599			1,560,000		
	1-р циклийн -уусгалт явна							725,799			520,000		
	2-р циклийн -уусгалт явна											520,000	
	3-р циклийн -уусгалт явна			487,507						725,799			520,000
2015 он	Дахин уусгалт	1,560,000			1,560,000			1,560,000			1,560,000		
	1-р циклийн -уусгалт явна	520,000			520,000			520,000			520,000		
	2-р циклийн -уусгалт явна		520,000			520,000			520,000			520,000	
	3-р циклийн -уусгалт явна			520,000			520,000			520,000			520,000

Image.3.10. Heap Leach technology flowchart



The pond is surrounded with a fence to prevent from entry of animals to the pond and is fully covered with floating “bird balls” to protect from birds. Refer to Image 3.11.



Image 3.11. Floating bird ball cover (October 20, 2012)

3.3.8. Leach solution and air monitoring

With the purpose to maintain pH at 10.0-11.0, lime is added to the crushed ore on conveyor. When necessary, burnt lime and slaked lime is added while the ore is staked at the ore preparation site. Moreover, caustic soda prepared as solution is used in special cases to adjust the solution pH.

Immobile pH meter is installed in the pregnant and attenuated solution pipes and the operator monitors the solution pH with portable pH meter. In order to control cyanide evaporation, immobile and portable devices are used to determine level of hydric cyanide in the air.

Table 3.8. Solution amount required for ore leaching

	Data calculation	UOM	Capacity
1	Crushed or density	tn/m ³	1.7
2	Solution and ore ratio (:)		1.00
3	Leach duration	day	60.0
4	Height of one layer of the stockpile	m	10.0
5	Ore at each quarterly leaching cycle	tn	1,000,000
6	One cycle area	m ²	28 000
7	Solution consumption	l/m ² /hour	0.20
8		m ³ /m ² /hour	0.012
9	Solution amount	m ³ /hour	340

3.3.9. Storm water pond

The storm water pond base is covered with 2 mm (80 mil) HDPE liner. The storm water that runs down into the ore stockpile from the higher areas will be diverted through diversion channels built around the heap leach stockpile. Potential flood water was estimated to have a volume of 39,200 m³ based on one potential occasion of a flood in 100 years, i.e. heavy rain that continues for 24 hours with falling precipitation of 104 mm.

The FS specified that the volume of the storm water protection pond must be 28,701 m³ below the overflow level based on water balance estimate results. The difference between the overflow level and the top edge of the separating berm between the PLS pond and the storm water pond is 0.75 m which adds up the capacity of 10,533 m³. The FS includes the engineering calculations and designs of the flood protection channels. Storm water pond will be dry at times except it collects the storm water or in case of overflow from the leaching process. In order to ensure it can contain the storm water, it is estimated to dry the pond every 10 days.

3.3.10. Pumping system

The pumping system includes pumps, solution transmission pipes, control panel and lifting device. The project transmission capacity during normal operations is 343 m³/hour and potential addition of precipitation water flow is 120 m³/hour. This enables complete disposal of 39.2 thousand cubic meters of storm water within 10 days to the tailings pond with complete detoxification.

High density polyethylene pipes will be used. These pipes are tolerant to high overload as proven with test works (ore stockpile with height of up to 100 m).

3.3.11. Process of attaching gold to carbon

Pregnant leach solution is taken through 5 columns with 2.3m diameter filled with activated carbon. PLS is fed through the bottom of columns and overflow will flow into next column. But carbon flow will be from lower column to upper column. When gold grade in carbon in the first column reaches 3000-5000 g/t, it is transferred to the classification unit of the plant where the gold is separated from carbon. CIC unit is located next to the PLS pond. PLS enters CIC unit from left and goes through to right. PLS overflow from the last carbon column is taken through carbon catching screens prior to being pumped to a heated and contained attenuated solution tank. Additional water and cyanide content stabilization is done again in attenuated leach solution tank. During overload period, attenuated leach solution tank releases overflow solution to the PLS pond and storm water pond. Attenuated leach solution goes through solution heater and is heated up to 10°C prior to being applied to the stockpile.



Image 3.12. CI carbon absorption unit

Table 3.9. CIC plant technical specifications

Type	Unit	Indicator
Carbon column diameter	m	2.44
Carbon column height	m	3.03
Carbon column number	ea	5
Coal amount		6 12
Carbon level in columns	%	50
Solution flow	m ³ /hr/m ²	73.3
Coal concentration, g/tn coal	g/tn (u + g)	5,000
Coal consumption	kg/tn	0.001
Concentrated carbon re-processing	To desorption unit of the mill	

Table 3.10. Output of ore processed through initial and repeated leaching

Indicator	UOM	Total years of operation			Total
		2014	2015	2016	
Gold production					
Ore to leach	tn	3,613,622	4,476,667	3,160,000	11,250,289
Average leached gold grade	g/tn	0.52	0.36	0.30	0.33
Gold in leach ore	kg	1,884	1,596	960	4,440
Recovery of gold in leach ore	%	42%	17.5%	2.5%	25.6%
Gold produced from leach ore	kg	793	280	66	1,139

3.3.12. Metal recovery from pregnant carbon (Desorption)

The next stage of processing gold-bearing pregnant carbon is desorption unit at the Boroo plant where the gold is separated from carbon. The cycle to separate the gold from carbon surface uses AARL (Anglo American Research Laboratories) desorption process. Concentrated carbon arriving from CIL cycle and Heap Leach project contains 2000-5000 ppm

of gold. Concentrated carbon is processed with sodium acid in columns to wash with acid with capacity of 3 tons removing calcium. Carbon washed with acid is heated up to 120°C in cyanide and sodium alkali solution in desorption columns and is reserved for 6 hours under 150 kPa pressure. At the end of process to separate gold from carbon surface the content of gold in carbon drops to 100 ppm. The carbon separated from gold is pumped to restoration heater with water pump. Here when necessary, the carbon is heated to increase activation up to 95%. Separated carbon is then taken to CIL cycle and Heap leach unit.

3.3.13. Electro-winning and smelting

Pregnant solution produced from desorption column is cooled down and is taken to storage tank with leaching solution of Acacia reactor. Gold content in the gold-bearing solution is 300-400 ppm. The solution is pumped into Electro-winning baths and the gold in solution is separated and attached to steel cathodes. After heating gold-bearing wooly steel at up to 600-800°C it is smelted in overturn furnace and gold bars are produced.

3.3.14. Chemical reagent use

The following reagent will be used in the Heap Leach Project.

Herein:

- N N: 0.2 kg of sodium cyanide is used for 1 ton of ore processed through leaching process. It is mixed with water and caustic soda and a 20% concentrate solution with pH 10.5 is prepared that is added to the attenuated leach solution tank of the leaching process. Sodium cyanide completely dissolves creating sodium and cyanide ions.
- After sodium cyanide is added to the leaching process, the solution's cyanide content is 150-250 mg/l, i.e. 0.03-0.05%. When cyanide ion reacts with and leaches the gold, it makes up cyanide-gold complex and iron and other basic metals contained in the ore creates stable compounds with cyanide. Cyanide may evaporate in a small amount when hydrogen cyanide gas is emitted to the atmosphere. Lime is added to the stacked ore to maintain the slurry pH at 10 and above to ensure protection alkalinity and reduce gas emission. In order to ensure air safety and quality standards in CIL area, hydrogen cyanide content is regularly inspected with portable electronic measuring device. Such device is usually adjusted at 10 mg/l hydrogen cyanide and it gives an audible signal. Hydrogen cyanide is shortly disintegrates into hydrogen, hydrocarbon and nitrogen in air. There is a mixer in cyanide mixing tank. Cyanide and water are added to the tank to prepare a solution with necessary concentrate. After cyanide is mixed and solution is prepared, the solution goes into the mill cycle through cycle pumps. These pumps operate in turns, i.e. when one is operating the other stays in reserve.
- Lime – In order to maintain the solution pH at 10.5-11 and provide protection alkalinity and avoid loss of hydrogen cyanide into the air, the crushed ore and collected ore are mixed with lime and stacked. The lime consumption is estimated to be 1.6-2.5 kg/tn. When necessary, hydrated lime is used to adjust solution medium.

- Caustic soda – NaOH is used to dissolve cyanide and in special cases to control pH. Caustic soda is packaged in bags of 25 kg and is mixed in a tank equipped with special mixing tool.
- Activated carbon – This carbon has large surface and used for this characteristics. The gold in ion form in the solution is absorbed onto its surface. There are 5 carbon columns in the heap leach section with 3 tons of carbon contained in each tank. The carbon is packaged in 500 kg packages, and 0.001 kg is used to leach 1 ton of ore. When the gold-bearing carbon grade reaches 5000 g/t, it is put to the next processing cycle to separate the gold and re-use the carbon.
- Antiscalant. This substance is used at the rate of 0.003 l/m³ in the technological solution in order to prevent from creating a layer on the walls of pipelines and other solution tanks.

3.3.15. Human resources, work force

In 2015-2015, 11 employees work throughout a year for the Heap Leach Project. Refer to the Table 3.12 for detailed work force plan.

Table 3.12. Heap Leach Project work force

Position	Persons/ shift, (number)	Total (number)
Management		
Shift foreman	2	2
Metallurgist	1	1
Processing		
Leach operator	4	4
CIC operator	4	4
Loading and crushing		
Loader operator	0,16*	0,16*
Total		11

Heap Leach employees work continuously on 12-hour shifts on 7/7 roster.

*- In 2015-2016 loader operator is planned to be employed for only one month.

3.3.16. Equipment and machinery

The list of main equipment to be used in implementation of the project, purpose of use and comments are in Table 3.13.

Table.3.13. Heap Leach Project equipment and technology level assessment

#	Equipment name		Quantity	Capacity, volume		Price. MNT mln	Ownership	Facility to operate at /soil, ore /	Manufacture date	Use life		Technical condition	Reflected in FS or not	Extra equipment	Comments
	Type	Model		Unit	Amount					Year	Meter, mot/hou r				
1	Dump truck	769D	2	m ³	24.2	434,8	BGC	Heap leaching	2004	10	20,500				
2	Dump truck	773E	2	m ³	35.2	530,4	BGC	Heap leaching	2003	10	30,000	medium			Requires major maintenance
3	Excavator	R984C	1	m ³	7	1,316.40	BGC	Heap leaching	2005	10	9.824	medium			Requires major maintenance
4	Wheel loader	990H	1	m ³	9	649	BGC	Heap leaching		10	34.71				Requires major maintenance
5	Bulldozer	PR764	1	kg	52.7	639.9	BGC	Heap leaching	2006	10	9.6	medium			
6	Jaw crusher	STJ 700	1	kg	14.5		BGC	Ore crushing	2006	10		good			
7	Cone crusher	HMC 440	1	kg	15.4		BGC	Ore crushing	2006	10		good			
8	Screen	herculus	1	kg			BGC	Ore crushing	2006	10		good			
9	Coal tank		5	m ³	11.3		BGC	CIC	2007	20		good			
10	Weak solution tank		1	m ³	115		BGC	CIC	2007	20		good			
11	Cyanide mixing tank		1	m ³	28		BGC	CIC	2007	20		good			
12	Caustic soda mixing tank		1	m ³	5		BGC	CIC	2007	20		good			
13	Pregnant leach solution pump	GrundFos	2	m ³	1000		BGC	CIC	2007	20		good			
14	Weak solution pump	Southern Cross	2	m ³	350		BGC	CIC	2007	20		good			
15	Sand stacker	Krebs	1				BGC	CIC	2007	20		good			
16	Solution heater		1				BGC	CIC	2007	20		good			
	Additional equipment and machinery required to acquire														

Operation technology	Open pit mining
Blasting is conducted or not	Buried charge blasting is conducted for soil stripping and ore mining uses

3.3.17. Land use status at the Heap Leach Project site

BGC Heap Leach Project in Bayangol soum, Selenge aimag will be implemented on 33 ha land under the Boroo mine license held by the company, and in order to recover gold with heap leaching, the land use certificate #0003090 has been obtained from Bayangol soum in 2007 which was extended for 5 years until 2017 based on the Decision A/214 of the Governor of Bayangol soum, dated August 25, 2012.

The below table shows brief information about the mining licenses held by BGC.

Table 3.14. BGC’s mining licenses held to mine the Boroo deposit

/	Mining license name	Jurisdiction	License number	Area (ha)
1	Boroo	Bayangol, Mandal	198	1398.55
2	Ikh Dashir	Bayangol	238	40.64
3	Boroo	Bayangol	1960	588.18
4	Boroo	Bayangol, Mandal	1970	642.64
5	Ikh Dashir	Mandal	11761	79.43
6	Ikh Mandal	Mandal	12039	910,57

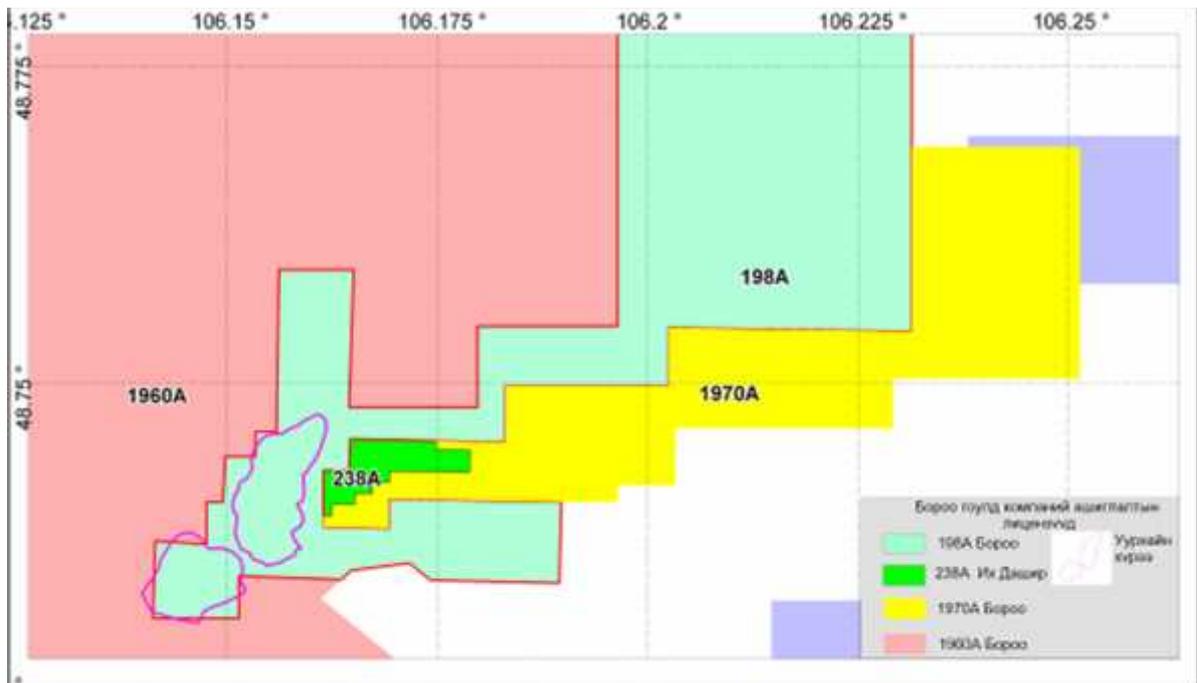


Image 3.13. BGC mining licenses and Boroo mine location map.

General map of the project land use in Image.3.21 is shown as “Boroo mine general layout” and Image 3.22 “Heap Leach pad layout”. The following table categorizes the land that will be affected with the project operations.

Table 3.15. Areas to be affected with heap leach project operations

Object	Area, ha	Comments
Heap leach pad	30	600 500 m
Pregnant leach solution pond	0,23	Volume is 14274 m ³
Storm water pond	0,774	Volume is 39200 m ³
Ore crushing site	1,5	
Other roads and areas	0,5	20 m wide road
Total	33,0	

According to the above calculations, the planning was made not to exceed the land specified in the land use certificate. General land use status was studied during the project site field work in October 2012 and May 2014 which is shown in Images 3.16-20.

Certain piece of land will be disturbed with project operations which will have to be reclaimed in accordance with the mine closure plan. Reclamation plan is reflected in Chapter 5.



Image 3.14. Heap leach stockpile



Image 3.15. Pregnant leach solution pond



Image 3.16. Crusher area



Image 3.17. Ore haulage



Image 3.18. Heap leach facility

Image 3.19. General layout map of the Boroo mine

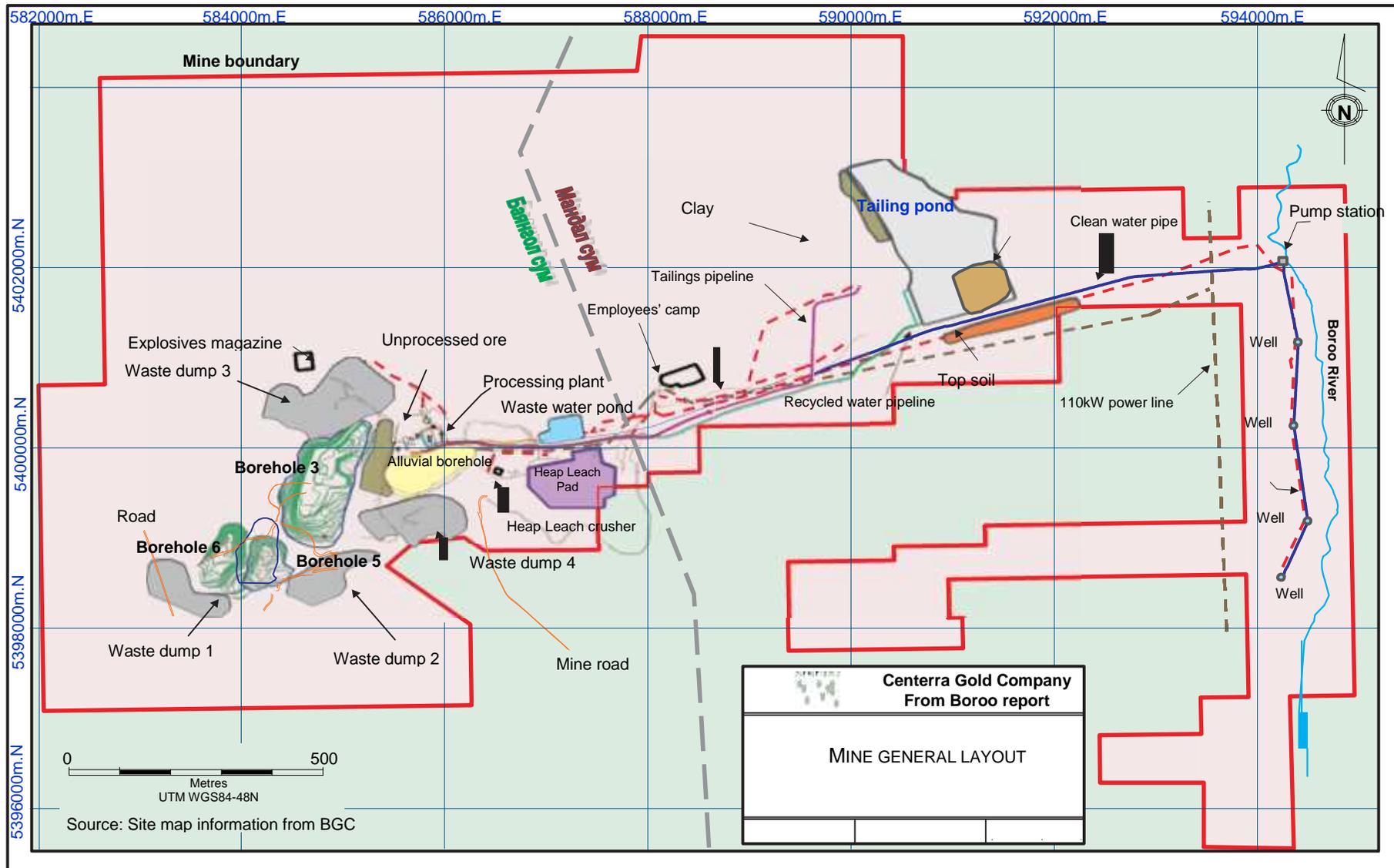
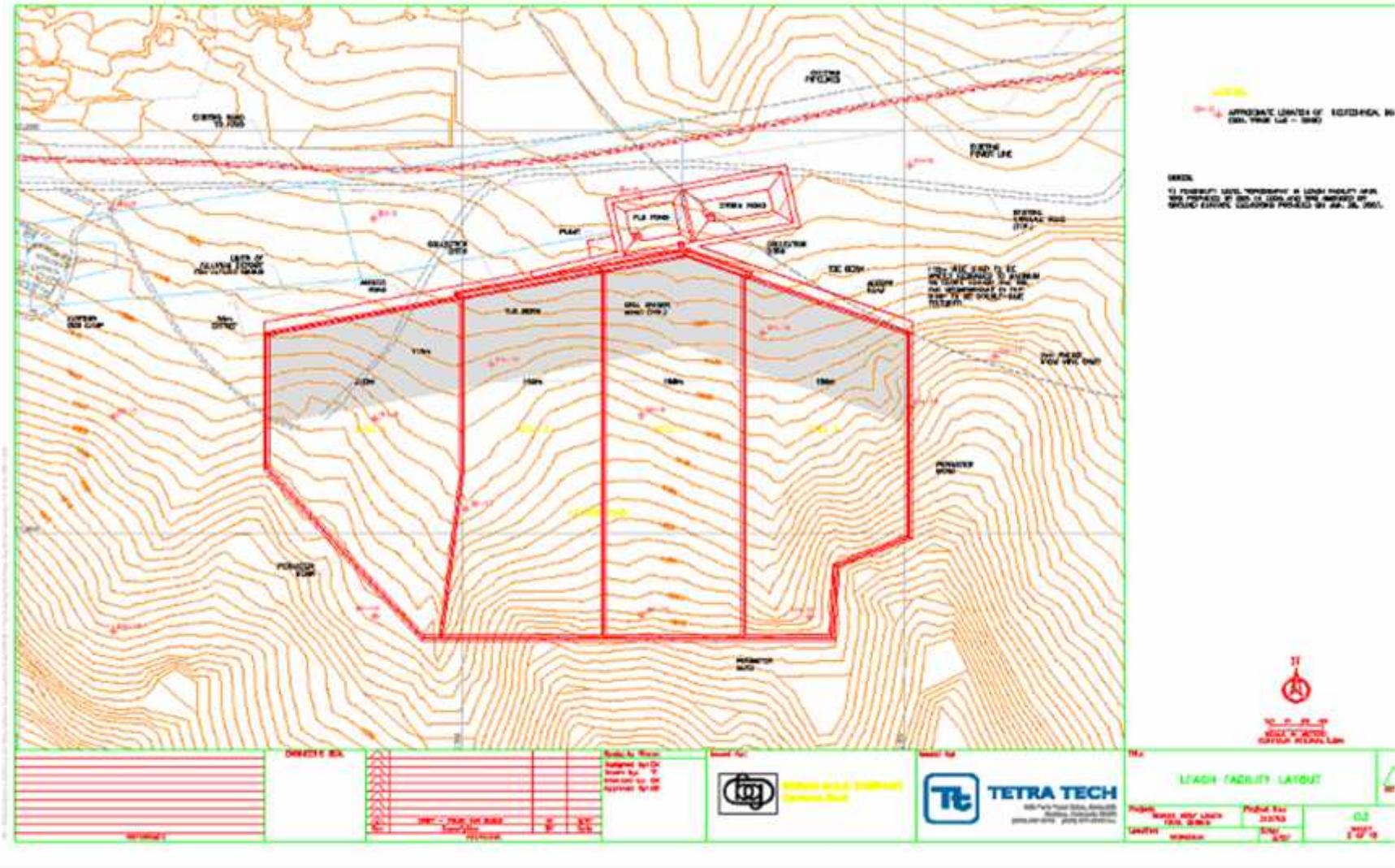


Image 3.20. Layout map of the heap leach pad



3.4. RAW AND SUPPLEMENTARY MATERIALS, END-PRODUCT, WASTE

3.4.1. Natural resources

BGC Heap Leach Project operations will use natural resources such as water, ore and coal and the below table reflects detailed information on their use, quantity and sources.

Estimation of raw materials. Estimate of natural raw materials to be used in Heap Leach Project operations is shown in Table 3.16.

Table 3.16. Raw materials estimate

	Name, type	Quantity		Comments
		unit	total	
Natural resource				
1	Ore	3 mln tn/year	9.8 mln tn	from pits
2	Water	-	55000 m ³ /month	from mill water
3	Coal		9.5 tn/year	To be imported and used in carbon column to recover gold from solution.

Water use:

Source: BGC mine supplies its water from wells located in 6 km from the mine and equipped by certified meters will be the main source of water to be used in Heap Leach Project.

. Industrial purpose water consumption: Water for the project activities will be used for processing and leaching operations as well as drinking and household purposes of employees.

Table 3.17. Quantity of required water, technological use

	Activity	Daily water consumption amount, m ³	Total, m ³
1	Heap leaching	150	55000
2	Irrigation to combat dust	10	2600
Total required water, m3		160	57600

B. Drinking, household water consumption: Total of 11 employees will work for the Heap Leach Project, and the below Table 3.18 shows the estimate of water consumption at the rate of 25 l if it is supplied from underground water transmission wells under the Decree #153 of the Minister of Nature and Environment on “Temporary norm”, dated 1995.

Table 3.18. Required water quantity, Employee’s drinking and household water use

	Water consumers	Norm	Number of people	Daily consumption, l	Work days	Annual consumption, l
1	Permanent employees	25 l/day	11	275	300	82500

Total water consumption: Estimation of total water consumption:

$$\text{Daily } 160 \text{ m}^3 + 0.275 \text{ m}^3 = 160.275 \text{ m}^3$$

$$\text{Annual } 57600 \text{ m}^3 + 82.5 \text{ m}^3 = \mathbf{57682.5 \text{ m}^3}.$$

Above estimation shows that total daily consumption of water is 160.275 m³ and annual is 57682.5 m³. Number of employees and number of work days are used as specified in the project.

3.4.2. Supplementary materials and chemical substances

During the project implementation period, no chemicals or radioactive substances will be used other than supplementary materials shown in table below. (Table 3.19)

Table.3.19.

Reagent name	Chemical formula	UOM	2014	2015	Total, tn
			43 603,622	4 476,667	8 080,289
Sodium cyanide	NaCN	kg/tn	194	149	343
Lime		kg/tn	875	875	175
Activated carbon		tn/day	41	28	69
Hydrochloric acid	I	tn/day	7	4	11
Caustic soda	N	tn/day	28	14	42
Antiscalant		l/m ³	12	19	31

Note: Refer to Chapter 6 for chemical risk assessment.

1. HDPE Geomembrane – High density geomembrane liner

0.94 g/cm³ high density geo-membrane material is produced by adding catalyst i.e. additional accelerator substance based on L203 to polyethylene resistant to 15-150 atm pressure and temperature of +200-2500C. As a result of adding stabilizer substances such as carbon black and oxidation stabilizer to this material, the material is made highly resistant to weather, ultraviolet rays and any chemical substances. This HDPE liner is highly resistant to friction and has exceptional physical parameters.

Parameters:

- Mechanical characteristics: highly flexible and tolerant to handling
- Chemical parameters: extremely resistant and tolerant
- Heat parameters: extremely tolerant to cold weather
- Parameters on reaction with pollutant substances: extremely tolerant to filtered waste water and alkali
- No leakage through weld joints as a result of thorough examination of wedge welding and monitoring during installation.

HDPE is used waste points, wastewater treatment facility, ponds and dams..

2. Diesel fuel

Fuel consumption of vehicles and equipments to be used for heap leach project is shown in Table 3.20.

Table 3.20. Fuel consumption amount

#	Equipment	Model	Daily work hours	Amount, ea	Hourly fuel consumption, l	Total operating days	Total fuel consumption, tn
1	Dump truck	773	20,86	4	41,7	300	2087,667
2	Loader	988	20,86	1	48,94	300	306,264
3	Bulldozer	Liebherr P674	20,86	1	35	300	219,03
4	Water truck	-130	20,86	1	10	300	62,58
5	Excavator	Liebherr R924	20,86	1	25	300	156,4
	Total			8			2831,98

3.4.3. End-product

The purpose of this project is to process 9.8 million tons of low-grade ore that cannot be currently processed through the processing plant of Boroo Gold LLC with heap leaching method and produce 4407 kg of gold.

- **Brief introduction of the BGC processing plant**

The processing plant (Image 3.21) operates all year around and the design of the plant is prepared to process the ore of the Boroo hard-rock deposit. The Boroo gold plant produces end-products in form of gold bullions by processing the hard-rock deposit ore and recovering gold by CIL technology which is widely used internationally.

This plant which recovers gold with hydrometallurgical method has a primary crusher, semi-automatic grinding (SAG) mill, ball mill, classification hydro-cyclones, CIL, desorption and detoxification equipment, gold recovering and reagent preparation units, technological gas and water supply equipment installed. Also, gold to be recovered with gravity concentration method is processed by cyanide of concentrate produced by centrifugal force method.

Primary crushing facility is a separate building which includes mill, sand pump, hydro-cyclone, gravitation and desorption equipment and a gold room and leaching and absorption tanks are placed outside the building. Thickener is made of metal structure and the walkways are placed on the top of the leach and adsorption tanks connecting the buildings. Waste catching screen, pumps, precipitant preparation equipment, mixing equipment, carbon screens are located in this building. Detoxification reactors and reagent mixing equipment are installed in a separate building and other equipments are in separate buildings. The plant technological flowchart is shown in Image 3.4.

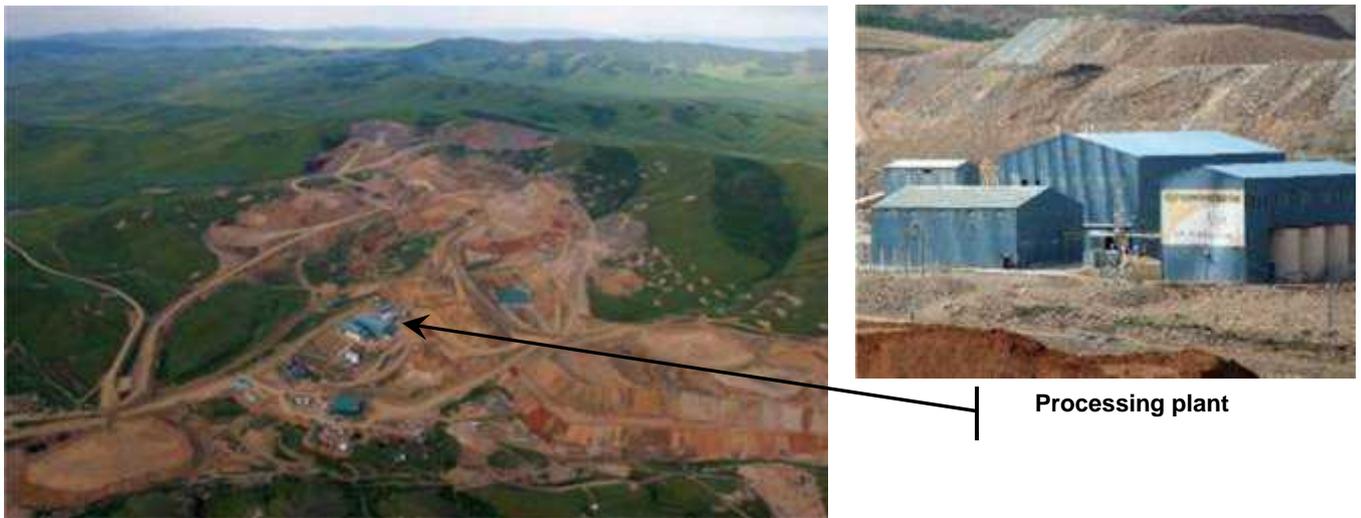


Image 3.21. General view of the processing plant of the Boroo gold mine

3.4.4. Waste

Solid waste:

The project operations will not directly produce large quantity of solid waste and the only solid waste is household waste.

Waste is placed in temporary waste dump site for a certain period of time and then transported to centralized waste dump area on the company vehicle.

Waste should be sorted and stored in sealed containers that are easy to move. Waste should be sorted as glass bottles, cans, paper, food residue and other waste. Recyclable waste should be delivered to the secondary raw material places and the rest, i.e. non-recyclable waste should be disposed in waste dumps.

Total of 11 employees will work for the Heap Leach Project, and their household solid waste was estimated based on the average of 2 kg per person per day as 22 kg (11 × 2 kg), i.e. in a month 30 days 22 kg = 660 kg.

Gaseous waste:

Gaseous waste includes dust produced due to heavy duty equipment and light vehicles to be used in Heap Leach Project operation and some other operations of the mine. (Table 3.21.)

Table 3.21. Air pollution sources

#	Equipment	Make	Quantity, ea
1	Dump truck	773	4
2	Loader	988	1
3	Bulldozer	Liebherr P674	1
4	Water truck	-130	1
5	Excavator	Liebherr R924	1
	Total		8

3.5. ECONOMICS

Total of MNT 26.2 billion was invested in heap leach project to process the low-grade ore.

As of the first 9 months of 2014 since 2008, total of 3,972 kg of gold has been produced and about MNT 14.7 billion has been paid to the state and local budget as taxes and mineral royalties.

In 2015-2016, proposed production is 346.5 kg of gold and total approximate budget is MNT 10.1 billion.

3.6. INFRASTRUCTURE OF THE PROJECT IMPLEMENTATION AREA

Road communication: The Heap Leach project is located in Bayangol soum territory in 140 km from Ulaanbaatar city, 10 km from Ulaanbaatar-Darkhan-Selenge highway, 19 km from Baruunkharaa, Bayangol soum center, 25 km from Zuunkharaa, Mandal soum center, 3 km from the processing plant, and 5 km from Boroo River. (Images 3.22, a and b)

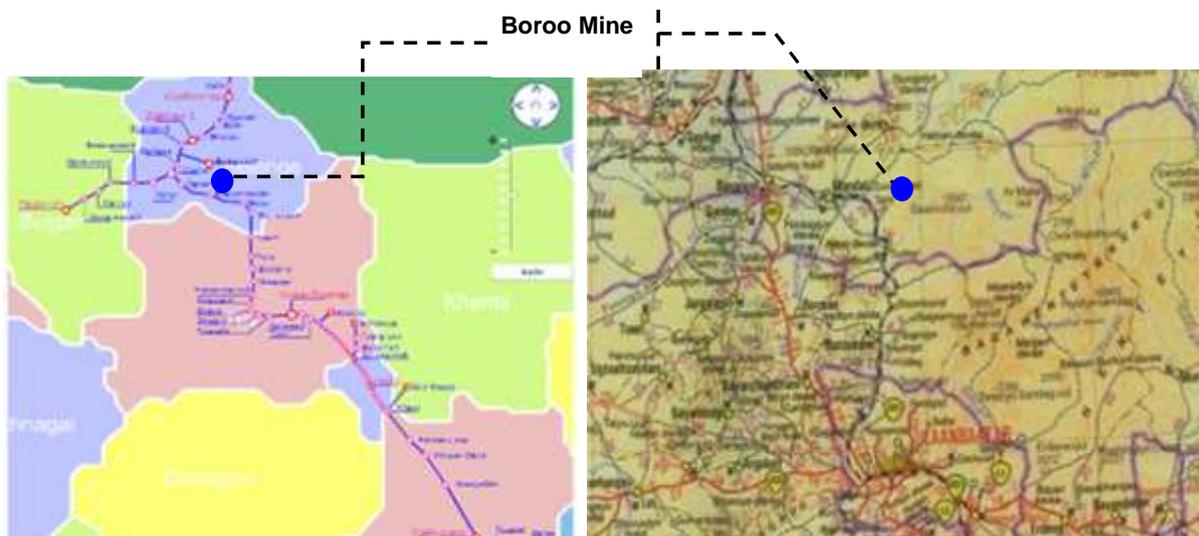


Image 3.22. Mongolian auto road and rail road network map

Source: <http://www.urtu.net>, road network map of Mongolia

Power supply: Power is supplied from a 10 MW sub-station connected to the Central Region centralized power lines (110 kV).

Water supply: The industrial and drinking water of Boroo mine is supplied from 5 wells with in-depth pump (4 operating, 1 reserve) located in the Boroo River valley in about 7 km to the east of the processing plant.

3.7. OTHER PROJECTS IMPLEMENTED IN THE AREA

The Boroo mine of Boroo Gold Company is operating at total of 1969 ha area in the territory of Mandal and Bayangol soums of Selenge aimag in 19 km from Baruunkharaa, Bayangol soum center, and 25 km from Zuunkharaa, Mandal soum center, on the property under mining licenses #1970A and 198A.



Image 3.23. View of the vicinity of the project implementation area (source: Google earth)

3.8. GROUNDS FOR ADDENDUM TO DETAILED ENVIRONMENTAL IMPACT ASSESSMENT OF THE PROJECT

General environmental assessment of Heap leach project of Boroo Gold LLC has been concluded by S.Bayartsetseg, expert of MNEGD. (General assessment conclusion is attached.)

General conclusion:

General environmental impact assessment has been concluded to documents of the Heap Leach project at the hard-rock gold deposit in Bayangol soum, Selenge aimag in accordance with regulation on environmental assessment of Law on environmental assessment and guideline for environmental assessment. As a result of general assessment it is viewed that **Detailed Assessment is required** for the project.

Special considerations:

- To have state certification on land characteristics and quality conducted on licensed property by authorized bodies within time specified
- Environmental auditing should be conducted once in 2 years as indicated in article 10 of Law on environmental protection
- Report of detailed impact assessment should include recommendations and conclusions of meetings with government officials and local communities of project implementation territory and meeting minutes should be attached to the report
- Detailed assessment and its conclusion should be drawn whether the project implementation territory overlaps with State and local protected areas, historical and cultural, archeological and paleontological rare findings sites and other legally restricted or limited areas, plant and wildlife habitat and migration path, spring head and forest reserve and watershed areas.
- To define environmental damage that will occur due to mine operation by each natural component such as vegetation, soil, water, fauna and air in accordance with “environmental damage assessment and reimbursement calculation method”, pre-assess total damage caused by disturbance of the land to draw clarification and conclusion of environmental responsibility and economic grounds of the project implementation.
- To define in detail direct and indirect impacts of project activities on natural reserves defined by environmental baseline study of the area, develop environmental protection plan on five-year basis with detailed description of time and cost for environmental protection, mitigation of any pollution and reclamation activities.
- To develop and include in environmental management plan a detailed plan on reclamation of areas impacted by ore extraction, heap leach operation and mine camp; develop the plan with detailed calculation of costs for implementation of technical and biological reclamations in accordance with effective reclamation guideline, monitoring of results of biological reclamation and complete reclamation and hand-over to local government of area disturbed by extraction.
- To define detailed methods to collect, classify, recycle and dispose special category wastes generated from heap leach operation such as industrial waste, exploited equipment, used flammable substance and lubricants with no harm to environment and man and animal

health and make it one of the integrated part of the project activity and prepare a recommendation on waste disposal with no environmental impact.

- Conduct detailed estimation of air and soil pollution caused by extraction and ore processing operations of hard rock gold mine, develop recommendations to mitigate and eliminate the impacts and select environmentally friendly technologies and equipment
- To prepare recommendation on preventive measures from impacts on health of employees due to operational safety of mine and mill equipment and occupational health and safety, and to reflect clarification on mining and processing technology.
- To construct a green zone and plant trees in strip planting suitable for the region at acceptable areas of mine tenure near the mine and mill constructions and facilities, prepare and include the green zone scheme in report as an attachment

CHAPTER FOUR. POTENTIAL AND MAIN IMPACTS OF THE PROJECT

4.1. ASSESSMENT OF POTENTIAL IMPACTS OF THE PROJECT

Methods such as systematic sequential and checklists and matrices methods developed by the UN Economic and Social Commission for Asia and the Pacific in 1992 currently used in Mongolia have been used in order to conduct detailed assessment of potential impacts on environmental components and develop impact mitigation methodologies during operations of the Heap Leach Project of the Boroo mine of Boroo Gold Company.

The systematic sequential and checklists method is widely used to define impact of production and mining activities on local environmental component, socio-economic condition, as well as to define form, duration and intensity of the impacts.

Therefore, decision was made that systematic sequential method is more appropriate for the Heap Leach project.

This method is used to identify forms of impacts on environmental components and local socio-economic condition during implementation of the project, re-impacting or one-time impacting of impacts, as well as duration, intensity the impacts. The method is based on whether or not such impacts exist during operations, and if they do, they are marked with "x".

Below table shows the assessment of potential impacts on environment, ecology and local socio-economy due to afore-mentioned operations with the systematic sequential method.

Table 4.1.

Coherence of the potential impact form, duration and intensity with the impact type

Environmental component	Form			Duration				Intensity		
	Direct	Indirect	self-coordinated	Long term	Short term	Re-impacting	One-time impacting	Strong	Moderate	Weak
1. Environmental issues related to the project location										
Impact on underground water										
Degradation of soil and vegetation										
Impact on air										
2. Environmental issues related to the project activities										
Environmental impacts caused by chemicals and cyanide										
Environmental impacts caused by machinery and equipment										
Impacts on water (underground)										
Noise impacts due to project activities										
Impacts on air quality										
Impacts during operations of the Heap Leach facility										
3. Natural resource use										
Underground water										
Soil, ground										
Use of accumulated precipitation water										
Soil fertility										
Vegetation										
4. Environmental changes										
Quality and quantity of potable water (underground)										
Soil erosion and pollution										
Air pollution										
5. Socio-economic issues										
Increase of private property and tax revenue										
Increase of local government revenue										

Increase of number of workplaces										
6. Other issues										
Impacts of noise										
Fire caused due to carelessness										
Flood due to heavy rain and storm										
Increased solid waste and sewage										
Impact of earthquake										
Total	16	6	-	11	10	-	3	6	11	7

Comments: -potential impact, if not checked it is not relevant to the project

- ❖ Direct impact – 16 out of total 24 indicators, i.e. 70.8% is under direct impact. In other words, it increases the probability increase of strength of impact intensity. Although there would be impacts such as soil erosion, centralized source of air pollution, increase of household solid and liquid waste and formation of centralized source of dust due to project operations using natural resources such as soil and ore, there are positive effects such as increase of revenue of private property, state and local budgets, prevention from soil and underground water pollution and ensuring sustainable operations of Boroo mine.
- ❖ Indirect impact – Total 6 impacts are indirect which is 29.1%. They include impacts such as noise produced by heavy duty equipment and machinery during mining operations that impacts employees' health, soil fertility and fire caused due to carelessness.
- ❖ Long-term impact – There are 8, i.e. 33.3%. Decrease of restoration capacity of underground water due to overuse exceed ding standard levels, soil and underground water pollution caused by accidental spillage of heavy metal and other chemicals, infiltration of oil and lubricants due to spillage and other improper actions may cause degradation of underground water quality infiltrated through soil. These impacts requires long period of time to restore.
- ❖ Short-term impacts – There are 14 effects, which is 58.3%. These impacts include effects of noise due to the project operations and environmental impacts caused by equipment and machinery. Short-term impact mitigation management should be optimized. Moreover, short-term positive effects include increase of revenue of private property and state and local budgets and creation of workplaces.
- ❖ Strong impact – There are 7 strong effects such as excessive extraction and use of natural resources including soil and ore, cause of fire due to carelessness and impact of flood due to heavy rain and storm, which add up to 29.1% of impact intensity. Some strong effects might be caused by employees' or organizational careless action.
- ❖ Moderate impact – There are 11, i.e. 45.8% of impact intensity including environmental issues related to project operations, environmental impacts caused by heavy duty equipment and machinery, impacts on air quality, degradation of soil and vegetation.
- ❖ Weak impact – There are 6, i.e. 25% of impact intensity including impact on employees' health caused by noise of heavy duty equipment and machinery during mine operations, as well as increase of solid and liquid waste, underground water use.

4.2. MAIN IMPACTS OF THE PROJECT

As mentioned above, the potential impact study shows that the project's positive aspects will add up if environmentally-friendly operations are carried out in timely manner by fulfilling the recommendations of the company conducted the assessment such as mitigation of environmental impacts on air, soil, vegetation and underground water, protection of soil from pollution and erosion, mitigation of air pollution and its protection during the implementation of the BGC Heap Leach Project in Bayangol soum, Selenge aimag.

The main impacts of the project is soil destruction on 33 ha land due to establishment of the heap leach pad, dust pollution caused by movement of heavy duty equipment used in heap leaching operations, cyanide and other chemical substances that may evaporate in the air or infiltrated into the soil from the heap leach stockpile, pollution of soil and vegetation due to spill

of oil and lubricants used for equipment, noise created from the project and steppe fire caused by carelessness.

In order to prevent from dust pollution created by heavy duty equipment, the roads and areas should be irrigated on regular basis, toxic gas filters should be installed in vehicles, all areas used for Heap Leach Project activities should be reclaimed in accordance with the Mine Closure Plan, and environmental monitoring program should be regularly implemented at heap leach area.

Afore-mentioned main impacts are related to the project operations. Tables 4.2-4.4 show main impacts related to the project operations and its location.

Table 4.2.

Main impacts assessment criteria

Level	Grade	Comments		
		Impact	Assets	Solution
V	– high	Formation of certain amount of dust pollution	Medium damage	Solution to mitigate the impact has been reflected
III	E – high	Spillage of oil and lubricants used in vehicle and equipment	Low damage	Operational control and proper use
IV	High	Formation of waste ore stockpile	Medium damage	Use for reclamation at mine areas
V	Medium	Noise and vibration pollution	Medium damage	Use protective equipment

Table 4.3.

Probability assessment criteria

Level	Grade	Comments
I	Not likely to occur	Might be risky at certain circumstances (<5%)
II	Might not to occur	Might be risky sometimes (5-20%)
III	Potential	Sometimes risk is created (20-50%)
IV	Might occur	Might be risky at almost every circumstance (50-70%)
V	Definite to occur	Almost every circumstance is risky (70-100%)

Table 4.4.

Risk quality assessment matrix

Probability	Consequence				
	minimal	low	medium	a lot	disaster
I almost never occur	L	L	M	H	H
II probable not to occur	L	L	M	H	E
III might	L	M	H	E	E
IV probable to occur	M	H	H	E	E
V definite to occur	H	H	E	E	E

Table 4.5.

Risk quality explanation

Risk level	Management
L –low risk	To be regulated with normal operational procedure

M- medium risk	To be the responsibility of the organizations' management and liabilities must be made clear
H –high risk	Senior management of the organization, local government and inspection organizations must pay attention to.
E- disastrous risk	Senior management of the organization, state specialized inspection agency and emergency management organization must pay attention and undertake special actions

BGC environmental monitoring and monitoring tools and devices

The company regularly carries out environmental monitoring activities using its own tools and devices.

Air monitoring: The mine site has an automated weather station located near the Boroo tailings facility. BGC has been monitoring and taking measurement of 6 chemicals including O₂, CO, SO₂, NO₂, HCN, NH₃, at 13 points within the mine territory with frequency of 10 days.

Soil monitoring: Soil samples are collected from pre-defined points at the mine and besides being sent to accredited laboratories, samples are sent to laboratory in US as well.

Underground water monitoring: 14 monitoring wells at the project territory is used for underground water monitoring, 8 of which are located on the east of the tailings dam and 5 at the Heap Leach project site.

The tools and devices are shown in the below Table.

	Name	Purpose of use / Measuring items	Image
A	Air aerosol and chemical element monitoring		
1	Portable gas detector (ARTM 0713)	Portable device to measure air quality, composition and levels and permissible levels of chemical elements (NO ₂ , O ₂ , CO, HCN, NH ₃ , SO ₂ , CH ₄)	
2	Safe gas detector (Drager Polytron 7000)	Stationary device to measure air quality, composition and levels and permissible levels of chemical compounds (HCN)	

<p>3</p>	<p>Safe gas detector (Dragger X-am 5000)</p>	<p>Portable device to measure air quality, composition and levels and permissible levels of chemical elements (NO₂, O₂, CO, HCN, NH₃, SO₂, CH₄)</p>	
<p>4</p>	<p>Gas Alert HCN extreme</p>	<p>Portable device to measure HCN in air and define its permissible level</p>	
<p>5</p>	<p>PM10 Dust monitoring equipment</p>	<p>Stationary device to measure coarse dust and aerosol in the air</p>	 
<p>Underground and surface water monitoring</p>			
<p>6</p>	<p>Aqua CPA pH Conductivity/ Temperature Meter</p>	<p>Portable device to measure conductivity, acidity, pH and temperature of water</p>	

7	pH/ Temperature Meter/Hanna waterproof pH meter	Portable device to measure acidity, pH and temperature of water	
8	HANNA HI 9828 Multi Parameter Water Quality Meter/Data Logger	Portable device to measure water quality, chemical and physical parameters (DO, pH, C ⁰ , Atmospheric pressure, Resistivity, Conductivity EC, TDS, Salinity, ORP)	
9	Water level meter (Solinst)	Portable device to detect and measure water level in the borehole	
10	Water flow velocity meter (General Oceanics-2135)	Electronic portable device to measure small stream velocity	
11	Bailer	Portable device to take underground water samples from borehole	

12	Ice auger	Drill to break ice on surface water	
13	Clements	Heating container /drier of sample containers	
14	Cooler ice	Cooler ice	
15	Socorex micro pipette	Automatic pipette with ml accuracy	
Soil and vegetation monitoring			
16	Automatic weather station (Campbell Scientific)	Automatic weather station, a stationary device to measure precipitation, evaporation, temperature, humidity, sun ray, wind direction and speed and air pressure	

17	GPS (Garmin-Etrex Geographic Position System)	Portable GPS device	
18	Canon digital camera	Photo monitoring	
19	Soil sampler auger	Portable device to take samples from soil depth and loose alluvium	
20	Electric scale (Citizen)	Electronic scale (with 0.000 g accuracy)	
21	Plant net	It is used in taking geobotanical record of plants and defining vegetation cover and species population	

22	Seed collector	Electronic portable device to collect plant seeds	
23	Seed sieve	Screen to clean collected plant seeds	
24	Pesticide sprinkler	Pesticide and herbicide sprinkler	

4.2.1. Air pollution, its impacts

Main source of air pollution are 8 heavy duty machineries that will be used in the project as specified in Table 3.11 of Chapter 3.

Air pollution caused by automobiles has been estimated by two methods, i.e. total pollution for the entire life of the project and amount of toxic gas pollution from the vehicles along the auto road for certain period of time.

The pollution created by air pollution sources is estimated as follows.

Calculation of toxic gases emitted by vehicles along the auto road

The pollution can be calculated with equation (K) (Begma and others, 1984; Shapalov, 1990) that evaluates concentrate of carbon monoxide emitted from machinery and equipment used in the Heap Leach project implemented by BGC in Bayangol soum of Selenge aimag.

$$K = (0.5+0.01N \cdot \dots) \cdot \dots \cdot \dots ;$$

Herein: 0.5 – background atmospheric pollution of non-vehicle source, mg/m³,

- N - Total traffic intensity on road, veh/hour.
- - coefficient of toxicity of CO exhausted from vehicle into atmosphere,
- - coefficient of aeration of a section
- - coefficient of reduction of atmospheric CO pollution along the road
- - coefficient of reduction of CO concentration caused by wind speed
- - coefficient of reduction of CO caused by atmospheric relative humidity
- - coefficient of increase of CO pollution at crossroads

Toxicity coefficient of vehicles is defined with the following equation deeming the traffic flow rate as weighed average.

$$= \sum_i K_{Ti}$$

Herein: \sum_i – percentage of units of auto transport structure.

During measurement (1 hour) total of 10 vehicles (1 light vehicle, 9 heavy duty equipment) are driven by, and total pollution is estimated as $C_{CO} = 1,85 \text{ mg/m}^3$. Compared to permissible maximum level of CO (5 mg/m^3), pollution is 2.77 times lower, that indicates that the road side air pollution amount is relatively lower than permissible maximum level.

Estimation of toxic gases emitted from project vehicles and equipment

Toxic gas produced from fuel combustion of vehicles and equipment used in project operations is estimated as follows.

Total of eight equipments are used including 4 dump trucks, 1 bulldozer, 1 wheel loader, 1 dump truck, and 1 water truck.

Light vehicles and light weight trucks use 40 l of fuel per day and heavy duty equipment uses 150 l of diesel fuel. Calculation of air pollutant gas is shown in Tables 4.6 and 4.7.

15.91 kg of toxic substances are produced from combustion of 1 ton of diesel fuel. (Table 4.6)

Table 4.6¹

Toxic gas	CO	NOx	Benzopyrene	SO ₂	Carbon	Carbon black
gr	0,1	0,04	0,32	0,02	0.03	15,5 kg

Table 4.7. Amount of toxic gas produced in one day of operation of main vehicles and equipment

	Toxic gas, gr	Vehicle and equipment		
		Light vehicle (year) - 2 pcs (200 l)	Heavy duty equipment and machinery -8 pcs (26000 l)	Water truck -1 (100 l)
1	CO	0,02 gr	1,13 gr	0,01 gr
2	NOx	0,008 gr	0,4 gr	0,004 gr
3	C	0,006 gr	0,33 gr	0,003 gr
4	SO ₂	0,004 gr	0,22 gr	0,002 gr
5	Benzopyrene	0,064 gr	3,61 gr	0,032 gr
6	Carbon black	3100 gr	135217,3 gr	1550 gr
	Subtotal	3400,12 gr (3,4 kg)	135222,99 gr (175,22 kg)	1700,6 gr (1,7 kg)
	Total	140323,71 gr (140,32 kg)		

Total toxic gas emitted in a month based on the above calculation:

$$140,32 \text{ kg} \times 30 \text{ days} = 4209,6 \text{ kg, i.e. 4,2 ton}$$

Total toxic gas produced throughout project life: /774 days/

$$140,32 \text{ kg} \times 774 \text{ days} = 108607,68 \text{ kg, i.e. 108,6 tons}$$

Dust pollution

¹ -Engineering reference-5, 2011

Certain amount of dust is created in area near the Heap Leach pad during the project operations and from use of heavy duty equipment in the project. Also, soil erosion and soil loosening caused by human activity and vehicle traffic creates dust pollution through wind blow and other mechanic factors. Results of analysis to define mechanic composition of soil at heap leach area are shown in Table 4.8.

Table 4.8. Soil mechanical composition

Cutting	Depth, m	Grain size, % (mm)		
		Sand, (2-0.075mm)	Dust/clay, (0.075>)	Gravel, (<2)
1	0 – 1	10,3	89,7	0
	1 – 3,5	35,3	64,4	0,3

Due to erosion, decrease of both content of humus and adhesiveness of soil forms loose soil that in turn, creates condition for dust dispersion in the air. It is considered that soil particles spread with wind in three ways. Large 0.5 mm dust particles roll on the ground in direction of wind; 0.1-0.5 mm particles are carried by wind into the air for certain period of time and fall down then blown again; and particles less than 0.1 mm (especially less than 0.01 mm) are carried high up in the air, do not fall on the ground blown by wind for a long period of time. Moreover, large particles with 31-62 mkm diameters may travel up to 320 km, particles with diameter of 16-31 mkm for 1600 km and fine particles less than 16 mkm may travel around the world².

Estimation of such sand migration uses software such as: for sand concentration - QM.for, calculation of dispersion - heavy_xy.for, and amount of migrating sand mass - MASS.for.

Dust particle concentration: Composition of sand particles at the project site shown in Table 4.8 consists mostly of, i.e. 89.7%, fine dust particles with diameter less than 0,075 mm. (Table 4.8)

The estimation considers 2 scenarios: average wind speed at 4 m/sec and maximum wind speed at 15 m/sec.

When wind speed is 4 m/sec, most of dust particles, i.e. over 80% is carried into the air up to 1-250 m and compared with total amount of 10.066x g/m²*s, it is 2.032 10³ g/m²*s at times of wind with speed of 15 m/sec. These results do not include sand humidity, adhesiveness and correlations, but is highly possible in relatively dry summer seasons. The area with potential dust pollution is 33 ha and amount of dust particles with size of 0.075 mm to be blown for 2 hours is calculated as follows: (average dust storm duration is 2 hours)

$$Q_1 = 3.3 \cdot 10^5 \text{ m}^2 \cdot 10,066 \text{ g/m}^2 \cdot \text{s} \cdot 7200 \text{ s} = 1.78 \cdot 10^8 \text{ g} = 178 \text{ tn (wind speed 4 m/sec)}$$

$$Q_2 = 3.3 \cdot 10^5 \text{ m}^2 \cdot 2,032 \cdot 10^3 \text{ g/m}^2 \cdot \text{s} \cdot 7200 \text{ s} = 6.8 \cdot 10^8 \text{ g} = 351,12 \text{ tn (wind speed 15 m/sec)}$$

Sand volume calculated from density of 1,72 tn/m³:

$$V = m/\rho = 178 \text{ tn} / 1,72 \text{ tn/m}^3 = 103.37 \text{ m}^3$$

Total area is 33.0 ha, i.e. 3,3*10⁵ m², thus sand thickness is:

$$H = V/S = 103.37 \text{ m}^3 / 3,3 \cdot 10^5 \text{ m}^2 = 0.0004 \text{ m, i.e. 0,04m.}$$

In other words, in two hours with wind at speed of 4 m/sec, 178 tons of 0.075 mm diameter sand particles will be blown by wind from disturbed area and mine road of the project, i.e. 4 cm clayey layer will be blown by wind.

The content of dust particles in air blown by strong wind becomes less in a distance from its source depending on wind speed. (Image 4.2, 4.3)

² - Spatial and temporal variations of dust concentrations in the Gobi Desert of Mongolia, Dulam Jugder, Masato Shinoda... etc

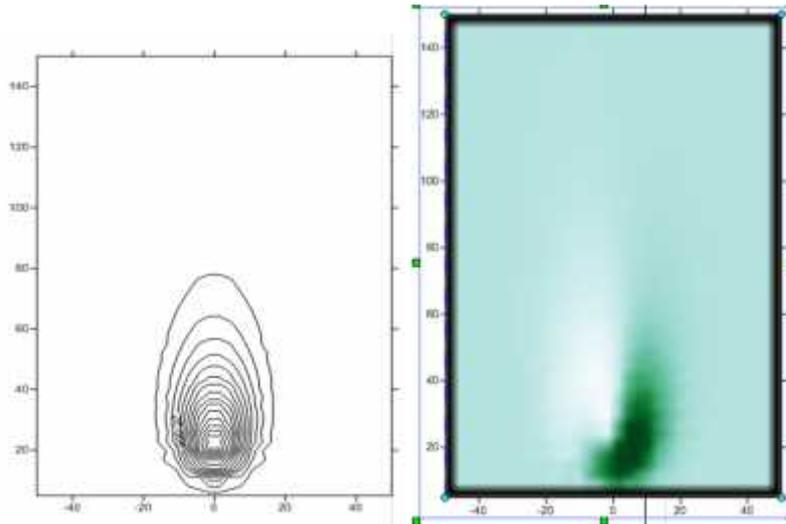


Image 4.2. Dust dispersion (50 150m)

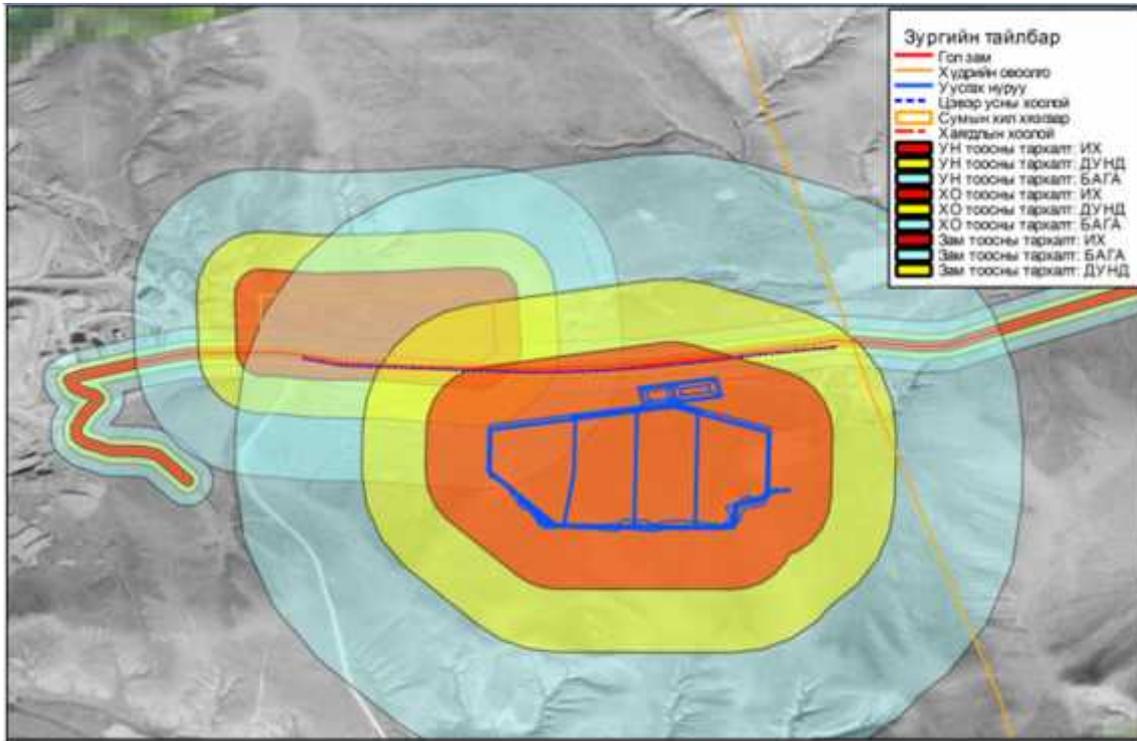


Image 4.3. Dust dispersion, impact zone³

Impact of dust pollution on human health:

PM10 and Ðì2.5 dust particles contain numerous chemical elements and with inhaling they enter human body and blood causing lung and liver cancer and pulmonary disorders, reduce oxygen in blood and number of red cells and weaken immunity. The following table shows effects of PM10 on human health prepared by WHO.

Table 4.9. Daily average amount PM₁₀ and its impact on health

Impact on health	Percentage of increase of risk with increase of PM ₁₀ by 10 µg/m ³
------------------	--

³ -DEIA report of BGC Heap leach project, JMR LLC, Usnii Erchim LLC, 2007

<u>Growth of average daily mortality</u>	
Total mortality	1.0
Mortality due to inhalation diseases	3.4
Pulmonary disorder	1.4
<u>Growth of hospital visits</u>	
Visit to hospital	0.8
Number of emergency calls	1.0
<u>Growth of bronchial asthma</u>	
Acute asthma	3.0
Number of emergency calls	2.9
Visit to hospital	1.9
<u>Growth of inhalation disease symptoms</u>	
Lower inhalation system	3.0
Upper inhalation system	0.7
Cold	1.2

Results of field study on air pollution

During environmental impact assessment study on May 17, 2014 air quality measurements have been conducted using dust metering device (Dust Track) and other devices at mill area, and samples are sent for analysis to Central Environmental Measurement Laboratory (results of analysis are shown below).

Table 4.10. Results of air analysis

	Sampling location	Sampling date	SO ₂ , mg/m ³	NO ₂ , mg/m ³	NO, mg/m ³	O ₃ , mg/m ³	Dust / 10/ content mg/m ³
1	Inside the mill	2014.05.17	0.065	0.031	0.093	0.301	0.076
	Air quality standard		0.450	0.085		60.0	0.100

Above results show that content of defined gases and dust are within the permissible levels specified in Mongolian standard MNS 4585:2007 on Permissible maximum levels of air pollutant in the environment.



Image 4.4. Air sample collection inside the mill /2014-05-17/



Image 4.5. Dust measurement in the mill using dust measuring DUSTTRACK device

Evaporation of hydrogen cyanide from sodium cyanide solution

When concentration of HCN reaches 5 ppm in atmosphere, the condition is considered as hazardous. Therefore, HCN sensors are installed. When the concentration reaches 10 ppm, the condition is considered as extremely hazardous and evacuation plan should be prepared for this case. HCN forms when cyanide solution pH=9.7, therefore pH of solution should be higher, 11 in average. When is too high, it increases the use of lime and contaminates activated carbon, therefore, the optimal pH is 11.

When the sodium cyanide evaporates, it can easily react in air and convert to hydrogen cyanide which creates a toxic substance content in air. The hydrogen cyanide HCN is a flammable and extreme toxic gas when temperature over 26°C. Permitted quantity in the air of working place is 0.3 mg/m³ and human body will be weakened and poisoned slightly when spend 1 hour in the air with quantity of 40-50 mg/m³.

Considering this situation, for the purpose of determining an assessment of impact on evaporation of sodium cyanide in air, the cross section of the heap leach facility is shown on Image 4.7, the heap leach profile is shown on Image 4.8 and an evaporation outline is drawn by ellipse.

Although, evaporation from 1m² areas of the heap leach facility is nearly equal to permitted maximum quantity of sodium cyanide, this 120-150 mg/m³ vapor will be accumulated (Table 4.12) in air over the facility as shown on Image 4.9 in a minute in calm weather condition. However, the sodium cyanide solution content will be 0.1% as planned, the most of the evaporation will convert into hydrogen cyanide when it drops down from pH 10 and it likely has an impact on the environment.

In result of our investigation, wind blows from east to west in day time and in opposite direction in night time around the heap leach facility. The vapour in the air will disperse by ellipse shape shown on the Image 4.9 when wind blows north direction from top of the facility to the ger camp in day time and its air volume has estimated from ellipse center within distance of 500-2000m (200-1700m from the surface of the facility) in the table 4.12.

The vapour content conversion in air, blew by wind, is shown in table 4.13. However, this chart is a possible vapour quantity in air content during evaporation of 0.1% sodium cyanide, in

comparison of permitted quantity of hydrogen cyanide in the air. It is nonhazardous at distance of 700m from the facility, but hazardous gas will increase inside it and it could be poisonous with toxic gas within distance of 100-200m from the heap leach facility's surface.



Image 4.6. Cyanide evaporation and its change in concentration caused by wind dispersion prepared using data of cross section of heap leach facility, 1st zone of evaporation and multi-year average evaporation of surface water in May and June



Image 4.7. Cross section of heap leach facility and 1st and 2nd zone of evaporation

Table 4.11

Multi-year average of water surface evaporation in May and June

Month	Evaporation			Area (m ²)	Volume (m ³)	
	Mm/month	Mm/day	Mm/hour		In hour	In a minute
May	171.7	5.72	0.36	300000	107	1.79
June	196.6	6.55	0.41	300000	123	2.05

Table 4.12

Surface evaporation g/m³-hour, min

Month	m ³ /m ² -hour	g/m ³ -hour	mg/m ³ -hour	mg/m ³ -minute	PML mg/m ³
May	358	0.0004	0.3577	0.0060	0.3
June	410	0.0004	0.4096	0.0068	

Image 4.8 Evaporation dispersed by wind shown in ellipse shape

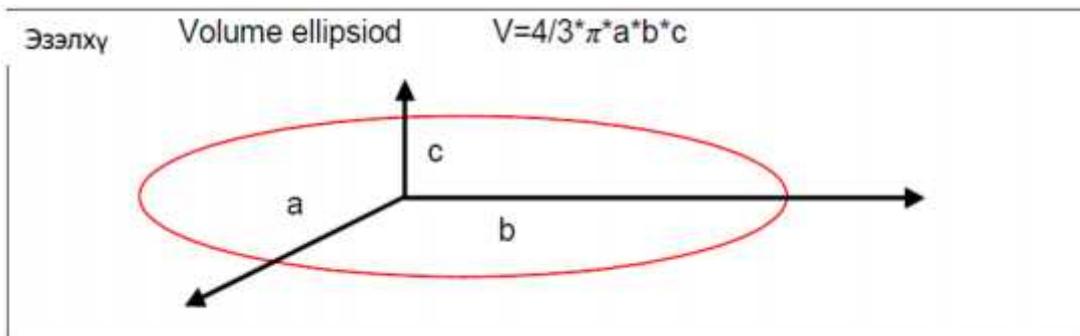


Table 4.13. Vapor content conversion in air blown by wind

#	a	b	c	V mln m ³	V ore Mltn	V Mlm ³	V aer Mlm ³
1	220	500	50	23.03	18.5	10.88	12.14

2	220	600	50	27.63	18.5	10.88	16.75
3	250	700	50	36.63	18.5	10.88	25.75
4	260	800	60	52.25	18.5	10.88	41.37
5	270	900	70	71.22	18.5	10.88	60.33
6	280	1000	80	93.78	18.5	10.88	82.90
7	290	1100	90	120.20	18.5	10.88	109.32
8	300	1200	100	150.72	18.5	10.88	139.84
9	310	1400	110	199.87	18.5	10.88	188.99
10	320	1600	120	257.23	18.5	10.88	246.35
11	330	1800	130	323.29	18.5	10.88	312.41
12	340	2000	140	398.57	18.5	10.88	387.69

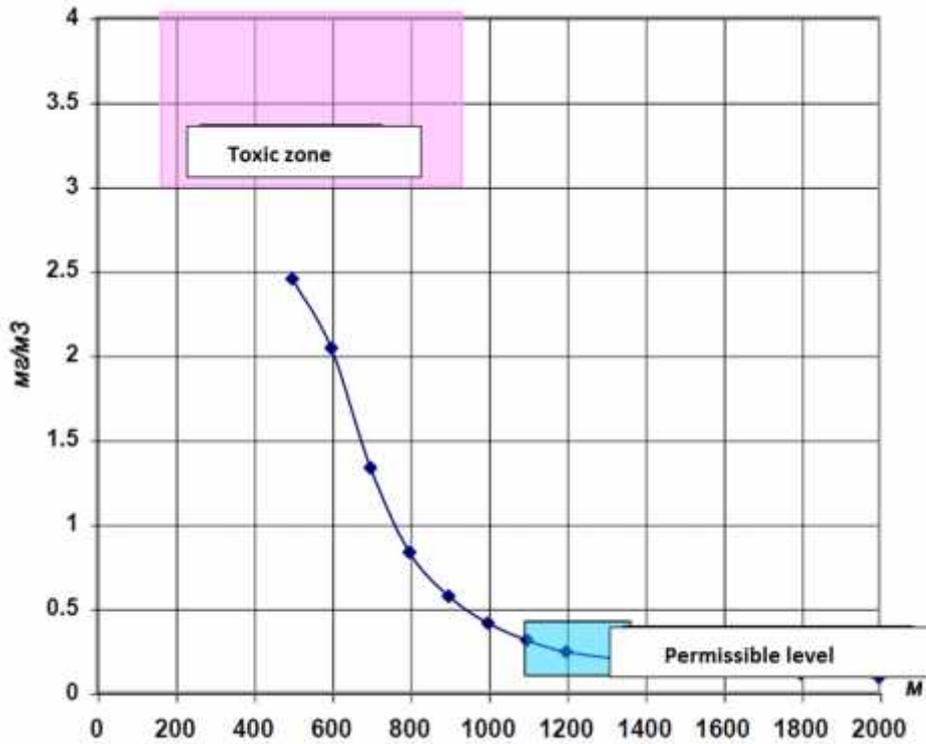


Image 4.9. Toxic zone

4.2.2. Soil erosion

Soil erosion is classified into natural and technogenic, and natural soil erosion is also classified into 2 categories based on erosion process: water and wind weathering.

Implementation of the heap leach project of BGC will disturb and cause erosion of 33.0 ha of undisturbed land.

Table 4.11. Land disturbed by heap leach project operation

Facility	Area, ha	Comments
Heap leach pad	30	600 500 m
PLS pond	0,23	Volume 14274 m ³
Flood water diversion channel	0,774	Volume 39200 m ³
Ore crusher area	1,5	
Other road and areas	0,5	20m wide road
Total	33,0	

The area disturbed due to mechanic activities as well as the tailings pond should be reclaimed in consistence with mine closure plan in certain phases in accordance with standards.

As mentioned in the soil pollution study section of the project characteristics report, results of the analysis of soil samples taken from project site and results BGC analysis show that the parameters of the results are within the permissible level indicated in Mongolian standard MNS 5850:2008 "Soil quality. Permissible maximum levels of soil pollutant substances and elements".

Cyanide is the main chemical substance used in the project which is an extremely toxic to environment and human health. As part of field study conducted in October 2012, samples have been collected specifically collected from top and middle sections of heap leach pad (level difference is 5 m) and sent to Central geological laboratory to analyze content of cyanide and to Central environmental laboratory for heavy metals.

Result of the analysis shows that amount of cyanide is within the permissible level of MNS 5850:2008 "Soil quality. Permissible maximum levels of soil pollutant substances and elements". However, result of analysis conducted at Central environmental laboratory shows that content of lead is 1600-2478 mg/kg and other 10 elements are within the permissible maximum level. (For test analysis, please refer to Annex)

Table 4.12. Results of analysis for heavy element /CEL, 2012-10-24/

#	Sampling point	Cl mg/kg	Cd mg/kg	Pb mg/kg	Hg mg/kg	Br mg/kg	Cr mg/kg	Zn mg/kg	Cu mg/kg	Co mg/kg	Sr mg/kg	Rb mg/kg	Zr mg/kg
1	Upper part of HL pad	0.0	0.0	2478.3	0.0	398.7	27.3	130.87	29.22	81.53	131.98	150.47	169.3
2	Middle part of HL pad	0.0	0.1	1601.3	0.0	96.6	0.0	113.62	28.88	126.27	124.14	225.16	177.47
PML	MNS 5850:2008		3	100	2		150	300	100	50	800		

Field study has been conducted again on May 17 2014, and samples have been collected from the below mentioned points and sent for analysis of heavy metal to Central Environmental Laboratory. (Table 4.13.)

Table 4.13. Results of analysis for heavy element /CEL, 2014-05-17/

	Sampling point	Cl mg/kg	Cd mg/kg	Pb mg/kg	Hg mg/kg	Br mg/kg	Cr mg/kg	Zn mg/kg	Cu mg/kg	Co mg/kg	Sr mg/kg	Rb mg/kg	Zr mg/kg
1	Upper part of HL pad	0.0	0.0	59.0	0.0	29.2	0.0	149.9	24.8	40.8	218.6	171.9	239.6
2	Near monitoring well HL-6	0.0	0.1	31.4	0.4	0.9	0.0	138.0	25.8	38.9	450.2	162.2	354.6
3	Near monitoring well HL-4	0.0	0.2	34.4	0.0	9.0	0.0	158.5	22.1	59.1	414.2	159.7	328.7
4	Near monitoring well HL-2	0.0	0.7	95.6	0.8	3.6	0.0	88.7	26.7	18.4	277.5	153.6	347.8
PML	MNS 5850:2008		3	100	2		150	300	100	50	800		

Compared to results of previous analysis, content of heavy metal has been decreased and all parameters have been within permissible level of MNS 5850:2008 standard.

Soil wind weathering: In spring when it is mostly dry, soil erosion may occur due to strong windstorms which blow away the surface layer of exposed areas.

Soil erosion water weathering: Soil may erode due to flood water.



Image 4.4. Soil haulage and ore stockpile

4.2.3. Underground water pollution

Underground water monitoring is conducted at 14 monitoring wells in the project property including 8 in the east of tailings dam and 5 at the heap leach project site.

Openly left solid waste and sewage, as well as spill of combustible materials and lubricants infiltrates into the soil and further pollutes underground water. The company management should take in to consideration above facts and should take preventive actions.

Control

The level of the Pregnant Leach Solution pond is measured on a daily basis and the wells to detect leaks (of the leak detection system) are measured on a weekly basis. Exposed liner, solution channel, pond and pipelines should be visually inspected on a monthly basis and all examination results should be recorded.

Underground water pollution study

As mentioned in the previous Chapter, content of most of the analyzed substances within the levels specified in standard MNS 6148:2010. As part of the assessment work, samples from heap leach monitoring wells has been collected twice and sent for analyses Central Water Laboratory of USUG and Central Geological Laboratory for heavy metals and cyanide. Results of analysis No.12/1191 of the Central Water Laboratory (October 1, 2012) show that parameters are within the permissible level specified in MNS 6148:2010 "Underground water pollutant substances' permissible maximum level" standard. Also, results of USUG Central Geological Laboratory analysis (May 17, 2014) show that parameters are within permissible maximum levels of the same standard.

BGC contracts Us Oyu LLC to conduct water sampling and results of sampling from heap leach monitoring wells obtained from the Central Geological Laboratory on April 22, 2014 show that parameters are within the permissible level indicated in MNS 6148:2010 "Underground water pollutant substances' permissible maximum levels" standard. *(For test analysis, please refer to Annex).*

Solution sampling

In order to correctly determine the sampling and operational baseline data it is important to know contents of each element in technological solution. In order to determine detailed characteristics of the solution, the solution parameters should be tested and monitored for the first 5 years of operation with frequency of at least once per year (and regularly afterwards). This enables to obtain necessary data for regular monitoring of underground water with the purpose to gather information on stability of chemical composition of the solution and to define parameters of potential pollutant substances. It also helps to define whether pollutants in water are originated from the heap leach process or other polluting sources.

Since commencement of heap leach operations, underground water quality monitoring has been conducted on a monthly basis. Samples are collected from heap leach monitoring wells and heap leach solution pond. These water quality indicators become baseline indicators of

water quality that is used in assessment of impacts on underground water. This monitoring baseline data is used in calculations to define highest permissible level of each element. When the results of analysis show that content of certain element is over the permissible level, results should be re-checked.

In order to determine the average of sample result with 95% coefficient level, one of the following two methods is used to calculate the highest content of each element. Herein:

1. First method is to increase the standard deviation by 3.188 and add it to the average in order to set the maximum limit of measurement.
2. Another method is preparation of monitoring graphic using multiplier of above mentioned standard deviation.

Once maximum limit is determined, next results of analysis should be compared to determined limit and any amount that exceeds the limit should be considered as a potential sign of migration of solution.

Additional monitoring information

If heap leach monitoring wells have been constantly dry during environmental monitoring period and if any measurable solution is found in the wells, it indicates potential entrance of pollutant substance. In this case, the leach solution water quality indicators should be compared with the above water quality parameters to determine whether the contaminant substances entered the wells from heap leach process.

When the monitoring works are conducted and maximum levels are defined, the monitoring could be conducted less frequent up to once per month for indicators that exceed the limits. Monitoring program should at least include the distance to water, pH, individual conductivity, total dissolved solids, WAD cyanide and two metals. Summarized monitoring of "parameter indicators" is one method to monitor operations as well as reducing sampling costs. In order to monitor ongoing impacts, entire monitoring components should be completely examined at least once in every two years.

RAIN/STORMWATER MONITORING

Water diversion channels built around the facility are aimed isolate leaching activities, therefore rain water should be analyzed for contaminants. Changes in color or odor, or floating particles are indicating a potential impact caused by operations that needs to be addressed. In order to ensure cleanness of channels and free flow, filtering sediments and other methods should be used to resolve the potential impacts that may be caused by operations.

Analytical monitoring storm water

If impacts are suspected from the visual inspections, water sample should be collected and sent to analysis for the standard suite of elements.

Quarterly underground water monitoring parameters

Monthly visual inspections of the diversion ditches and the storm water pond should be conducted to ensure absence of process water or other materials in water drainage system. If isolation of solution is maintained, chemical analysis are not required.

ACTION LEAKAGE RATE GUIDELINE

1. INTRODUCTION

This guideline has been developed by Alberta Environmental Protection because of the reality that all liners will leak to some extent and because of the resultant history of underground water contamination at some sites. This guideline focuses on double lined ponds with a primary liner consisting of a geomembrane liner, a secondary liner (normally consisting of a geomembrane liner or a clay liner), and a leak detection/collection system in between the two liners, by ensuring that the liner leakage is minimal and that it is controlled. This process primarily involves monitoring the amount of leakage through the first or primary liner of a double lined system, comparing this leakage to the action leakage rate (ALR), and taking corrective action

when needed Leakage through the primary liner into the leak detection/collection system is monitored and compared to expected performance for a properly functioning geomembrane liner (i.e. the action leakage rate). The ALR is set by this guideline as the amount of leakage that would occur through a geomembrane liner that was constructed with good construction quality assurance. If the ALR is exceeded, the owner or operator is to take remedial actions. Taking appropriate remedial action when needed will ensure that any hydraulic head of leakage on the secondary liner is very small, thus ensuring no or very little migration of contaminants through the secondary liner. This will help ensure protection of underlying soil and underground water. This guideline does not apply to single lined systems that may have been constructed in the past. It also does not apply to double lined systems where the primary liner is a clay liner. Questions regarding this guideline should be directed to staff of the Industrial Waste and Wastewater Branch at Edmonton (403 427-5883) or Calgary (403 297-8054).

2. RECOMMENDATIONS FOR ACTION LEAKAGE RATES

An action leakage rate (ALR) must be developed for each double-lined wastewater or process liquids pond by the owner or operator. It is recommended that an ALR be developed in accordance with the liner performance method. The ALR is defined as the amount of leakage that would occur through the top liner of a double liner system, based on two holes per hectare, (see Section 3 for details) each with a diameter of 2 mm. In addition the ALR must be not greater than the flow capacity of the leak detection/collection system (see Section 4).

A Response Action Plan (RAP) must be developed by the owner or operator which specifies monitoring, inspection, and corrective measures (Section 6.2) to be implemented if the action leakage rate is exceeded. Response when the ALR is marginally exceeded can be when convenient to the owner or operator, but generally within one year. Response when the flow capacity of the drainage layer or the pumping capacity of the leak detection sump is nearing exceedance must be immediate.

The liner performance method was originally developed by Giroud and Bonaparte (1989) and is based on liner performance with good installation and maintenance. From their preliminary survey's and later work by the U.S. EPA (1992a) it was found that a geomembrane lined facility installed with good construction quality assurance will have about 2 holes of 2 mm diameter per hectare. This number (two defects per hectare) is considered to not be overly low given that ponds installed with good construction quality assurance have shown virtually no leakage (EPA, 1992a and Bonaparte and Gross, 1990). In these surveys, five out of eight ponds with a single geomembrane as the top liner had no leakage occurring, one had leakage occurring at 0.4 liters per hectare per day, while in the other two, leakage was occurring at 27 to 80 liters per hectare per day.

For existing facilities with a bottom liner or leak detection/collection system of suspect quality (e.g. incompatible clay liner or drainage medium not meeting current specifications), increased diligence in monitoring with adjacent underground water monitoring wells is recommended. Regular liner inspections will also be necessary.

3. BACKGROUND INFORMATION ON LINER LEAKAGE

Flow through holes in a single geomembrane liner can be calculated in accordance with Giroud and Bonaparte (1989) as follows. This equation applies to holes with a diameter approximately equal to or greater than the thickness of the geomembrane, and where the liner system has an underlying material (i.e. leak collection system) with a hydraulic conductivity higher than 10⁻³ m/s (freely draining).

$$Q = C_b a (2 g h_w) \dots \dots \dots (1)$$

Q - leakage rate (m³/s)

a - hole area (m²)

C_b - dimensionless coefficient, 0.6 for sharp edges (default value)

h_w liquid depth (m)

g - gravity (m/s²)

Equations to predict leakage due to *permeation or diffusion* can be found in Giroud & Bonaparte (1989). Permeation is a small component of leakage and is not normally considered when developing action leakage rates due to its low value in comparison to that of leakage through defects. To illustrate this, permeation through an 80 mil HDPE liner with 3 meters of liquid is calculated to be 1.2 m³/ha/mo.

The above equation (1) is for the primary geomembrane liner of a double liner system. Empirical equations to predict the rate of leakage through a hole in a composite liner have been developed based on analytical studies and model tests (Giroud et al, 1992). A composite liner consists of a geomembrane placed in close contact with a low-permeability soil liner. These equations are not presented in this document due to their complexity and as most facilities have a single geomembrane as the primary liner. For the purpose of calculating a reasonable action leakage rate, the use of equation (1) is acceptable.

The collected leakage should be analyzed regularly for parameters indicative of the pond contents and the leakage volumes should be measured or estimated by recording the quantity collected or the quantity pumped back to the pond. By reviewing the leakage volumes, and comparing the leakage chemistry to that of the liquids in the pond, one can estimate how much actual leakage, including any trends is. Reviewing the chemistry is important as the leakage volumes may inadvertently contain other waters such as construction water, compression water from granular drainage systems, clay consolidation water, and underground water infiltration (Bonaparte and Gross, 1990).

4. CAPACITY OF THE LEAK DETECTION/COLLECTION SYSTEM

This is calculated according to the following equations (U.S. EPA, 1992a) using the method of flow originating from two holes per hectare. It is based on a maximum head allowable on the secondary liner of 0.3 m. For either case a factor of safety of 2 should be incorporated as well.

Granular Drainage Layer Case.

$$Q = k h \tan \quad B_{\text{ave}} \quad (2)$$

Q – flow rate in the leak detection system per hectare

k – hydraulic conductivity of the drainage medium (e.g. 1 x 10⁻¹ cm/s)

h head of the bottom liner (e.g. 0.3 meters, the design number)

slope of the leak detection system in degrees

B_{ave} width of flow in the leak detection system, perpendicular to flow (e.g. 100 feet or 30.5 meters), where $B_{\text{ave}} = D/\sin$ and $D \approx h$

D drainage layer thickness (m)

Synthetic Drainage Layer (Geonet)

$$Q = 2 \quad \alpha h \quad \text{with} \quad \alpha = k_d D \dots \dots \dots (3)$$

Q flow rate in the leak detection system per hectare

α hydraulic transmissivity of the drainage medium (e.g. 3 x 10⁻⁴ m²/s)

k_d in plane hydraulic conductivity of the drainage (m/sec)

D drainage layer thickness (m)

h head of the bottom liner (e.g. 0.3 meters, the design number)

The solution to these equations for a pond meeting all of EPA's minimum technical requirements, incorporating a factor of safety of two, and adjusting the number to reflect two holes per hectare, yields in the order of 10,000 liters per hectare per day for ponds and 1000 liters per hectare per day for landfills.

5. EXAMPLE POND CALCULATIONS

Given: Double Lined Pond with a Leak Detection/Collection System in Between the two Liners

Pond Surface Area = 2 ha

Average Liquid Depth = 3m

Geonet Case: $d = 3 \times 10^{-4} \text{ m}^2/\text{s}$ and $h = 0.3 \text{ m}$

Granular Drainage Layer Case: Slope = 1% ($\sin \theta = 0.01 = \tan \theta$)

$k = 0.001 \text{ m/s}$ and $h = 0.3 \text{ m}$

ALR Calculation:

Leakage Rate per hole $Q = C_b a (2 g h_w)_o$ (equation (1))

$= 0.6 (0.001) (2 \times 9.81 \times 3)_o$

$= 1.446 \times 10^{-5} \text{ m}^3/\text{s}$

$= 37.5 \text{ m}^3/\text{month}$

ALR = leakage rate per hole $\times 2 \text{ ha} \times 2 \text{ holes/ha}$

$= 37.5 \times 2 \times 2 = 150 \text{ m}^3/\text{month}$

Geonet Case: Calculation of the Capacity of the Leak Detection/Collection System

$Q = 2 d h$ (equation (3))

$= 2 \times (3 \times 10^{-4} \text{ m}^2/\text{s}) \times 0.3 \text{ m}$

$= 466.6 \text{ m}^3/\text{mo. per hole}$

$Q_{\text{cap}} = 466.6 \times 2 \text{ holes/ha} \times 2 \text{ ha}$

$= 1867 \text{ m}^3/\text{month}$

$\approx 900 \text{ m}^3/\text{month}$ after applying a factor of safety of 2.

Granular Drainage Layer Case: Calculation of the Capacity of the Leak Detection/Collection System

$B_{\text{avg}} = D/\sin \theta$ and $D \approx h$

$= 0.3/(0.01) = 30 \text{ m}$

$Q = k h \tan \theta B_{\text{avg}}$ (equation (2))

$= 0.001 \text{ m/s} \times 0.3 \text{ m} \times 0.01 \times 30 \text{ m}$

$= 9.0 \times 10^{-5} \text{ m}^3/\text{s}$

$= 233.3 \text{ m}^3/\text{month}$

$Q_{\text{cap}} = 233.3 \times 2 \text{ holes/ha} \times 2 \text{ ha}$

$= 933 \text{ m}^3/\text{month}$

$\approx 450 \text{ m}^3/\text{month}$ after applying a factor of safety of 2.

6. ACTION LEAKAGE RATE DEVELOPMENT

6.1 Each operator shall develop an action leakage rate for each wastewater or process liquids pond with a double liner system, in accordance with this guideline.

6.2 Should the streams collected in the sump associated with the leak detection/collection system of the wastewater or process liquids ponds (and which originates from the pond itself) have a total flow per month greater than the action leakage rate (Section 6.1), then the operator shall implement a response action plan. A response action plan shall include:

- (a) notification to the Director of Air and Water Approvals within 7 days of the leakage;
- (b) assessment of the source of leakage and possible location, size, and cause of any leaks,

(c) remedial actions to lower the leakage through the pond liner into the leakage detection/collection systems to below the action leakage rate, within a time period consistent with Section 2 or as otherwise authorized by the Director of Air and Water Approvals; and

(d) written monthly reporting to the Director of Air and Water Approvals summarizing the results of clauses (b) and (c), or as otherwise authorized by the Director.

7. MONITORING

7.1 Leakage streams collected in the liner sumps associated with the leak detection/collection systems of the ponds, shall be returned to the ponds or an alternate location approved by the Director of Air and Water Approvals.

7.2 The operator shall monitor streams collected in the liner sumps associated with all leak detection/collection systems of the wastewater or process liquids ponds as specified in Table 7-1.

TABLE 7-1: LEAKAGE COLLECTION MONITORING

Water contaminants or parameters to be monitored	Frequency	Sample type
Total flow (m ³ /mo)	Once /week	Estimate
Parameters Characteristic of the Leakage	Once / month	Grab sampling

7.3 In order to determine the average chemical concentration in each wastewater or process liquids pond, the operator shall collect a representative grab sample of each pond once per month, and have the sample(s) analyzed for parameters characteristic of the pond contents. If it can be shown that the results are relatively stable, less frequent monitoring (i.e. twice per year) is acceptable.

4.2.4. Waste impact

Impact of industrial waste

No industrial waste will be generated during the project. Water and other chemical will have cycling use. Potential evaporation of cyanide in air is constantly monitored.

Impact of household waste

A waste disposal, burn and containment area has been set up under the guidance set forth in the DEIA report at a location designated by the governor of Mandal soum.

It is stipulated in Article 8.4.1 of the Waste Law that the governors of soums and districts, pursuant to their full powers, will designate the location of waste disposal areas and temporary waste containment points in accordance with the general land management plan of their soums or districts. In line with this, Decree No. 75 dated 2 March 2005 was adopted by the GOVERNOR OF MANDAL SOUM, SELENGE PROVINCE whereby a piece of land has been granted, which includes two hectares for waste disposal and a hectare for burn and disposal of empty containers and boxes of chemicals, respectively, and accordingly, waste landfills have been set up in those designated areas (*Decree No. 75 by the governor of Mandal soum, Selenge province is enclosed herewith*).

It is specified in Section 1.3.7 "Waste removal" of the DEIA report for Boroo Gold project prepared in 2000 by panel of forty scientists of JEMR LLC with director Oyun R., Associate Doctor, that "landfill should be established in a remote or secluded area. It should have wire fences to prevent unintentional access by humans and animals, and afterwards should be buried with waste rocks".



Image 4.5. The safety fences of the landfill at the mine site

As specified in the assessment report, the waste area has been set up leeward in 400-500 meter from the workers’ village, with a 3-5 meter-deep hole dug in an area of 40-50 m² fenced with two meter-high eaves. Two meters-high wire fences were erected to prevent unintentional access by humans and animals, and a warning sign “Household waste area” has been posted (*Landfill location map is enclosed herewith*).



Image 4.6. Household waste area, eaves of the household waste area

After the commencement of its operation, Boroo set up a household waste landfill of the same size beside the current area; as it filled up during the operation, it was reclaimed as specified in the assessment report.

1.3.2 Fulfillment of waste management plan

BGC operates with adherence to the regulations for the collection, transportation and disposal of waste (“50542 E SOP016 – Waste collection, transportation and disposal”). In accordance with the regulation, waste is classified as household and hazardous, and disposed by way of burying in the waste disposal area, burning in a special furnace, collecting in a designated area and re-processing or recycling outside the mine, etc. Currently, there is an area for waste landfill-disposal and a special furnace, and waste irons, waste oil, rubber, used batteries, plastic waste, etc. are sorted and gathered in a specifically prepared area and sent for recycling.

Actions indicated in Waste management plan have been fulfilled in accordance with laws and regulations.

Table 4.14. Fulfillment of waste management plan

Environmental parameters	Main actions	Specifications of actions	Actions taken
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Environmental parameters	Main actions	Specifications of actions	Actions taken
Waste management plan	Disposal of household waste	The waste is sorted, transported and submitted to the centralized spot for collection of secondary raw materials	<ul style="list-style-type: none"> Waste (plastic bottles, metal and rubber materials) is sorted and collected at a temporary storage site. Other household waste is collected in designated containers and transported on vehicles to a special dump site. Currently, the mine site has 1 dump site to bury and dispose waste and 1 special incinerator, and scrap metal, waste oil, rubber, used batteries and plastics are sorted, collected and sent for recycling. <p><i>Image-1.3.7.1 Household waste dump site</i></p>  <p><i>Image-1.3.7.2 Special incinerator</i></p>  <p><i>Image-1.3.7.3 Waste sorting and collection site</i></p> 
	Hazardous waste	To contract individuals and entities with permits to collect and transport waste and ensure fulfillment of such contracts	<ul style="list-style-type: none"> Waste is sorted, collected and handed over to a contracted company that has an appropriate license for recycling. Used oil is collected in steel tanks with good containment and transported to Hai Bi Oil LLC recycling factory. <p><i>Image-1.3.7.4 Waste oil storage steel tanks</i></p>  <p>In accordance with instruction given</p>

Environmental parameters	Main actions	Specifications of actions	Actions taken
			<p>from MNEGD, empty packages and containers of chemicals are stored at “Temporary hazardous waste disposal site” from March 2014.</p>  <p>(Image-1.3.7.5 Temporary hazardous waste disposal site)</p> <ul style="list-style-type: none"> Letter has been sent to MNEGD on clarification of citizens and entities certified for waste collection and transportation. (Attachment-47 BGC official letter)

- BGC regularly keeps waste logs and quarterly report on waste logs according to “hazardous waste log sheet and report form”, “list of coded classification of waste hazards emerged from sources” and “ -7 form” is prepared under relevant procedures and submitted to the Bayangol soum Governor. (Please refer to table- 8.2 for Log sheet of waste materials provided to the local community in 2015)
- Also, the payment for producing waste is paid to local budget according to applicable laws.

Table 4.15. Amount of waste 2013-2014

Type	2013	2014	Disposal
		(As of October)	
Hazardous waste (boxes and packaging of chemicals)	309.2m ³	29,920.7 kg	Temporary storage site at the mine site
Hazardous waste (boxes and packaging of chemicals)	0	69376.7 kg	At temporary storage site from April 2014
Household solid waste	420 m ³	240 m ³	Household waste site
Scrap metal	141.9 ton	48 ton	Recycling – Mandal soum
Waste oil	102.11 ton	64 ton	Recycling – Ulaanbaatar
Plastic waste	79.2 m ³	500 kg/ 166.6 m ³	Recycling – Darkhan
Waste tire	0	0	Recycling
Waste hose	8.5 m ³	500 kg	Bayangol soum

Wastewater: Waste slurry produced from mill is flown into tailings pond after detoxification process, as well household water is flown into pond after treatment.

Fulfillment of previous environmental impact assessment and other official assignments

Detailed environmental impact assessment for 2007 has been conducted by environmental study and assessment company "Jemr" and recommendations have been given to mitigate below mentioned impacts. As well as fulfillment of the recommendations are given below.

Recommendation -1

1. Take measures to prevent damage of ground surface and formation of new channels and ravines caused by water disposed by protection dam.

Fulfillment: Flood water dam has been constructed taking in consideration of maximum level of flood occurred in 100 years.

Recommendation -2

2. During project implementation and construction period polyethylene (LLDPE) (DPE) lining works should be executed and monitored in accordance with international standard ASTM.

Fulfillment: The heap leach area, solution pond and flood dam are all lined with high density polyethylene (LLDPE) (DPE) and even with double lining in some areas. Installation of LLDPE and HDPE liners has been conducted in accordance with international ASTM, AASHTO, ISO standards and standard of installation of LLDPE and HDPE has been developed and approved first time Mongolia.

Recommendation -3

3. Underground water reserve and quality monitoring should be conducted in accordance with the program, results of the analysis should be compiled and processed, dynamics and patterns should be determined and conclusion should be prepared.

Fulfillment: Samples are collected from total of 5 underground water wells situated at Heap Leach area on a monthly basis. Results of the analysis are analyzed and monitoring program is continuously implemented. As well as reports and conclusion on water reserve and dynamics have been prepared.

Recommendation -4

4. Monitoring well should be established in 200 m down the hill from the solution pond

Fulfillment: Total of 5 underground water wells in heap leach area are located in 200-400 m downhill as indicated in above recommendation.

Recommendation -5

5. Works on stripping 0.3 m topsoil from heap leach area and stockpiling work should be implemented in as less as possible days.

Fulfillment: The heap leach area was a non-crop field. Topsoil of area newly disturbed in connection with heap leach project is stockpiled and stored in accordance with standards.

Recommendation -6

6. Properly select road and stockpile locations providing 50-100 m distance from dust dispersion area to load/unload and transportation areas i.e. afar from living and working areas.

Fulfillment: Ore stacking, crushing and haulage works are completed in 2012 and at that time, mine roads have been irrigated on hourly basis in order to combat dust, as well as crusher and conveyer areas have been fenced.

Recommendation -7

7. 8 hours of work at work place with noise above 85 dBa with frequency of 1000 Gz causes negative impact to human hearing anility. Therefore, production activities should be organized to prevent from noise impact on employees.

Fulfillment: Although the noise level in the plant area is always below 85 dBA, the employees always use ear protection devices. Also, mill employees work for less than 8 hours in 2-3 shifts.

Recommendation -8

8. HCN detector alarm should automatically activate to warn in case when CN content inside the processing plant building exceeds the permissible levels.

Fulfillment: Cyanide level meter is placed in the solution pond as well as other areas. Also, work clothes employees are equipped with constantly working evaporation meter.

Recommendation -9

9. BGC should develop and enforce a procedure on transportation and storage of cyanide and other toxic chemicals. 20-ton sealed containers should be used in transportation and storage.

Fulfillment: Safe operation procedure of the company has been developed in accordance with the applicable laws and regulations on cyanide transportation and storage, and cyanide is transported and stored in sealed containers and as well as disposed packaging is stored in sealed containers pursuant to directions given by MNEGD.

Recommendation -10

10. Technological requirement to maintain cyanide solution pH at not less than 10-10.5 should be strictly followed and control system reliable operations should be ensured

Fulfillment: Cyanide solution pH is monitored at certain processing points and detectors are installed.

Recommendation -11

11. Action plan and safety procedures should be developed and strictly followed in case of evaporation

Fulfillment: Evaporation and other emergency response plans are in place.

Recommendation -12

12. Relocate ger camp situated in 205 m from the Heap leach pad.

Fulfillment: There are no houses or camps in about 500-800 m radius from the mine site.

Recommendation -13

13. Heap Leach facility protection zone should be established and fenced in 100 m to the west and east from the dam and flood water channel and limited by road on north.

Fulfillment: Heap leach facility and mill area are identified as protection zones of the mine and are fenced with metal fences.

4.2.4. Hygienic study

Total of 45 people work at Boroo Gold LLC project. Main sources of noise pollution are heavy duty equipment used by the project.

Noise impact study

Noise and vibration is spread in environment as fluctuating waves impacting man, flora and fauna. Pattern of both noise and vibration are similar and the impact is similar on nature and the environment (man, flora and fauna, settlements and buildings and constructions).

Not all sounds are noises. Some sounds are pleasant to man (music for example) when some are annoying. A single sound might be pleasant to one man when it displeases another. Therefore displeasing sound to a man is considered as noise.

Vibration is a fluctuating movement with certain frequency of mechanic systems. Transmitted through ground, floor and construction parts, vibration impacts man, flora and fauna, buildings and construction and monuments and most of the cases is the source of noise.

Main sources of noise and vibration in urban area are industrial and maintenance places, auto, aerial and railroad means of transportation.

. Noise impact

Noise impacts on man and the environment:

- Impact on central nerve system by damaging brain cells causing quick tiredness, inattention, discomfort that decreases labor productivity.
- Changes cardiovascular function causing increase of blood pressure, disturbing normal function of metabolism and stomach and impacts digestion.
- Particularly impacts on hearing ability. Especially continuous high frequency noise causes gradual hearing loss leading to deafness. Ear loses its hearing ability for certain period of time when a person temporarily works in noisy place and restores gradually when he comes out. Therefore a person that works in noisy area for long period of time is under potential risk of becoming deaf. As well as blowing a high pressure air (blow out), hammer metal or explosion and blast near the ears generates dramatic noise that tremendously impacts hearing ability.
- Noise creates camouflage impact as well, i.e. interrupts normal communication which leads to loss of signals and warning. Employees that work in noisy plants with lack of normal communication condition that causes lack of attention leads to potential accident.

Impacts caused by noise are mainly at plants of different sectors creating unpleasant condition for employees and affecting their health. Besides, loud noise spreads over a large area in urban settlements disturbing citizens, waking up at night and leading to physical and mental depression.

Noise is spread in environment as fluctuating waves and high and low frequency is measured by Hz (Herz). Higher the frequency, louder the noise. The ability of human auditory organ is within 16-20000 Hz. Sounds less than 16 Hz is too low and over 20000 Hz is too loud that man cannot hear.

Noise is a combination of high and low frequency sounds. In other words, noise spread in the environment is not a single sound. Changeable noise is more harsh than the monotonic. As well as high sound rather than low and clear sound rather than combined are more bothering and more likely to cause injury.

Noise pollution study

Noise pollution study has been conducted at mine site near the heavy duty equipment in May 2014 using noise measuring device manufactured in Japan estimating average of 2-3 meanings. (Image 4.5.)

Amount of noise generated from equipments during heap leach project implementation:

- | | |
|--|-------|
| ➤ Self-unloading trucks | 90 dB |
| ➤ Loader | 80 dB |
| ➤ Bulldozer | 85 dB |
| ➤ Internal environment of the plant | 55 dB |
| ➤ Noise from equipments to transport and | |

Distribute ore for heap leaching in 200m is less than 75 dB.

Actions included in feasibility study: Ear plugs are included in personal protection device of each employee that works at Boroo mine site. Employees that particularly work at noisy places are provided with headset. These devices protect man from noise.



Image 4.5. Noise measuring device

Results of the study show that most of the maximum meaning of the measurements exceeds permissible maximum level of 80 dB. However, meaning at some measurement points are within the permissible maximum level but long term effect creates continuous noise impact on human, fauna and the environment.

Following actions should be taken to mitigate noise level and protect health of employees:

- Regularly conduct annual capital maintenance of heavy duty machinery, the main source of noise
- Continuous noise of 85-90 dB and above can damage hearing ability. Working more than 5 hours in such condition might damage hearing ability. Therefore, employees working near the heavy duty equipment for long period of time should be provided with ear protection device and should be included in regular medical examination and treatment.

5. REPORT SHEET ON ASSESSMENT OF WORKING CONDITIONS AT WORK PLACES OF BOROO GOLD LLC

Assessment of workplace safety, health and working condition has been conducted on May 27 2014 at mine and geological exploration mine site situated within Bayangol and Mandal soums territory of Selenge aimag, Mongolia.

1. Goal

Goal of the study is to conduct integrated study of the workplace safety, hygiene and working condition, prepare results of assessment, define concerns and provide professional guidelines and recommendations within the legal framework.

2. Objectives

1. Study working condition, safety and risks, conduct hygienic, physical and chemical analysis (air temperature, relative humidity, workplace illumination, general level of noise, vibration, electromagnetic field, carbon monoxide and general content of dust) and assess the results
2. To get acquainted with actual implementation of occupational health and safety decrees, resolutions and procedures
3. To get acquainted with mine working condition, safety and protection
4. Include recommendations and proposals of local citizens in the assessment

3. Working group

1. Ch.Davaajav /medical doctor/
2. Ch.Davaasuren /Executive director of Global Environ LLC, ecologist /
3. Dorjgotov, PhD /Professor of chemistry, MUST/

4. Time and location

Working condition study has been conducted at BOROO GOLD LLC site situated at Bayangol soum territory of Selenge aimag on May 17 2014.

5. Methods and guidelines applied for study of workplace hygiene

- “Workplace air. Method to measure workplace air temperature and humidity.” MNS 5375:2004
- “Occupational safety and hygiene. Workplace environment. Hygienic requirements MNS 4990:2000”
- Law on occupational safety and health to conduct assessment of workplace working condition
- Norm on workplace illumination, general requirements of measurement method. MNS 4996:2000
- Occupational safety and hygiene. Noise. General requirements. MNS 5002:2000
- Occupational safety and hygiene. Vibration. General requirements. MNS 4994:2000
- Occupational safety. Industrial hygiene. Power frequency electric fields. Permissible levels of field strength and requirements for control at workplace MNS 5149:2002
- Occupational safety, industrial hygiene, its classification, factors and assessment of working condition MNS 5080:2001”
- Soil quality. Permissible maximum level of soil pollutants and elements MNS 5850:2008
- Potable water-General requirement for field testing of water, Potable and industrial water-water analysis methods MNS 3935:1986 MNS 3936:1986

ONE. CURRENT HYIGENE AND SAFETY CONDITIONS

Boroo Gold Company has Health and safety department and Environmental department, as well as occupational hygiene, safety and environmental committee that are in charge of activities related with occupational hygiene, safety and environment of the company.

*Staff of 2 doctors and 2 nurses work with constant preparedness at mine site on 14 day route between 7⁰⁰-19⁰⁰ 12⁰⁰-13⁰⁰ lunch hour) and if required, provides medical services any time of the night.

*Doctors room is equipped with required examination and emergency equipments and devices, 2 beds, medication center with medicine, syringes and bandages; fully equipped ambulance and include in medical check workers that need medical check before sending to work in the morning. (Image 4.6)



Image 4.6. Medical room



Image 4.7. Medical equipments



Image 4.8. Medical room



Image 4.9. Ambulance



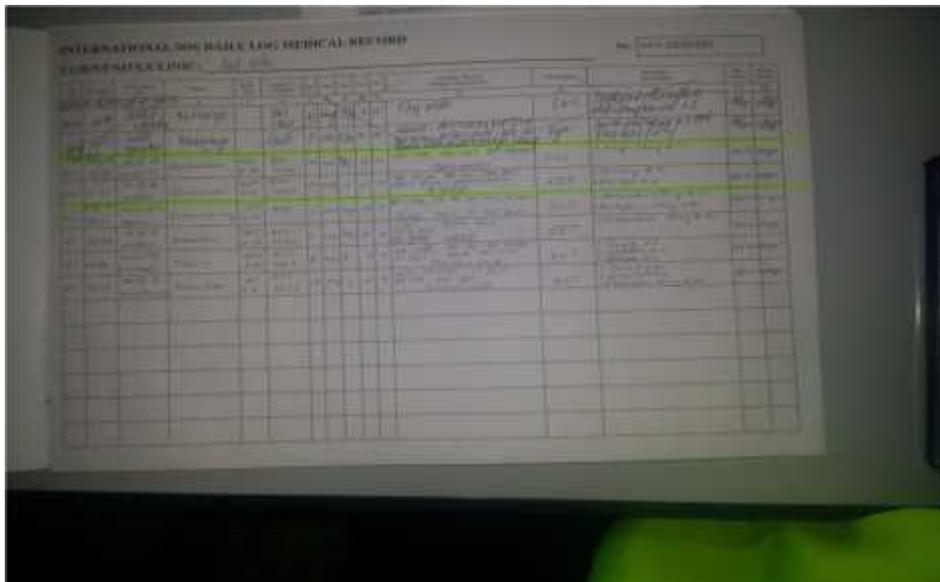
Image 4.10. Prepared and placed list of necessary medications and injections.



Image 4.11. Medications that require cool storage are placed in refrigerator and temperature is recorded.



Image 4.12. Medical examinations are registered, each employee has own medical check record book.



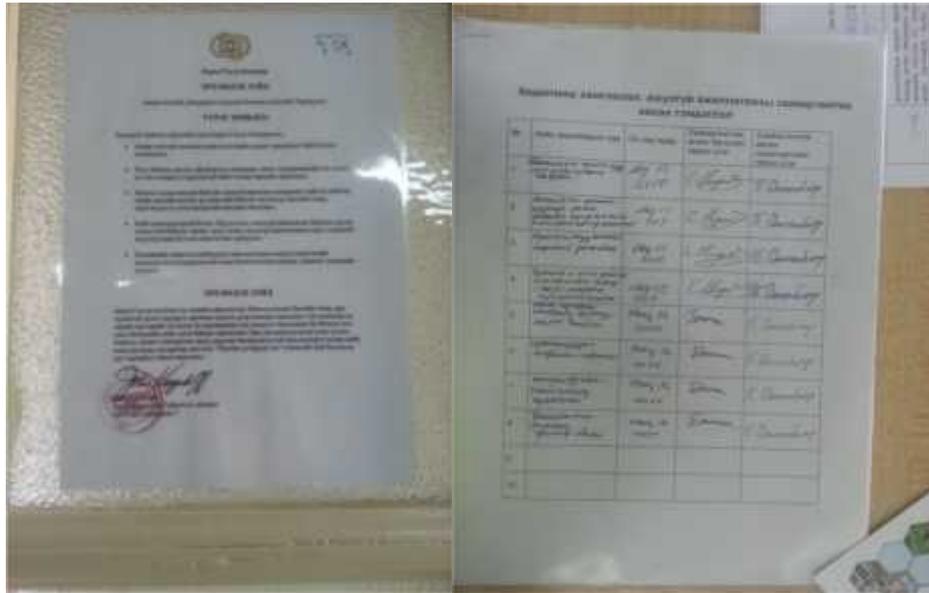


Image 4.14. Employees are provided with safety induction before beginning work and notes are taken

*Weekly safety report placed on board. As well as occupational hygiene, safety and environmental committee meeting minutes is placed on board for employees. (Image 4.15)

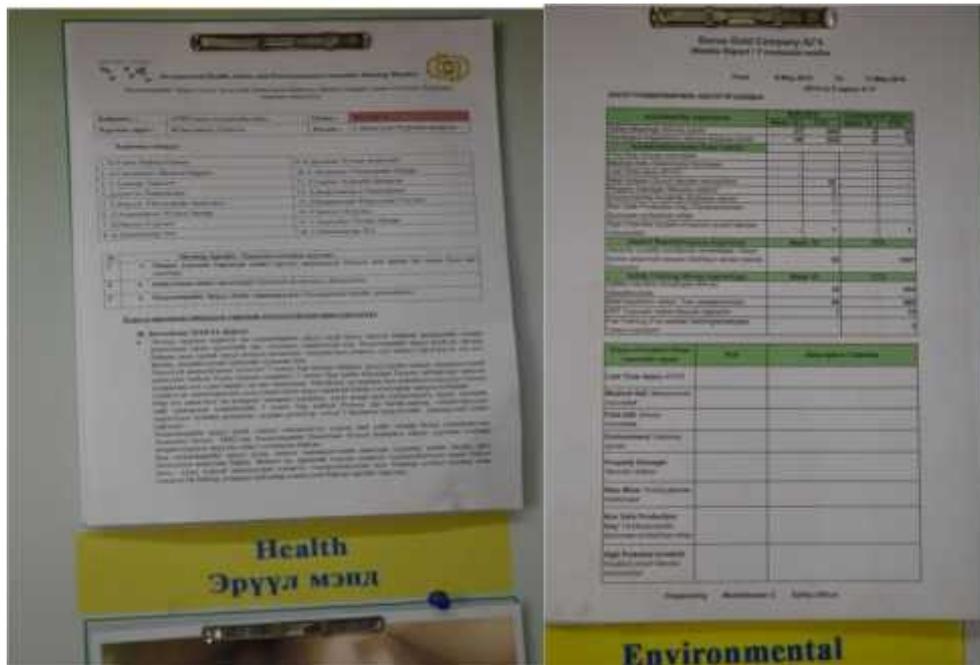


Image 4.15. Occupational hygiene recommendations

*Instruction on use of disinfection substance is placed at workers bathrooms at noticeable place and cleaning records are kept. (Image 4.16.)

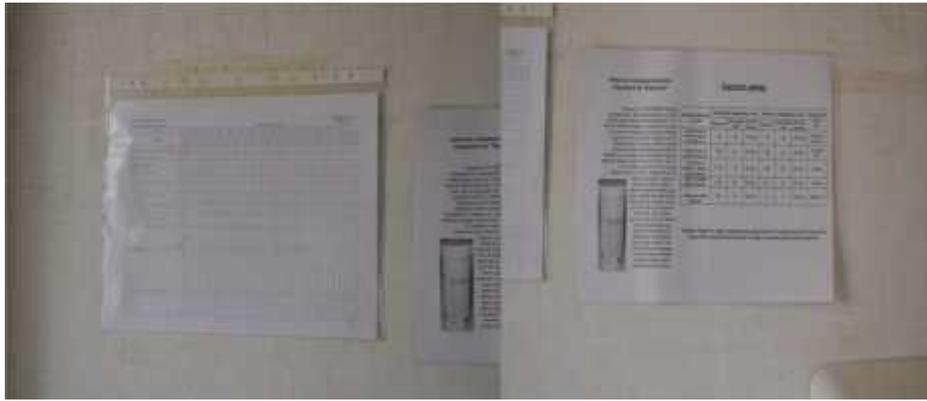


Image 4.16. Instructions to use disinfection substance



Image 4.17. Washrooms of employees are neat and clean, provided with liquid soap and disinfection substance.



Image 4.18. Fire extinguisher and instructions to use, fire alarm and emergency exit signs.



Image 4.19. Warning and prohibition signs are placed in noticeable places

Planned medical examination of employees is held on annual basis (employees in hazardous work condition twice a year) at National occupational disease center and Songdo hospital in UB. All employees have medical book.

WORKING CONDITION AND ITS CLASSIFICATION

Working condition is workplace and plant environment with single or multiple impacts on health and working ability of a man during his work.

Normal working condition is (NS 4967:2000 Occupational health and safety, terminology) a condition when factors of plant environmental have no impact or within permissible level on human.

Abnormal working condition is (NS 4967:2000) a condition unavailable to eliminate its impacts through occupational health and safety actions that does not meet occupational standards.

Below are the classification of working conditions as defined by NS 5080:2001 Working condition, its classification, factors and assessment of working condition.

Normal working condition is classified into suitable and permissible conditions.

Suitable working condition is a working environment that when health conditions of the worker stays constant during the time of work keeping high level of working ability and classified as "1st class" (hereinafter referred to "1").

Suitable amount of industrial factors are defined by standard by micro climate indicators and some factors of work activities.

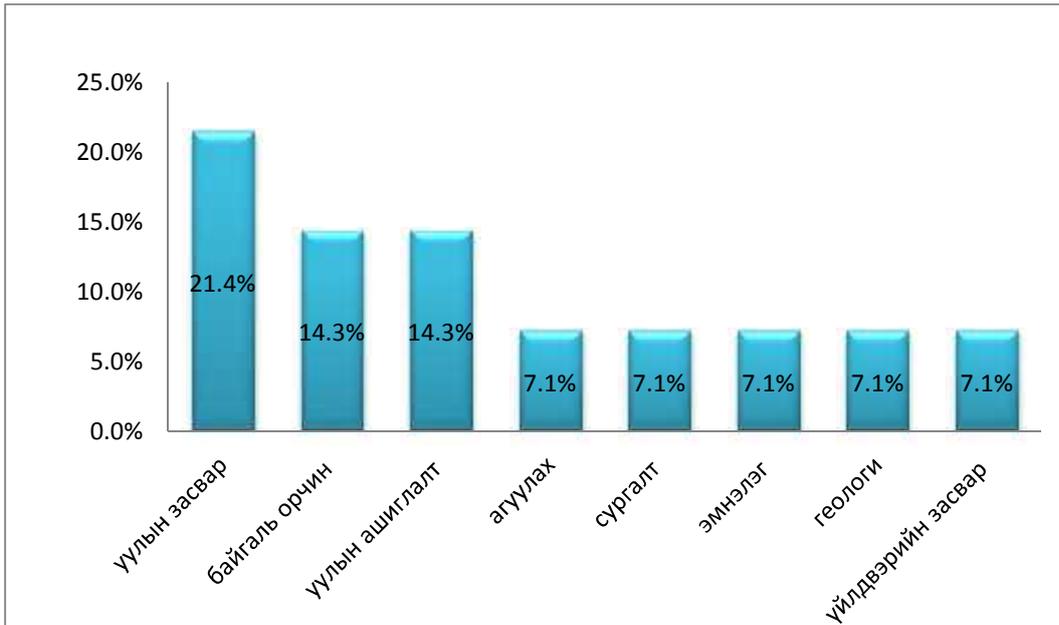
Permissible working condition (2nd class and hereinafter referred as "2") is a condition when industrial toxic factors occurred during the work or was at workplace that are within the permissible level with no further impact on health of the worker and that gradually restores his normal working condition during the after work hours before next working day.

Abnormal working condition is classified to toxic and hazardous conditions depending on excess from permissible level and its impact on health and level of decrease of working ability.

3. Questionnaire on work place conditions of BGC employees

. General

1. Departments of employees participated in the survey.



21,4 % - Mine Maintenance, 14,3% - Environment, 14,3% - Mine Operations, 7,1% - Warehouse, 7,1% - Training, 7,1% - Clinic, 7,1% - Geology, 7,1% - Mill Maintenance.

2. Years of service



42.9% worked for 10-15 years, 35.7% - 0-5 years, 21.4% - 5-10 years. There is no employee who worked for over 15 years.

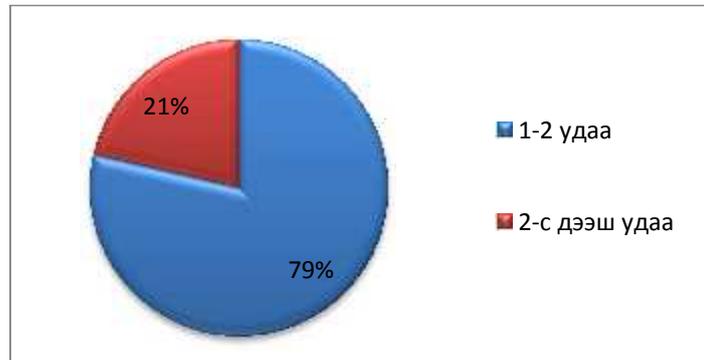
3. Work place conditions are as follows



35.7% - hot, cold, deal with chemical substances and materials, noisy and dusty conditions, 21.4% - normal conditions, 14.3% - normal, hot, cold, with chemical substances and materials, 14.3% - normal, hot, cold, noisy and dusty, 7.1% - chemical substances and materials, noisy and dusty, 7.1% - normal, hot, cold conditions.

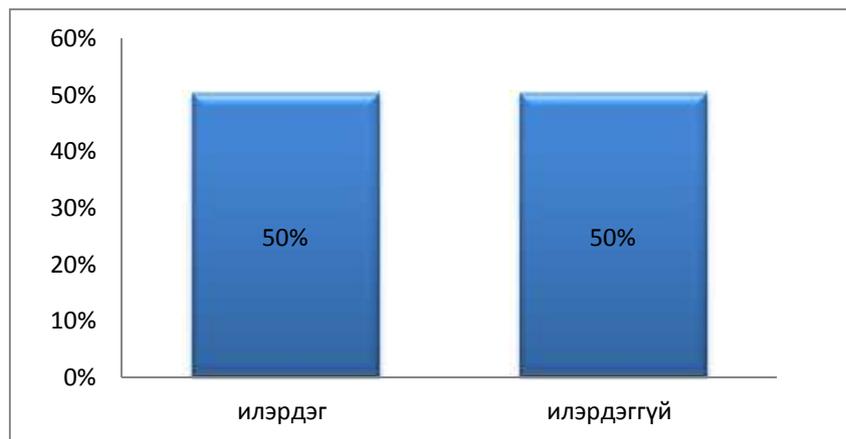
. Health questionnaire

1. How many times per year do you catch a cold?



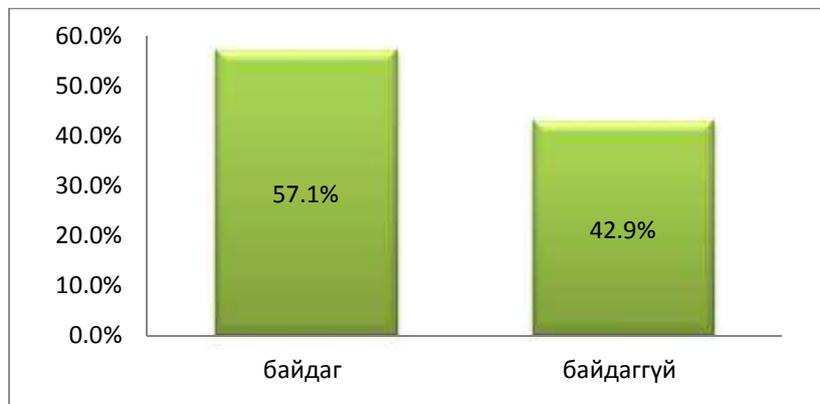
78.6% - 1-2 times, 21.4% - above 2 times.

2. Do you have symptoms such as conjunctivitis, red eyes or eye itch?



50% responded "Yes" and 50% "No".

3. Do you have symptoms of coughing, itching nose or throat?



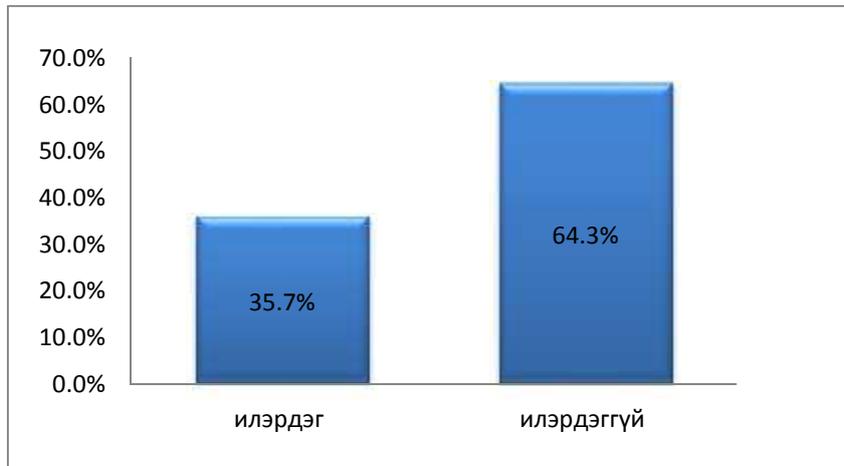
57,1% - Yes, 42,9% - No.

4. Do you have stomach problems?



57,1% - Yes, 42,9% - No.

5. Do you have any symptoms of allergies?



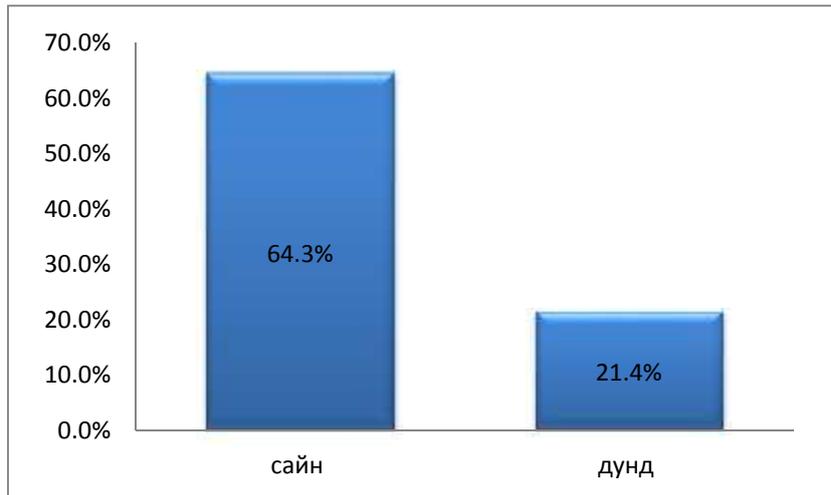
35.7% - Yes, 64.3% - No.

6. In your opinion, what impacts does your work place have on your health? What is the biggest impact?

	Health impacts	%
1.	Dusty	21.4%
2.	All impacts that may be caused in dusty, noisy, toxic conditions	7,1%
3.	Mining heavy duty equipment and its maintenance has negative impact on health. Back and other organs are affected.	7,1%
4.	No negative impact	14,3%

When impacts on health are categorized, 14.4% of all employees that took the survey responded they work in dusty conditions, 7.1% all impacts that may be caused in dusty, noisy and toxic conditions, 7.1% - mining equipment and machinery and their maintenance causes negative effects and impact back and other organs, 40,3% - no impact and 50,1% did not respond.

7. How well does your work place environment meet health requirements?



64,3% - good, 21,4% - moderate, 14,3% - not answered.

. Work place conditions and safety

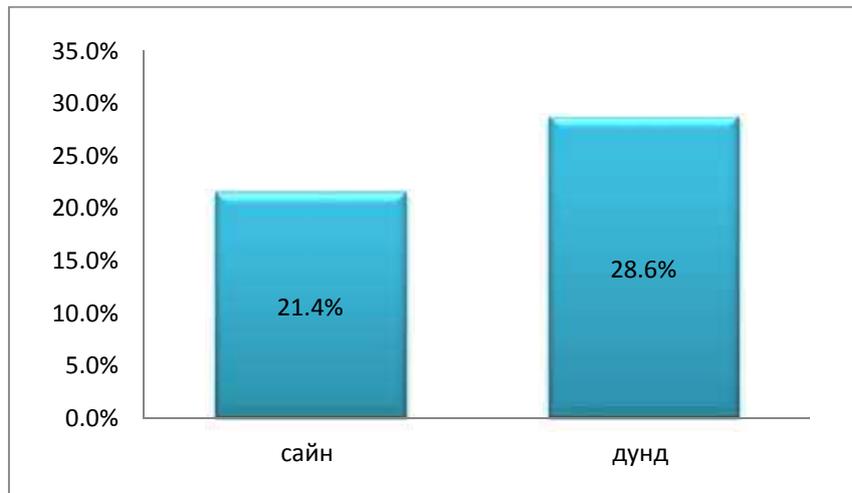
1. Your work hours

Work hours Morning 7⁰⁰-12⁰⁰ ,

Evening 13⁰⁰-19⁰⁰

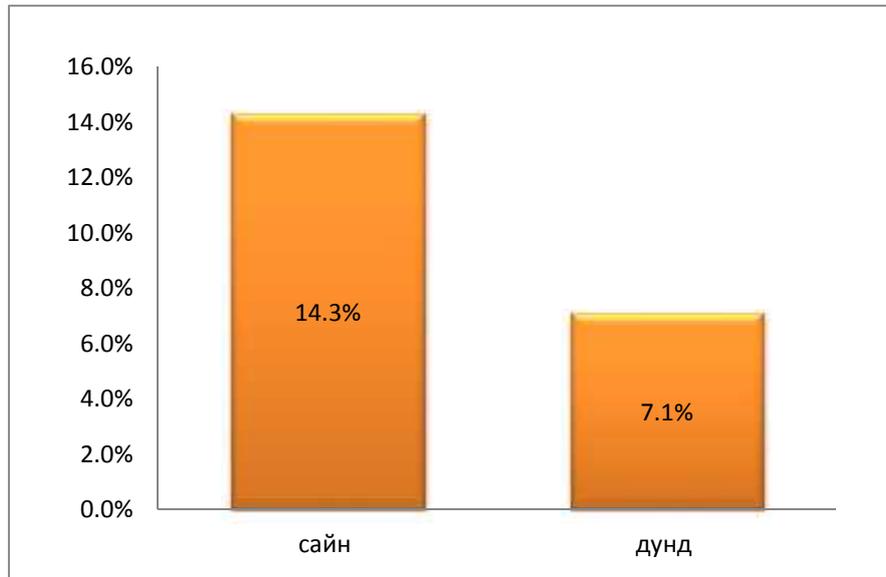
Lunch time 12⁰⁰- 13⁰⁰ as answered by all employees.

2. How good is air ventilation in your work place?



21,4% - good, 28,6% - moderate, 50% did not answer this question.

3. If your work place is exposed to chemical substances and materials, do you have supply of detoxifier?

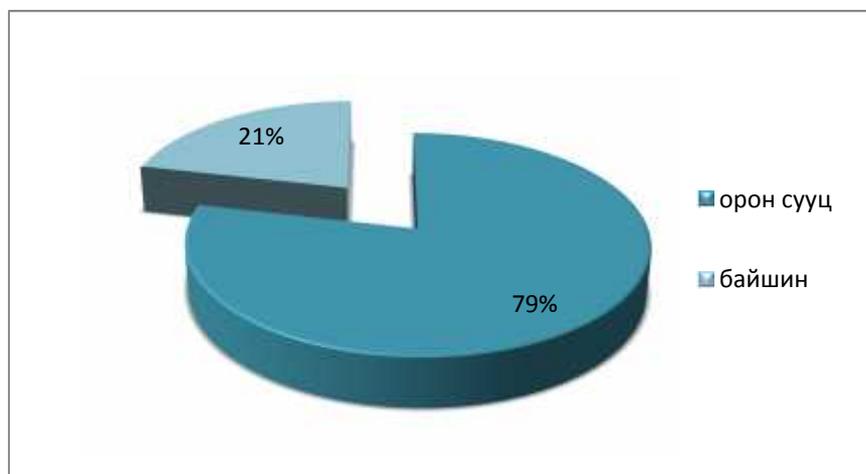


Supply is good - 14,3%, moderate - 7,1% and 78,6% did not respond.

4. What personal protective equipment, tools and clothing are provided to you? When are they replaced?

- Boots, PPE – 1 per year, gloves weekly, goggles every day - 21,4%,
- Goggles, boots, fire proof clothing when necessary - 21,4%,
- Goggles, mask, full set of clothing to protect from burn, gloves, boots, ear plug, protective clothing - 14,3%
- Gloves, ear plug, mask, boots, protective clothing - 42,9%.

5. Please describe your family dwelling.



79% - apartment, 21% - house.

FOUR. RECOMMENDATION ON MITIGATION AND ELIMINATION OF IMPACTS

- Working in noisy place has following impacts on health: increase or decrease of pulse rhythm in cardiovascular system, increase or decrease of blood pressure, change in ECG and exhaustion of auditory organ and ear membrane cells that might become a reason to become deaf. Working in low frequency noise for long period of time may lead to decrease of hearing ability, noise in ears, headache, increase of arterial pressure, tiredness, decrease of working ability, weakening of caution, sweating, sleep disorder, hand and finger shaking, pains in chest, fast heart beating and occurrence of gastric ulcer. Therefore, it is required to take actions to mitigate noise.

- Provide workers at noisy workplaces with protective devices and include in hearing medical examination on annual basis.
- Support employees immune system, select and provide employees with nutritious meals suitable to their specific working condition and provide employees that work in hazardous working condition with meals rich in pectin, vitamin C, milk, dairy products and fresh fruits to support their immune system.

6. SUGGESTIONS OF LOCAL COMMUNITY

As per the contract conducted between our company and Boroo Gold LLC, addendum to DEIA has been prepared for Heap leach project. In accordance with provision 1.8 of article 8 of Law on environmental impact assessment of Mongolia, meeting has been held to introduce the report and exchange ideas with local community of Gonir bag and 3rd bag of Mandal soum.

The meeting has been held at Boroo mine site on October 14 2014.

As a result of the meeting, decision was made that local citizens' representative khural will send a letter to MNEGD with following conclusions:

1. After on-site tour of Heap leach project and environmental protection measures held, there are no rejection in continuance of the project.
2. Environmental protection and reclamation works reflected in DEIA and EMP should consider relevant laws, regulations and procedures of Mongolia. (For Decision of local community meeting, please refer to attachment.)



Image 4.20. Meeting with local community of Gonir bag. 2014-10-14

7. ECOLOGICAL AND ECONIMICAL ASSESSMENT, ECOLOGICAL DAMAGE

Ecological baseline assessment of soil

Ecological assessment of soil by its content of humus is considered as a relatively realistic method. Naturally, soil forms for hundreds of years, therefore, when soil disturbed, it requires large amount of money for reclamation and takes decades to return to its natural form.

It is important to prevent soil cover from degradation, erosion and pollution as much as possible.

Ecological and economical assessment of disturbed soil has been conducted based on decree # A-166 of Minister of NEGD issued on May 27 2010, tables 3.1, 3.2, 3.3, 3.4 and 3.5 of "Methodology of estimation of environmental damage assessment and reimbursement", results of laboratory analysis and records of field morphology study.

Only mountain light clayey brown soil distributed at heap leach project area of Boroo Gold Company is expressed in currency. Soil ecological and economical assessment is not required for other two types of soil because soil with less than 10 cm thick humus layer is directly mounded for reclamation.

Table 4.14. Soil characteristics

Cutting #	Layer index	Depth (cm)	Rock (%)	Mechanic composition	EC _{2,5} dS/m	Carbonate	Soil coefficient		Coefficient t
Mountain light clayey brown soil									
2	A	11	0,9	1,0	0,800	1,0	0,7	1,0	0,90
		11	0.9	1,0	0,130	1,0	0,7	1,0	0,79
	1	48	0.9	1,0	0,110	1,0	0,7	1,0	0,78

Table 4.15. Geographic assessment indicators

Cutting #	Layer index	Depth cm	Sloping degree	Ravine	Vegetation cover	Rocks and cliffs	Minor slopes	Water and moist	Coefficient
Mountain light clayey brown soil									
2	A	11	0,5	0.7	0,8	0,7	0.9	0.9	0,75
		11	0,5	0.7	0,6	0,7	0.9	0.9	0,71
	1	48	0,5	0.7	0,6	0,5	0.9	0.9	0,68

Table 4.16. Table of integrated soil ecological and economical assessment (Table 5 is based on table 3.4).

Cutting #	Depth cm	Humus %	Weight g/cm ³	Humus reserve in layer /thousand/ ton	Coefficient of soil characteristics	Geographic coefficient	Soil group coefficient	Soil area ha	Price of humus, tug	Total price, thousand tug
Mountain light clayey brown soil										
2	11	3,93	1,3	56,2	0,90	0,75	0,7	1	276,0	7329,0
	11	3,11	1,3	44,4	0,79	0,71	0,7	1	2,76,0	4811,4
	48	1,31	1,3	81,7	0,78	0,68	0,7	1	276,0	8372,0
Total				182,3	Average				6837,33	

Soil stripping will be conducted on 30 ha of area during the heap leach project and soil ecological and economical damage based on table 4.16 is:

$$30 \text{ ha} \quad 6837,3 \text{ thousand tug} = 205120,1 \text{ thousand tug}$$

Damage of underground water

57682,5 m³ of potable and household water will be used during the heap leach project of Boroo Gold mine. Therefore ecological damage of underground water is:

$$= \mu \cdot (0.6 + 0.3) \cdot V$$

$$= 0.4 \cdot 57682,5 \text{ m}^3 \cdot (0.6 + 0.3) \cdot 4072 \text{ tug} = 84\,557\,930,4 \text{ tug}$$

Herein:

- – price of 1m³ underground water, Selenge aimag -4072 tug
- μ - coefficient of water discharge of water bearing layer 0,4
- – assessment coefficient of water static reserve of water bearing layer 0,6
- – currency coefficient of water damage 0.3

Damage of subsoil

Total of 4822.0 thousand m³ of mine work will be conducted. This amount of empty space will occur in subsoil.

Reclamation cost is used to estimate damage of 1.0 m³ space. This will include costs to take topsoil from stockpile by excavator, transport to reclamation site by dump truck and flattening the dumped topsoil by bulldozer. This estimation is taken from chapter on calculation of reclamation costs.

Loading of 1.0 m³ of rock is 180 tug, transportation cost is 50 tug, and cost to even the soil is 220 tug.

Then cost for filling 1.0 m³ is: 180 + 50 + 220 = 450 tug/m³. Total damage of subsoil is

$$= 4822.0 \text{ thousand m}^3 \cdot 450 \text{ tug/m}^3 = 216990.0 \text{ thousand tug}$$

Ecological and economical damage of atmosphere

Dust occurred during the transportation and emission exhausted from the transportation devices with internal combust engine used for heap leach project are the main sources of air pollution.

Environmental damage caused by air pollution is estimated by below formula.

$$= G \cdot f \cdot K_1 \cdot K_2 \cdot f$$

Herein:

– constant value used to assess pollutant spread in air per year and for this condition is 2000 tug/ year.ton /As indicated in Law on air/

G – Relative hazard indicator of air pollution that depends on specifics of local conditions, pasture and area – 0,2

K₁, K₂ – coefficient of estimation of pollution spreading height and pollution source (pollution is far from urban settlements, unpleasant for tourism, small area - K₁=0.1, from height of pollution distribution K₂=1.3)

f – Adjusting coefficient of dissolving characteristics of pollutants spread in air and defined by below formula if sedimentation speed is 1-20 cm/s.

$$f = \sqrt{\frac{1000}{60 + \varphi \cdot H}} \cdot \left(\frac{4}{1 + U} \right)$$

H- Height of pollution, 0,5 m

U- Average wind speed, 3 m/s

φ - Intermediate meaning of height and defined by below coefficient.

$$\varphi = 1 + \frac{\Delta T}{75^\circ \text{C}}$$

ΔT - Difference of air temperature at the end of the vehicle exhaust pipe and average annual temperature of waste gas, 100 °C

$$\varphi = 1 + \frac{\Delta T}{75^\circ \text{C}} = 1 + \frac{100}{75} = 2.33$$

$$f = \sqrt{\frac{1000}{60 + \varphi \cdot H} \cdot \left(\frac{4}{1+U}\right)} = \sqrt{\frac{1000}{60 + 2.33 \cdot 0.5} \cdot \left(\frac{4}{1+3}\right)} = 4.04$$

– converted weight of waste distributed in air per year,

$$M_a = \sum_{i=1}^N A_i \cdot m_i$$

A_i – relative hazard indicator of the component i , year.ton/t

m_i – i total weight of pollutants distributed in air, ton

Dust pollution from 33.0 ha disturbed area:

$$= S \cdot W_c \cdot X$$

Herein: S – open area, m^2 ;

W_c – dust blow, in rock soil (-) $W_c = 0.1 \cdot 10^{-6} \text{ kg}/(m^2/s)$

X – rock crushing coefficient, approximately 0.1.

$= 330000 \text{ m}^2 \cdot (0.1 \cdot 10^{-6} \text{ kg}/m^2 \cdot s) \cdot 0.1 = 0.04098 \text{ kg/s}$ i.e. 147.52 kg in hour and 221.92 tons in a year.

Duration of mine operation is taken as 300 days.

In one operational year, in average 221.92 ton of dust, 0.078 ton of carbon monoxide, 0.0315 ton of nitric oxide, 0.0157 ton of sulfuric acid, 0.0236 ton of carbon, 25.24 ton of benzopyrene and 122.29 ton of carbon black polluted the air.

Table 6.2. Weight of pollutants

#	Pollutant	m, t/year	A	M, t/year
1	Dust	221,92	83.5	18350,32
2	Carbon monoxide	0,078	1.2	0,0936
3	Carbon	0,0236	1,8	0,042
4	Nitric oxide	0,031	102,69	3,18
5	Sulfuric acid	0,0157	102,69	1,58
6	Benzopyrene	25,24	10,0	252,4
7	Carbon black	122,29	2,5	305,75
Total		369,59		18913,34

$$a_r = T_{ar} \cdot G \cdot f \cdot M_a \cdot K_1 \cdot K_2 = 2000 \text{ tug/ton} \cdot 0.3 \cdot 4.04 \cdot 18913.34 \cdot 0.1 \cdot 1.3 = 5\,959\,971,7 \text{ tug}$$

Results of ecological and economical assessment of ecological damage that will occur during the Heap leach project of Boroo Gold LLC situated at Mandal soum territory of Selenge aimag

Ecological and economical damage caused by any project implementation is a sum of environmental (water, soil, ground, subsoil, air, vegetation and etc.) damages. Total damage to environmental components caused by power and heavy industry activities are estimated by below formula.

$$= \quad + \quad + \quad +$$

– Total damage to the environment caused by project, thousand tug;

– Water damage, thousand tug;

– Soil damage, thousand tug;

– Ground damage, thousand tug;

– Air pollution damage, thousand tug;

Therefore total ecological and economical damage is:

$$=(205\ 120\ 100 +84\ 557\ 930,4 +216\ 990\ 000 +5\ 959\ 971,7)= \mathbf{512\ 682\ 002.1\ tug}$$

In case the company will not conduct reclamation works, total amount of ecological and economical damage after implementation of heap leach project of Boroo Gold LLC at Bayangol soum territory of Selenge aimag will be **512 682 002.1 tug**.

CHAPTER FOUR. RECOMMENDATIONS ON MITIGATION AND ELIMINATION OF PROJECT IMPACTS AND RECLAMATION PLAN

5.1. RECOMMENDATIONS ON MITIGATION AND ELIMINATION OF IMPACTS

Proper use and protection of natural resources and mitigation and elimination of potential environmental impacts are the fundamental responsibility of the project implementer.

Therefore, below mentioned technological, management and administrative recommendations are given to Boroo Gold LLC to mitigate and eliminate potential environmental impacts during its heap leach project.

Boroo Gold LLC is responsible for environmental damages caused by project activities.

ACTIONS TO MITIGATE AIR POLLUTION:

- ❖ It is recommended to constantly monitor content of gas exhausted from vehicle and machinery and strictly follow exploitation procedure
- ❖ Conduct reclamation works of disturbed area and heap leach area on timely basis
- ❖ Limit to the extent possible from evaporation of cyanide solution during the process of ore heap leaching to recover gold
- ❖ Main method to mitigate air pollution is to cover ore transportation roads with less dust generating material and constantly irrigate the roads. As of current road treatment procedure, dust will be mitigated if snow combined with road sand is evened and compacted by grader in winter and irrigated in summer.
- ❖ Constantly measure PM10 according to the schedule

ACTIONS TO MITIGATE SOIL POLLUTION:

- ❖ Camp area should not be littered by household and other solid and liquid waste
- ❖ In order to eliminate soil wind erosion, improve surrounding environment by reclamation and re-vegetation of area disturbed during the implementation process of above mentioned project
- ❖ It is prohibited to store flammable substances, lubricants and soil polluting items in open area
- ❖ Soil monitoring should be constantly conducted at heap leach territory and its nearest areas
- ❖ Construct leaching stockpile in accordance with size and shape indicated in baseline study, ensure its stability conditions and constantly monitor liners and their proper function
- ❖ Conduct timely and high quality technical and biological reclamation
- ❖ Constantly take samples for pollution analysis from monitoring points situated in 300 meters leeward on both sides of heap leach fence and comparative conclusion should be made on annual basis.

ACTIONS TO MITIGATE WATER (UNDERGROUND) POLLUTION:

- ❖ Execute with accuracy in accordance with international ASTM standard and monitor the quality of polyethylene (LLDPE) (DPE) lining during construction stage and implementation of the project.
- ❖ Implement underground water monitoring in accordance with the program, integrate and analyze test results, define, and prepare conclusion on its dynamics and tendency

MANAGEMENT AND ORGANIZATIONAL MEASURES:

- ❖ Prevent from fire hazards
- ❖ Include environmental protection costs in annual Environmental management plan and implement actions indicated in detailed impact assessment report
- ❖ Strictly follow open pit occupational health and safety procedures to prevent from potential hazards
- ❖ Provide annual medical examination to employees
- ❖ Avoid working next to heavy duty machinery for a long period of time at once and use ear plugs to prevent from noise pollution
- ❖ According to related regulation, environmental impact assessment should be prepared over again each time when amendments are made in technique and technology not specified in this report.

RECOMMENDATIONS ON DISPOSAL OF CONTAINERS AND PACKAGING OF HAZARDOUS CHEMICALS

General methodology to dispose containers of hazardous chemical substance. This methodology has been developed using “Laboratory environmental sample disposal” (EPA, EPA/600/R-10/092 October 2010) and “Hazardous chemical waste management program” (TEXAS A&M University) as a source material. The methodology does not include disposal of radioactive elements and its containers.

Disposal procedure of “empty” containers of hazardous chemicals is different than disposal procedure of chemicals.

Empty means

- ❖ For containers of 416.1 l (110 gallons) or less, residue is no more than 3% by weight of the total capacity
- ❖ For containers greater than 416.4 l (110 gallons), residue is no greater than 0.3% by weight of the total capacity

Containers that held acutely hazardous waste are considered empty only after being triple rinsed with a solvent capable of removing the acutely hazardous waste residue. For instance, cyanide solution could be rinsed by diluted sodium hydroxide solution. Small amounts of chemical agents and glassware contaminated with chemical agents in laboratory can be neutralized prior to disposal, using a solution of 5 – 10% sodium hypochlorite (NaOCl). Complete neutralization may require mixing times from several hours to overnight depending on chemical properties.

Decontamination waste should be disposed in accordance with procedure to dispose liquid chemical waste.

If neutralized glass and polymer containers are re-usable, it should be sent back to the first manufacturer. If it is impossible to send to first manufacturer, it should be landfilled. Land disposal containers and packaging should meet the following requirements:

- ❖ Containers and package should not have solid and liquid residue
- ❖ Should be rinsed triple time
- ❖ Labels should be taken off
- ❖ Caps should be taken
- ❖ Bottom of metal and plastic containers should be cut (there are no requirements to brake glass containers)

Waste treated in accordance with above mentioned requirements then is disposed in accordance with joint decree 249/201 of Minister of Health and Minister of Nature and the Environment “classification, collection, storage, transportation and disposal of health organizations” issued in 2002.

Below are study of legal environment (National and international) of hazardous wastes and definition of disposal of hazardous waste reflected in Mongolian law on waste and law on toxic and hazardous chemicals.

1. MONGOLIAN LAW ON WASTE

Article 13. Disposal of waste

13.3. Hazardous waste shall be disposed at facilities for intended purpose that meet standard requirements.

13.4. The Government shall approve list of hazardous waste specified in the Provision 13.3 of this law.

Article 14. Re-use and recycling of waste

14.2. The state central administrative body in charge of environmental issues shall grant permission to engage in activities to recycle hazardous waste.

Article 15. Export of hazardous waste

15.1. Citizens and business entities may export hazardous waste.

15.2. The state central administrative body in charge of environmental issues shall grant permission to export hazardous waste based on conclusions issued by a specialized organization as per conditions as follows:

15.2.1. Techniques and specific equipment to recycle and re-use hazardous waste do not exist;

15.2.2. Import of hazardous waste is accepted by a given country.

15.3. A person to export hazardous waste shall enclose the following documents in his/her request application requesting for permission:

15.3.1. An agreement executed with a person importing hazardous waste, request of an importing person in writing;

15.3.2. A permission granted by a respective authority of a given country to a person importing hazardous waste.

2. MONGOLIAN LAW ON TOXIC AND HAZARDOUS CHEMICALS:

Article 14. Basic requirements for deposition of hazardous and toxic chemicals

14.1. The waste of hazardous and toxic chemicals shall be deposited on the basis of conclusion of the related professional organization to the place determined by the soum or district governor in compliance with the procedures set by in the provisions of the article 6.1.2 of this law by means that don't endanger or intoxicate human health, the environment, domestic animals and wildlife, and the commission consisted of the local environment and sanitation inspector and officer, specialist in emergency situations, shall be engaged in this operation.

14.2. The commission stated in the provisions of the article 14.1 of this law shall sign the act on deposition of hazardous and toxic chemicals and deliver it to the soum, or district governor.

In terms of international treaty, there is Basel convention on Control of Transboundary Movements of Hazardous Wastes and Their Disposal.

BASEL CONVENTION ON CONTROL OF TRANSBOUNDARY MOVEMENTS OF HAZARDOUS WASTES AND THEIR DISPOSAL

ARTICLE SIX. Transboundary movements between parties

1. The State of export shall notify, or shall require the generator or exporter to notify, in writing, through the channel of the competent authority of the State of export, the competent authority of the States concerned of any proposed transboundary movement of hazardous wastes or other wastes. Such notification shall contain the declarations and information specified in Annex V A, written in a language acceptable to the State of import. Only one notification needs to be sent to each State concerned.

2. The State of import shall respond to the notifier in writing, consenting to the movement with or without conditions, denying permission for the movement, or requesting additional information. A copy of the final response of the State of import shall be sent to the competent authorities of the States concerned which are Parties.

3. The State of export shall not allow the generator or exporter to commence the transboundary movement until it has received written confirmation that:

- (a) The notifier has received the written consent of the State of import; and
- (b) The notifier has received from the State of import confirmation of the existence of a contract between the exporter and the disposer specifying environmentally sound management of the wastes in question.

4. Each State of transit which is a Party shall promptly acknowledge to the notifier receipt of the notification. It may subsequently respond to the notifier in writing, within 60 days, consenting to the movement with or without conditions, denying permission for the movement, or requesting additional information. The State of export shall not allow the transboundary movement to commence until it has received the written consent of the State of transit. However, if at any time a Party decides not to require prior written consent, either generally or under specific conditions, for transit transboundary movements of hazardous wastes or other wastes, or modifies its requirements in this respect, it shall forthwith inform the other Parties of its decision pursuant to Article 13. In this latter case, if no response is received by the State of export within 60 days of the receipt of a given notification by the State of transit, the State of export may allow the export to proceed through the State of transit.

5. In the case of a transboundary movement of wastes where the wastes are legally defined as or considered to be hazardous wastes only:

(a) By the State of export, the requirements of paragraph 9 of this Article that apply to the importer or disposer and the State of import shall apply mutatis mutandis to the exporter and State of export, respectively;

(b) By the State of import, or by the States of import and transit which are Parties, the requirements of paragraphs 1, 3, 4 and 6 of this Article that apply to the exporter and State of export shall apply mutatis mutandis to the importer or disposer and State of import, respectively;

ARTICLE EIGHT. Duty to re-import

When a transboundary movement of hazardous wastes or other wastes to which the consent of the States concerned has been given, subject to the provisions of this Convention, cannot be completed in accordance with the terms of the contract, the State of export shall ensure that the wastes in question are taken back into the State of export, by the exporter, if alternative arrangements cannot be made for their disposal in an environmentally sound manner, within 90 days from the time that the importing State informed the State of export and the Secretariat, or such other period of time as the States concerned agree. To this end, the State of export and any Party of transit shall not oppose, hinder or prevent the return of those wastes to the State of export.

Countries ratified in Basel convention shall pay special attention in import of chemical substances.

5.2. HEAP LEACH PAD CLOSURE AND RECLAMATION

Reclamation work of heap leach area will be conducted in connection with Boroo mine closure. Ground reclamation is a complex action to reclaim agricultural value and efficiency of damaged area, as well as to improve the environment meeting public interest.¹

Therefore, qualified performance of reclamation work is a responsibility of the entity to state, public and further, to next generation. Based on the experience to conduct reclamation works on timely basis, BGC has all potentials to successfully conduct the heap leach reclamation works.

This chapter includes reclamation plan for heap leach area.

RECLAMATION PROGRAMS CURRENTLY IMPLEMENTED AT BOROO MINE SITE

In its environmental reclamation activities, Boroo Gold LLC complies with internationally recognized practices and relevant provisions in the Table #1 and provisions 6.1 and 6.2 of the standard of Mongolia MNS 5917:2008, and technical requirements specified in the standard MNS 5918:2008.

Environmental activities to be carried out in the specific year by the company are preliminarily planned in the beginning of the year, and in accordance with relevant provisions of the Environmental Protection Law, Minerals Law and the Law on Environmental Impact Assessment and the Regulation on development, review, approval and reporting of the Environmental Protection Plan and Monitoring Program approved with the Annex I to the Decree #36 of the Minister of Nature, Environment and Green Development, dated in 2011, are prepared and approved by the Ministry of Nature, Environment and Tourism. Costs of environmental

protection activities in the specific year are budgeted and pursuant to Article 39.1.9 of the Minerals Law, 50% of the funds required for performing environmental protection and reclamation activities are allocated in the special bank account of local administration and MNET during the reporting period of mining operations as collateral.

Boroo Gold LLC has been conducting reclamation concurrent with the mining operations which commenced in 2003 at the mine site, surrounding abandoned alluvial mine sites, land disturbed during construction activities, borrow pits of sand and gravel, and exploration drilling areas.

Each year based on the Mine Plan, a reclamation plan is prepared and rehabilitated land is handed over to administrations of Selenge aimag, its Bayangol and Mandal soums in the end of the year.

Reclamation program has been implemented in line with extraction works (2003) and technical and biological reclamation has been successfully conducted on 430 ha, reforestation on 42.1 ha and 430 ha of reclaimed has been handed over to local authorities.

Reclamation activities carried out concurrent with mining operations (2003 – 2014):

#	Year	Reclaimed areas (hectare)	Type of Reclamation
1	2003	10	Technical and biological reclamation
2	2004	15	Technical and biological reclamation
3	2005	16	Technical and biological reclamation
4	2006	48.5	Technical and biological reclamation
5	2007	21	Technical and biological reclamation
6	2008	44.6	Technical and biological reclamation
7	2009	52.1	Technical and biological reclamation
8	2010	56.3	Technical and biological reclamation
9	2011	55.2	Technical and biological reclamation
10	2012	41	Technical and biological reclamation
11	2013	40	Technical and biological reclamation
12	2014	30	Technical and biological reclamation
Total ha:		430	Technical and biological reclamation

#	Description	Year	Area (ha)
1	Total disturbed area (h)		888,5
2	Reclaimed areas (h)	2003-2014	430
3	To be reclaimed areas (h)	2015-2018	376.8
4	Pit wall (ha)		92.0

Technical reclamation

Technical reclamation is the base, i.e. core work that should be conducted for reclamation. In other words, results of biological reclamation are directly depends on fulfillment of technical reclamation. Technical reclamation work is divided into main 2 work directions such as sloping

and covering with topsoil. Excavator, bulldozer, grader and dumps are used to perform technical reclamation work. Technical reclamation work is implemented in accordance with mapping prepared by mine engineers. Sloping design of reclamation area should consider surrounding landscape including hills, valley and meadows and should be aimed to have as much natural as possible landscape. In order to keep stability of sloping and prevent from run-off washout, technical reclamation work is conducted in accordance with MNS 5917:2008 Environment. Reclamation of land destroyed due to mining activities. General technical requirements standard for further use of land as a pasture land. Herein, sloping should not exceed 15° , topsoil thickness should be 10-20 cm. in order to verify that technical reclamation work is performed in accordance with standards, Environmental department of the company constantly monitors the reclamation work process.

As pit 6 closed, 1st section of the pit is refilled with 1.2 m^3 waste rock at 1195 m on south side as was reflected in the plan.

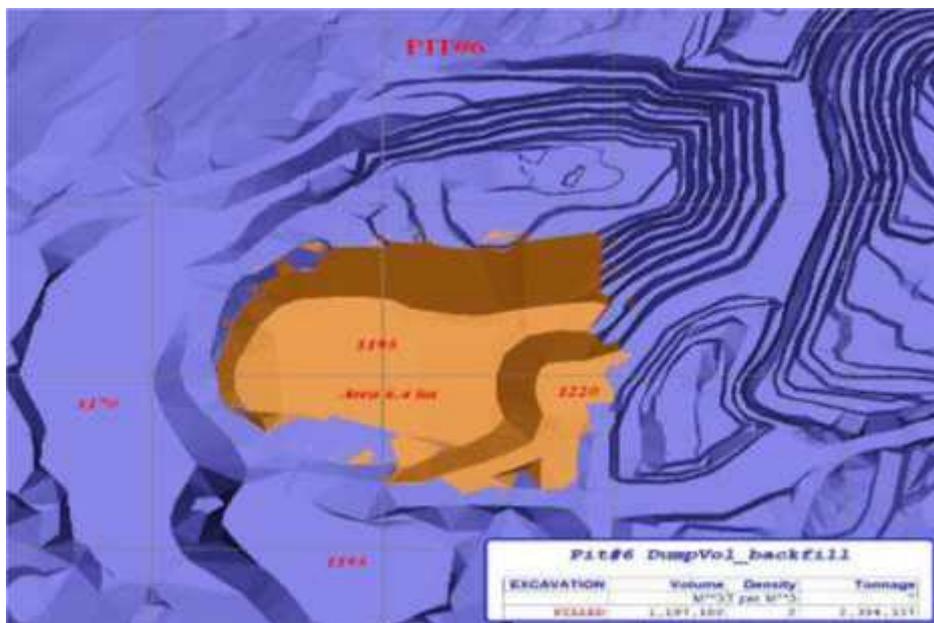


Image 5.1. Filled section of pit 6



Image 5.2. Open pit 6

Refill and reclamation of placer deposit open pit of Mon Dulaan LLC.



Image 5.3. Placer deposit extraction before and after reclamation

Steps of technical reclamation

1. Waste dump sloping should not exceed 15 degrees. Therefore, surveyor conducts measurements and calculates sloping angle and foot spreading.



Image 5.4. Measurement of dump sloping

2. In order to evenly spread topsoil in prepared area, it is first hauled next to the area and prepared for bulldozing.



Image 5.5. Topsoil hauled and prepared to spread on area prepared in accordance with standards

3. Topsoil should be spread and evened with 0.2-0.3 m thickness using a bulldozer.



Image 5.6. Spreading and evening the topsoil

4. Environmental department employees frequently monitor the thickness of topsoil layer. If thickness is insufficient and does not meet the standards, more topsoil should be layered.



Image 5.7. Measuring thickness of topsoil layer

Biological reclamation

Current reclamation procedure in Mongolia is a general procedure that includes aspects of further use of land after reclamation, vegetation and safety of human and livestock.

Biological reclamation is vegetation of area where technical reclamation has been conducted sowing seeds of perennial plants. Any type reintroduction of animal species and reforestation is also considered as biological reclamation.

After mine closure, the land will be used as pastureland and cropland. Therefore, biological reclamation work has been conducted aiming to perform best to meet the purpose. For further use of disturbed area as a pastureland, mix of below mentioned perennial plants endemic to the region plants with good adaptation has been planted:

- ❖ Wheatgrass /*Agropyron cristatum*/

- ❖ Stipa /*Stipa*/
- ❖ Brome grass /*Bromus inermis*/
- ❖ Yellow alfalfa /*Medicago falcata*/
- ❖ Siberian wild rye /*Elymus Sibirica*/
- ❖ /*Elymus Secalinus*/

Biological reclamation has been conducted in accordance with standard MNS5918:2008 Environment.

Besides time of planting and quality of soil and seeds, big role in biological reclamation plays indicators such as quality of work execution and depth of seeds and norms and others.

Reclamation area of mines is usually waste dumps, therefore, sloping angle is approximately 15 degrees. As of Boroo mine, biological vegetation is conducted manually. To support local sustainable development and provide workplace for local community as part of main policy of the company, Boroo Gold temporary hires local citizens.

In order to increase public participation, give understanding and provide with information, each year the company hires 20-40 workers (overlapping number) from Mandal and Bayangol soums providing reclamation and environmental trainings.



Гар аргаар тарууланг хийж байна

Image 5.8. Vegetation

Besides, in places where machinery could be used, seed sowing 2.1/3.6 equipment is used. In accordance with 3.8 of MNS 5918:2008, seeds have been sowed in depth of 2.0-2.5 cm and as indicated in 3.5 of the standard, planting has been conducted in horizontal and across pattern.



Image 5.9. Sowing equipment

Seed quality and sowing norm

In selection of plant for biological reclamation, it is more important to choose plant endemic to the region rather than paying attention to adaptability and significance. In other words, vegetate disturbed area by plant species that previously grew in dominance, which in turn will stabilize micro ecosystem of the area ensuring sustainable shift to natural occurrence. Based on baseline study of Boroo Gold tenure, perennial grasses such as Agropyron, brome grass and elymus seeds mixed with pastureland plant seeds are used for reclamation. Thus reclaimed area easily shifts to its natural occurrence, new plant species naturally start to grow increasing number of plant species and furthermore biodiversity restores. 3.9 of MNS 5918:2008 standard indicates that “species of shrub, tree and plant endemic to the region should be used in reclamation.”

In order to fulfill above mentioned objective, good quality and cleaned seeds are required for reclamation. Therefore, 1 and 2 quality class seeds are purchased from national entities and used for reclamation. Growth speed and sprouting rate of these seeds are verified by “plant restriction laboratory”.

Rate of laboratory sprouting and field sprouting is the main indicator of planting norms. Therefore, before field planting work starts in spring, sprouting and growth speed of 100 seeds are defined indoors, as well as 5 gram of seeds of each species are sampled to defined amount of waste matter in order to estimate amount of seed required for 1 ha area.

Sprouting: 100 seeds are sprouted twice indoors for a week. 20 seeds are placed in each cup and each specie is tested. Sprouting rate is defined by counting sprouts after 8 days.



Image 5.10. Seeds prepared for indoor test to defined sprouting rate



Image 5.11. Seed sprouting

Cleanliness: 5 grams of seed is taken and divided into seed and waste and weighed with 0.0001 g accuracy. Weight of waste and other species seeds is then subtracted from initial mass.



Image 5.12. Seed sampling



Image 5.13. indoor sprouting at the beginning and later

Preparation of perennials mix: *Elymus sibirica* -20%, *Bromus inermis* -10% Agropyron-40%, Alymus-30%. To sustain soil, 5-8 kg of rye, barley and oat seed is planted per hectare.

After reclamation monitoring is required to define results of reclamation, its sustainability and ability of further territorial distribution and increase of numbers of species.

After reclamation biodiversity monitoring of Boroo mine has been conducted in constant cooperation with scientists and researchers of national institutes such as division of Biology of University of Agriculture, Insect and microbial synthesis research laboratories of Academy of Science, Plant protection institute, Pasture management union of Mongolia and Darkhan

Nogoon Aral LLC. Two series of picture guide books have been published within the scope of above mentioned activity.



Image 5.14. Series of picture guide book published within the scope of biodiversity study of reclaimed area

Long term biodiversity monitoring of reclaimed area on annual basis plays a big role in defining results and ecological sustainability of reclamation works, improvement of further actions and organization of next the stage activity.



Судлаачдын баг хаягдлын далан орчмын шувуудын ажиглалт хийж байна

Image 5.15. Observation of researchers

Besides scientists and researchers of specialized organization, each year environmental department officers take measurements and conduct observation of plant species and vegetation cover of reclaimed area with certain frequency. Thus provides information on field sprouting of species, dominant species and growth level and further defining adaptability and the vegetation cover mass provides baseline information necessary for planning and implementation of future reclamation works.

For instance, in 2014, nine monitoring points in total of 30 ha area have been selected in consideration of land relief, planting date and method and other specifics.

During reclamation work, rain water and flood washes out and erode topsoil. Therefore, it is important to plant species with strong root system that sprouts in short period of time. Thus plant roots sustain soil preventing from washout and erosion. Moreover, such species shade and protect other species as well as store more moist creating favorable condition for other species. Taking in consideration above mentioned, seeds of cultivated species such as rye, wheat, oat and barley is mix with seeds of endemic plants, outcomes of which is efficient.



Image 5.16. Measurement at reclaimed area



Image 5.17. Vegetation cover of 1m², *Elymus Secalinus*

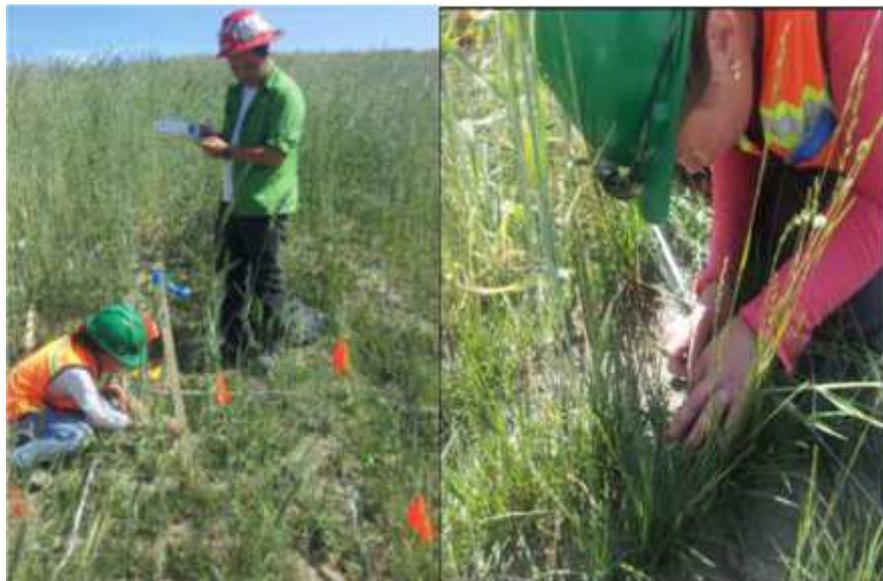


Image 5.18. Plant inventory, plant is counted by number of stem



Image 5.19. Artemisia Scorparia, Agropyron Cristatum

Maintenance and treatment of reclaimed area

Soil washout and erosion cases take place at reclaimed areas due to precipitation and spring ice melt creating channels and washing our fertile soil. Timely action should be taken to prevent from further erosion filling, repairing, sloping and covering with topsoil large ravines and channels using heavy duty equipments. However, such actions require lot of time and large amount of money. Therefore, preventive actions should be taken in first place.

Ways to prevent from washout and erosion

- Placing hay bales

One of the best international practices to prevent from soil washout and erosion is to place hay bales. Due to successful experimental use of hay bales took place in 2012 to prevent soil washout and emergence of channels, this method of prevention has been used in 2013 and 2014 to prevent areas reclaimed in previous years.



Бодлын өвсийг үүссэн суваг шуудуунуудад байрлуулсан байдал

Image 5.20. Hay bales placed at eroded and washed out areas

14 citizens have been hired in 2014 between June 18 and July 24 to place 975 hay bales at reclaimed area of pit 2 waste dump.

Hay bales are placed in minimum 10 cm dug holes and thoroughly fixed by poles. Hay bales slow water flow in channels and distribute water evenly in soil accumulating moisture and improving growing conditions. Therefore hay bale placement is an internationally recognized practice that prevents enlargement of channels and improves growing condition for plants.



БООДЛЫН ӨӨСИЙГ ТЭЭВЭРЛЭН АВЧИРЧ ТАЛБАЙД БАЙРШУУЛСАН БАЙДАЛ

Image 5.21. placement of hay bales



Image 5.22. Placed hay bales (2013)



Image 5.23. Placed hay bales (2014)

Topsoil stripping, storage and use

One of the leverages of successful performance of reclamation work is topsoil. In other words, topsoil is invaluable and nonrenewable natural resource. Therefore, internal procedure on stripping and storage of topsoil has been developed and followed from the very beginning of commencement of Boroo mine operation. Currently, total of 2,782,746 tons of topsoil is stored in 16 stockpiles in accordance with relevant standard to use in reclamation of 370 ha area in future. Samples are collected from these stockpiles to verify if the fertility of the topsoil meets

the requirements. As indicated in 7.5 of MNS 5916:2008 standard, stockpiles are not higher than 5 m, and vegetated as indicated in 7.3 of the same standard. Signs with stockpile number and created year are checked on annual basis and replaced or repaired if required.



Image 5.24. installation of renewed sign for topsoil stockpile

REFORESTATION

Besides sowing perennial seeds for vegetation of pastureland, intensive reforestation works are implemented within the scope of biological reclamation. Reforestation work has been started in 2007 when young trees were transferred and planted in another place. As of 2014, total of 49200 trees of 10 species has been planted in 41.2 ha area. Establishing own tree nursery in 2008, 2011 and 2014 and using for reforestation of reclaimed area is a big advantage of reforestation program of environmental department of Boroo Gold company. Besides, the company works in collaboration with local and Ulaanbaatar city tree plantation entities.

1. Reforestation program conducted in collaboration with Tree Global company 2012- 2014

Reforestation project has been implemented in collaboration with Tree Global company (now UB Tree) in 2012-2014 planting 26920 trees in 21.8 ha area. Tree Global seedlings with high growth rate and no necessity to irrigate are grown in special tubes, special substances has been used during the growing process allowing the plant to grow strong roots, as well as organic fertilizer and moist preserving substances have been added prior planting. Thus increases vitality of the seedling. In spring 2013, inventory of trees planted in 2012 shows that the growth rate is 100%, not including damages caused by external impacts (damage of roots by rabbits and small rodents, tramped by livestock)



Image 5.25. Tree planting instruction given to temporary workers



Image 5.26. Receiving seedling from Tree Global company

2. Tree nursing area

Tree nursery has been established in collaboration with “Darkhan nogoon aral” company in 2008 and 2011. Environmental department of the company has been in charge of nursing and irrigation of the trees. More than 30 000 tree seedlings have been grown in nursery and used not only in reforestation and re-plantation of trees at tenure, but also donated to local administration. In spring 2014 third tree nursery has been established on 0.2 ha area in collaboration with “Darkhan nogoon aral” company.

Table 5.1. Number of trees planted in tree nursery in 2014 by each species.

No.	Seedling type	Number seedlings	of	Total
1	Maple	3,000		13,200
2	Aspen	3,500		
3	Willow	2,000		
4	Elm	3,500		
5	Siberian peashrub	1,200		



Улиасыз тайрдасуур сүүлгэсэн байдаг



Тайрдасуудыг сүүлгэхээс өмнө хэрс бэлтгэсрүллэвч хийж байна

¹ Methodology for technical and biological reclamation of area disturbed by mine operations, 2009

Image 5.26. Aspen grown from branch, soil processing

Fruit tree

Initially, 600 buckthorn trees have been planted by branch in 2010 with sprinkler irrigation. Growth rate has been no single tree loss. As specialists suggested, 4 species of fruit trees including apple, black current, hackberry and Siberian crabapple have been established in 2014 at 0.5 ha area and protection green stripe was established planting aspen and willow.

Table 5.2. The number of trees in the fruit tree field by species

No.	Tree type	Number of trees	Total number of trees	Area
1	Apple	50	700	0.5 ha
2	Blackcurrants	150		
3	Hackberry	150		
4	Siberian crabapple	150		
5	Aspen	100		
6	Willow	100		

**Image 5.27. Planted fruit trees**

Compared to other deciduous trees, fruit trees require more nursing. Therefore, water sprinkler irrigation system similar to one used in buckthorn field has been installed at fruit field using internal means of the company. Besides decreases water evaporation, sprinkler system saves labor and time.



Модны суулгац тус бүр дээр ус дуслвар хүрдэг



Ус дамжуулах үндсэн шугам

Image 5.28



Үндсэн хоолойноос суваг тус бүрлүү



Услагдсан суваг

Image 5.29

Tree nursing and replanting

Although outcome of any work is greatly depends on performance, after performance monitoring plays big role. Especially reclamation work, reforestation requires lot of time, nursing and irrigation. The company hires two assistant workers and contracts one water truck in warm season only to nurse, irrigate and exterminate weeds. If required, measures using herbicide and pesticide are taken in collaboration with specialized organization (Academy of plant protection). Each year after tree planting in spring and fall, trees are counted and if required, area is replanted with trees from the tree nursery.



Image 5.30. Tree inventory, irrigation of trees



Image 5.31. Trees are taken from tree nursery using machinery



Image 5.32. Replantation and fall charge irrigation conducted by temporary local employees

SEED COLLECTION

2-3 years after biological reclamation in an area, vegetation density and number of plants in 1 m² increase forming conditions to collect seeds from reclaimed area. In order to increase temporary work places and awareness and collection of perennial seeds, "Collection of perennial seeds" project for local community and students begun in 2008 and within the scope of the project, 10-20 citizens are hired for 14-20 days each year. In fall when seeds of perennials are mature enough to collect, seeds of some perennials growing in dominance such as wheatgrass, rye and brome grass are collected from reclaimed areas and seeds of wild onion, stipa, feather grass and brome grass are collected from natural fields and reserved for the next year reclamation works. Thus accelerates the process of reclaimed area to reach its natural property as well as increases the number of plant species. In other words, number of species naturally increases each year at reclaimed area and results of study shows that in 4-5 years, in some reclaimed areas number of species naturally increased by 10 species. Collection

of seeds of perennial plants growing in dominance at areas reclaimed 2-3 years ago is beneficial both controlling over dominance of certain species and supports growth of naturally spread new species.

Since 2012, seed cleaning and preparing works positively affects vegetation work of the next year. It has been prepared 560 kg clean seeds ready to directly plant next year. Seeds of stipa and brome grass is easy to collect when it's harder to collect seeds of *Elymus dahuricus* and *Bromus inermis* have a lot of weight loss after cleaning.



Image 5.33. Seed collection and cleaning



Image 5.34. seeds stored after cleaning

MARMOT REINTRODUCTION

In August 2008, first time in Mongolia in mine operation industry, Boroo Gold LLC initiated activities to reintroduce Mongolian marmot at their tenure in order to protect and reclaim biodiversity in cooperation with Institute of Biology of Academy of Science, Eco-Asia Institute and Administration of Bayangol soum. Studies have been conducted on distribution, population, location, number, density and habitat of reintroduced marmots. Total of 10 marmots have been brought from Khustain national park to reclaimed area at Boroo mine site and further reintroduction activity has been handled by Eco Asia university and Environmental office of Bayangol soum.

Results of field study conducted in 2014 show that there are total of 72 marmots in 11 families.



Image 5.35. Marmot reintroduction, 2008

Mine Closure Plan outline



Community engagement in closure reclamation activities

Boroo mine biological reclamation is conducted every year with participation of citizens of Bayangol and Mandal soums who are instructed by specialists of the Boroo Environmental Department. Every year about 30-40 local citizens are hired for the period of 2-3 months as temporary employees as specified in the Annual Reclamation Plan. Seed planting is carried out with use of agricultural equipment where possible. Participation of local citizens in the mine closure reclamation according to the 2015-2019 Plan is highly important as every year 25-40 people will be provided with temporary jobs from May till October during these years. In addition, agricultural equipment and machinery of entities operating in the region will be hired for certain areas.

HEAP LEACH AREA RECLAMATION PLAN

Closure Program for the Boroo Heap Leach

Closure of the Boroo heap leach pad will be done according to the most widely used closure practice for heap leach pads in the West. After gold recovery is complete, the cyanide water in the pad will be allowed to drain down after which the pad will be recontoured, topsoiled and seeded. The heap leach pad will not be rinsed with clean water as a decontamination step as was the original plan for closure of the heap leach pad.

Rinsing is not the chosen closure practice in the USA at present and not at Boroo for several reasons:

1. Furthermore this rinsing would deplete the clean water reserve to some extent and add polluted water to the waste water reserve. Using clean water to rinse a pad that contains deleterious materials would result in contamination of the clean water.
2. Using clean water to rinse a contaminated source is counter to the philosophy of a good environmental program (the US EPA is averse to approving any such program). Clean water must not be polluted in order to improve a contaminated material.
3. The rinse water that is contaminated following a rinsing step would at that time need to be managed as a contaminated material which would require special handling and disposal.
4. Rinsing heap leach pads has also been shown to be counterproductive because of the chemical reactions that can occur within the pad during rinsing. Water in the pad can react with chemicals that are contained within the pad to produce different acids and metal byproducts that would not have been produced had the pad not been rinsed. These byproducts can be more harmful in some cases than the chemicals that would have been produced if the clean water had not been introduced.
5. In the case of the Boroo leach pad, it is estimated that one pore volume would equal about one million cubic meters of water. The required pore volumes would be three million cubic meters of water. If the one million were clean and the three million was contaminated, then there would be three times the volume of contaminated water that was produced in order to clean the pad. In order to manage the 3 million cubic meters of water, the contaminated water would need to be treated in some manner before it was released. This treatment is typically very expensive and the clean water would likely not be re-introduced into the clean water reserve where it could be used as clean water. Typically the treated water is disposed of or used in another manner that makes the treated water unavailable as the original clean water.

Discussion: During the first years of heap leach closure, rinsing of the heaps with clean water was thought to be the only approach to reduce concentrations of cyanide in a cyanide heap leach pad. Because this closure approach represented the prevailing concept for

closure at the time, this closure approach was identified as the chosen pad closure method for the Boroo heap leach pad. However numerous scientific testing have proven that rinsing is less desirable as a closure approach than other methods that will be discussed.

Rinsing with clean water has in fact, been shown to produce more negative results than positive. Rinsing in many cases has been shown to result in an increase in deleterious elements rather than to decrease the concentration of these elements. Frequently a rinsing program that was undertaken to remove Cyanide had in fact resulted in little reduction of Cyanide and instead had created an increase in the concentration of other undesirable elements. With this finding, alternative methods of closing heap leach pads were reviewed until an approach was discovered that proved to be superior to rinsing in reducing the toxicity of the pad and pad solutions and meeting closure obligations. Investigators discovered that a more active approach to closure was not superior but instead a more passive approach to closure of the pad provided better results.

The closure process now preferred by the regulatory community in the west now consists of a step-wise process that begins with the finalization of heap leach production and ends with the construction of a protective soil cover on a de-commissioned heap leach pad.

Heap leach production is halted when the gold recovery process is finished. At that time the recirculation of heap leach fluid (containing cyanide) is stopped and the de-commissioning or closure phase starts. The residual water that is contained within the heap leach pad at the end of operations and the start of closure would be allowed to drain out of the pad naturally (by gravity; referred to as "drain down").

The drain down water is periodically tested to determine if treatment is required to meet applicable criteria for either; direct discharge, as land application water, in shallow groundwater injection points or for placement within the Boroo tailings facility. All of the discharge methods require Arsenic to be at 0.01 ppm or lower (Cyanide concentrations vary according to the standards that are applied), whereas discharge to the Boroo tailings facility would be held to the Arsenic and Cyanide standard of 1.0 ppm or less.

One of two general treatment approaches would be employed if treatment of this drain down water were required: (1) Contaminated water would be delivered to the existing Boroo detoxification facility for treatment (using the detoxification system that has been an effective program since mine startup) or; (2) an in-line treatment approach using hydrogen peroxide or other chemical that is metered into the water at a rate that is based on the water quality and the criterion that must be met. This in-line approach would be designed to bring the cyanide and arsenic concentrations to acceptable levels before discharge to the tailings pond.

Delivery of drain down water would either be to the Boroo Tailings facility or application as surface irrigation water.

After the heap leach drain down program is completed, a program of constructing a soil cover on the pad will be undertaken. The purpose of the soil cover is to stop infiltration of

meteoric water as much as possible. From 0.5 to 1.0 meter of soil cover will be used to construct the soil cover.

The quality of the water that is applied, the vegetation and soil that are impacted and the shallow and deep groundwater in the application area would all continue to be monitored using the same monitoring program this has been operational since the heap leach operation was initiated. If significant impacts are noted which could possibly be linked to the land application, then mitigation measures would be implemented to control the impacts.

Technical reclamation

Technical reclamation will be conducted in accordance with NS5917:2008 standard. Total area will be about 45 ha. Technical reclamation cost is estimated as follows.

Cost of spreading top soil on evened ground

About 33 ha evened ground to be covered with 20 cm soil will require $330000 \cdot 0.2 \cdot 1.05 = 69300 \text{ m}^3$ top soil.

Table.5.1. Cost of loading the top soil from stockpile with bucket loader and hauling

Indicators	Formula	Estimate, comments
Loading and haulage amount	$V_{\text{н}} = S_{\text{J}} \cdot h \cdot k_c$	$V_{\text{н}} = 23604 \text{ m}^3$
Bucket loader's loading and haulage hourly productivity	$Q = \frac{3600 \cdot K \cdot E \cdot K_c \cdot \gamma}{\left(t + 3.6 \left(\frac{L_{\text{н}}}{V_{\text{н}}} + \frac{L_{\text{п}}}{V_{\text{п}}} \right) + t \right) \cdot K_c}$ <p> Q – hourly productivity of bucket loader, m^3 K – time consumption coefficient K_c – bucket fill coefficient, (0.8-1.2) t – work cycle duration $t = 87.8 - 10.65q + 0.52q^2$ $q_{\text{н}}$ – loader capacity, tn $L_{\text{н}}, L_{\text{п}}$ – distance to drive with a load and empty, m $V_{\text{н}}, V_{\text{п}}$ – speed to drive with a load and empty, m/sec E – bucket capacity during haulage, m^3 γ – density of hauled soil, tn/m^3 t – unloading time K_c – looseness coefficient </p>	$t = 87.8 - 10.65 \cdot 5 + 0.52 \cdot 5^2 = 45.55$ $Q = \frac{3600 \cdot 0.85 \cdot 3 \cdot 1.1 \cdot 1.8}{\left(45.5 + 3.6 \left(\frac{100}{11.5} + \frac{100}{16} \right) + 3 \right) \cdot 1.05} = 159.5$
Total operating hours:	$T = \frac{V_{\text{н}}}{Q \cdot K_c}$ T – duration to perform the task P – hourly productivity of bucket loader, m^3 $K_{\text{экс}}$ – looseness coefficient	$T = \frac{6}{1 \cdot 1.05} = 511,17$
Fuel, combustible and lubrication materials (CLM) cost	$C_{\text{ДТ}} = 1,15 \cdot P$ $C_{\text{ДТ}}$ – fuel, CLM necessity - hourly fuel consumption norm 1,15- fuel station at 15% of fuel cost P – 1 l diesel fuel price, 1300 tug.	$C_{\text{ДТ}} = 511,17 \cdot 15 \cdot 1.15 \cdot 1.7 = 1482.3 \text{ thous.tug}$
Parts:	$C_{\text{чс}} = k \cdot t / T$ $C_{\text{чс}}$ - parts cost - price of bucket loader k - rate of use of parts	$C_{\text{чс}} = 69600 \cdot 0,02 \cdot 511,17 / 4800 = 2390.25 \text{ thous.tug}$
Payroll	$C_{\text{п}} = T \cdot \text{rate}$ $C_{\text{п}}$ – total payroll cost – hourly pay rate for a machinist	$C_{\text{п}} = 511,17 \cdot 2,5 = 2062.5 \text{ thous.tug}$
Social insurance premium	$C_{\text{ИДШ}} = C_{\text{п}} \cdot 0,13$ Social insurance is calculated at 13% of payroll	$C_{\text{ИДШ}} = 2062.5 \cdot 0,13 = 268.125 \text{ thous.tug}$
Depreciation cost	$C_{\text{экс}} = \text{price} \cdot k \cdot t / T_k$ $C_{\text{экс}}$ – depreciation premium - depreciation norm 10%	$= 69600 \cdot 0,1 \cdot 825 / 4800 = 1196.25 \text{ thous.tug}$

¹ Methodology for technical and biological reclamation of area disturbed by mine operations, 2009

	T_k – total operating time in a year t- soil haulage total time	
Total cost of bucket loader:	$S = 3975.73 + 239.25 + 2062.5 + 268.125 + 1196.25 = 7741.86$ thous.tug	

Compacting cost

The area to be reclaimed with biological reclamation will be compacted with scraper.

Table 5.2. Scraper operating cost

Cost	Formula	Comments
Quantity of evening work: - volume m^3 - area m^2	$V = S \cdot h \cdot k_c$	$V = 330000 \cdot 0.2 \cdot 1.05 = 69300 m^3$
Productivity of wheel scraper to even the ground, m^3 / hour	$Q = \frac{k_1 \cdot k_2}{t_1 \cdot k}$	$Q = \frac{1.6 \cdot 4.5 \cdot 3}{1 \cdot 9.06} = 241.54$
Duration of a cycle	$T = t_u + t_{u1} + t_{u2} + t_{u3}$	$T = 20 + 93.9 + 15 + 50 = 178.9$ sec
Total operating hours	$T = \frac{V}{Q} \cdot k$	$T = \frac{6}{2.5 \cdot 1.15} = 338,9$ цар
Fuel, combustible and lubrication materials cost	$C_{дт} = T \cdot \dots \cdot 1.15 \cdot$	$C_{дт} = 114,9 \cdot 25 \cdot 1.15 \cdot 1.7 = 5619.06$ thous.tug
Parts	$C_{сз} = XO_{сзп} \cdot k \cdot t/T_k$	$C_{сз} = 5500 \cdot 0.02 \cdot 266/4800 = 6.09$ thous.tug
Payroll cost	$C_{п} = \dots \cdot U_{п}$	$= 266 \cdot 2.5 = 665$ thous.tug
Social insurance premium	$= \dots \cdot 0.13$	$= 665 \cdot 0.13 = 86.45$ thous.tug
Depreciation cost	$= XO_{сзп} \cdot H \cdot t/T_k$	$= 55000 \cdot 0.1 \cdot 266/4800 = 304.79$ thous.tug
Total scraper cost	$= 15619.06 + 6.09 + 665 + 86.45 + 304.79 = 20044.2$ thous.tug	

Total cost of technical reclamation:

$$3 = \dots + \dots = 7741.86 + 20044.2 = 27786.06 \text{ thous.tug}$$

Cost of technical reclamation per hectare 27786.06: 33 = 842.01 thous.tug

❖ **Biological reclamation cost**

After completion of technical reclamation and overburden is stabilized and condensed on the stockpile and other areas, the top soil that was stored in stockpiles will be spread which is the start of the biological reclamation on **disturbed** land.

Total biological reclamation area will be 33 ha.

The cost of this work is summarized as follows:

$$\begin{aligned}
 0 &= SHC \cdot H \cdot P + \dots \cdot T \cdot N + \dots = \\
 33 \cdot 20 \cdot 18.0 + 28,26 \cdot 30 \cdot 4 + 120.0 &= 15391,2 \text{ thous.tug} \\
 1 &= Shc \cdot H_1 \cdot P_1 + 1 \cdot T_1 \cdot N_1 + \dots = 33 \cdot 20 \cdot 18.0 + 28,26 \cdot 30 \cdot 5 + 150.0 = \\
 &720 + 2250 + 150 = 16269 \text{ thous.tug} \\
 &= 0 + 1 = 15391,2 \text{ thous.tug} + 16269 \text{ thous.tug} = 31660,2 \text{ thous.tug}
 \end{aligned}$$

Herein:

- total vegetation cost,
- 0 – cost of vegetation with plant seeds
- 1 – cost of vegetation with perennial seeds
- SHC – total area of biological reclamation, ha
- H – norm of plant seeds required for one unit land, kg
- P – market price of 1 kg plant seeds
- salary of 1 employee per unit time, thous.tug
- T – duration of vegetation activities, days
- N – number of people to work on vegetation activities
- equipment cost

Total cost estimate for reclamation of disturbed land after Heap Leach Project completion

Total cost of technical and biological reclamation activities is summarized in the below Table 5.3.

Table 5.3. Reclamation cost

#	Cost	UOM	Total	Year to carry out activities
	Technical reclamation cost	MNT thous.	27786,06	
	Biological reclamation cost	MNT thous.	31660.2	
	Total reclamation cost	MNT thous.	59446,26	

Methodology of biological reclamation and re-vegetation

Biological reclamation at the Boroo Heap Leach project site will be conducted in accordance with MNS 5918:2008 standard on "Vegetation of disturbed land. General technical requirements".

It includes:

- ❖ In the event the mechanical composition, fertility and solution environ of the soil to be spread do not meet the standard requirements, actions should be taken to fertilize with nutritious and mineral fertilizer and improve the mechanical composition of the soil.
- ❖ Reclamation will not use plants from 1-2 years old
- ❖ Planting timing is selected as shown in the below table.5.4 based on the features of the plant species, climatic and regional conditions of the land for planting.

Table.5.4

	Natural region	Without irrigation	With irrigation
1	Mountainous	3 rd 10 days of June	3 rd 10 days of May
2	Forested steppe, steppe	2 nd 10 days of June	2 nd 10 days of May
3	Gobi, desert	3 rd 10 days of May	1 st 10 days of May

- ❖ If the slope of the area to vegetate is more than 15^o, the plants should be planted either horizontally or across the inclination.
- ❖ Seeds are planted in the depth of 2.0-2.5 cm.
- ❖ Native trees and shrubs are used in reclamation. In Khangai region, birch, aspen, poplar, larch, pine and spruce should be planted in rows with distance of 5 m in between the rows and 4 m between trees (500 trees per ha), and elm in rows with distance of 4 m between rows and 3 m between trees (833 trees per ha); in the steppe and Gobi region, aspen and poplar should be planted in rows with distance of 4 m between rows and 3 m between trees (833 trees per ha), elm in rows with distance of 3 m between rows and 3 m between trees (1111 trees per ha), and all species of brushwood and shrubs such as apricot, almond, hawthorn, and wild plum should be planted in any region in rows with distance of 2 m in between and 1.5-2 m between the plants (2500-3333 plants per ha).
- ❖ After planting, depending on the status of sprouting of perennials and growth of shrubs, bushes and seedlings, additional planting or other actions shall be undertaken, if necessary.

CHAPTER SIX. RISK ASSESSMENT AND RISK MANAGEMENT OF THE BOROO HEAP LEACH PROJECT

Introduction

In this chapter potential risks have been assessed that may occur during operations to recover gold with heap leaching method at the Boroo hard-rock gold deposit in the territory of Mandal soum, Selenge aimag. The purpose of this risk assessment is to define and assess the risks of accidents and hazards that may arise due to project operations, and potential risks that may be caused to human health and environment due to chemical substances used in gold recovery with leaching process, to estimate their consequences, and define mitigation actions.

This risk assessment has been prepared in accordance with the “Methodology to assess risks of toxic and hazardous chemicals” approved by Annex #2 of Joint Decree #A-50/378/565 of the Minister of Nature, Environment and Green Development, Minister of Health and Chairman of the National Emergency Management Agency, dated October 25, 2012.

The risk assessment has been conducted within the following scope by predicting circumstances that may arise.

Herein:

1. Risk to health of employees of the heap leach operations at the Boroo hard-rock mine,
2. Risk to environment during leach process of gold from the Boroo hard-rock deposit ore,
3. Potential accidents and risks that may arise during leaching the gold from the ore.

6.1. ASSESSMENT OF RISK TO HUMAN HEALTH

The scope of risk assessment and processing methodology is the same for risks to human health and to environment. The phases are:

1. Determining the issue,
2. Determining exposure,
3. Determining toxicity,
4. Determining risks.

6.1.1. Determining issues that may affect human health

While making an assessment of potential risks to health of employees working at the heap leach facility, the risk overview is made in order to define pollutants, the person exposed and transmission ways. The following issues are identified with risk assessment.

Person exposed: There are 11 employees that work at heap leach facility. There are no local citizens residing near the project site, thus the persons to be exposed only employees working in heap leach facility.

Chemical substances: In order to define toxic and other chemicals that the employees will be exposed to, results of tests on air, water and soil made by accredited laboratories during environmental baseline study are taken into account, the test results are compared with the

Mongolian standards, and risk assessment is conducted on chemical substances that exceed the permissible levels.¹

Soil pollution and erosion status

The Boroo river valley and Ikh and Baga Dashir valleys are areas highly eroded and disturbed badly due to mining operations. After operations of the Boroo alluvial deposit, reclamation work has not been conducted, and it has been common that top soil and has waste rock has been stripped without order and stacked and left without plans. But with commencement of the hard-rock gold mine and processing plant operations, the mine property has been fenced and strict security procedures has been put in place which has been a progress step to protect the environment and conduct constant reclamation.

Starting from early 20th century, mercury has been used to recover gold from the ore, thus its residue is still stored in high amount in the soil around the banks of the Boroo River which is confirmed with soil chemical tests.

In order to define the current level of soil pollution, soil samples are taken from the vicinity of the Boroo mine, tested in accredited laboratories and the sampling River points are shown in the below image. (Image.6.1.)

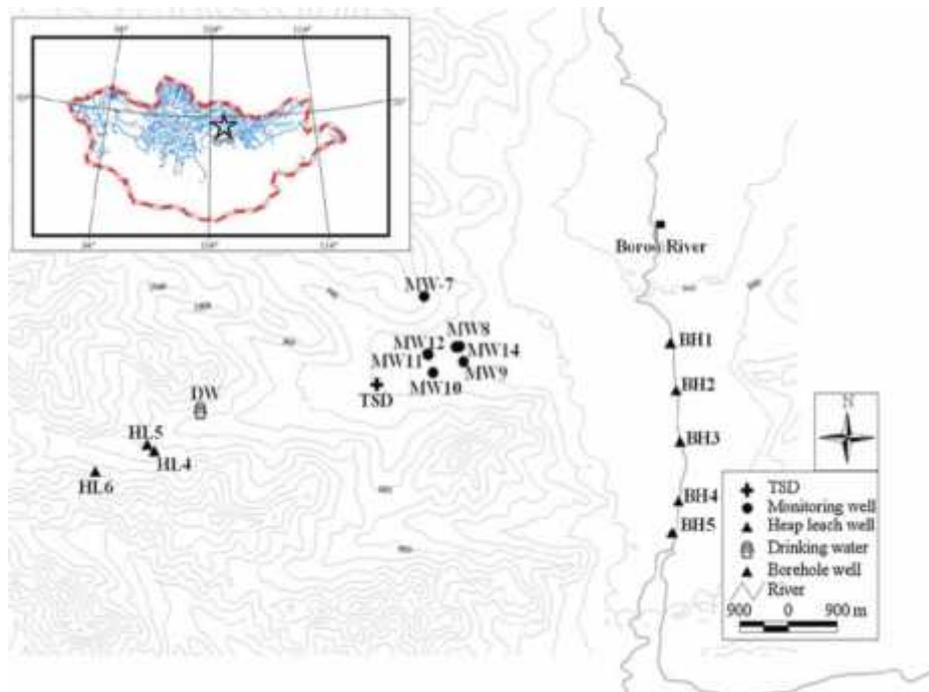


Image.6.1. Sampling locations

Results of soil tests are shown in the below table compared with permissible maximum levels under Mongolian standard “Soil quality. MNS 5850:2008”. (Table 6.1).

Table 6.1 Heavy metals in soil near the Boroo Gold mine, mg/kg²

¹ Methodology to conduct risk assessment of toxic and hazardous chemicals, page 13

Sampling points	As	Cd	Cu	Ni	Pb	Zn
Soil near heap leach area	8,6	-	10-15	11.5-21	8,5-18,3	50.0
Monitoring area	3.4	-	15	19.1	8.0	42
Mongolian soil standard	6	3	100	150	100	300

According to above results, most of heavy elements in soil are within standard levels but content of arsenic is exceeding the standard level.

2012 test results of heavy elements in soil around the Boroo heap leach area of Boroo Gold LLC are shown in the below Table (Table 6.2).

Table 6.2. Results of tests on heavy metals in heap leach soil of BGC

Element	UOM	Sampling point	Lab	Jan 12	Jan 16	Jul 17	Sep 13	MNS 5850:2008
HL area								
Cadmium	mg/kg	HL Intersection	SVL	<0.20	<0.20	<0.20	<0.20	3
Calcium	mg/kg	HL Intersection	SVL	6760	6520	6720	6980	-
Chromium	mg/kg	HL Intersection	SVL	30.1	34.6	35.2	34.2	150
Copper	mg/kg	HL Intersection	SVL	21.1	24.2	22.4	23.1	100
Iron	mg/kg	HL Intersection	SVL	23900	24200	27500	26400	-
Lead	mg/kg	HL Intersection	SVL	11	12.3	11.1	11.2	100
Magnesium	mg/kg	HL Intersection	SVL	6020	6100	6580	6170	-
Nickel	mg/kg	HL Intersection	SVL	20.9	22.3	24.8	20.2	150
Sodium	mg/kg	HL Intersection	SVL	141	120	137	126	-
Zinc	mg/kg	HL Intersection	SVL	55.5	62.9	60.0	62.3	300
Mercury	mg/kg	HL Intersection	SVL	<0.033	<0.033	<0.033	<0.033	2
pH	pH	HL Intersection	SVL	7.68	7.63	7.24	7.48	
Cyanide (WAD)	mg/kg	HL Intersection	SVL	<0.500	<0.500	<0.500	<0.500	25
Cyanide (total)	mg/kg	HL Intersection	SVL	<0.50	<0.50	<0.50	<0.50	
Cyanide (free)	mg/kg	HL Intersection	SVL	<1.00	<1.00	<1.00	<1.00	
Chloride	mg/kg	HL Intersection	SVL	16.2	11.4	12.2	5.6	-
Nitrate	mg/kg	HL Intersection	SVL	15	18.5	7.30	7.40	-
Sulfate SO₄	mg/kg	HL Intersection	SVL	29.9	43.5	39.2	37.8	-
Solid residue	%	HL Intersection	SVL	92.7	92.1	91.3	90.9	-
Arsenic	mg/kg	HL Intersection	SVL	13.1	7.1	6.5	15.0	6
Heap leach cell #4								
Cadmium	mg/kg	HL Cell#4	SVL	<0.20	<0.20	<0.20	<0.20	3
Calcium	mg/kg	HL Cell#4	SVL	18000	13000	11100	11700	-
Chromium	mg/kg	HL Cell#4	SVL	6.26	6.11	4.37	3.87	150
Copper	mg/kg	HL Cell#4	SVL	10.7	10.5	7.94	8.16	100
Iron	mg/kg	HL Cell#4	SVL	16600	14800	18100	16400	-
Lead	mg/kg	HL Cell#4	SVL	12.9	11.1	14.3	13.6	100

Magnesium	mg/kg	HL Cell#4	SVL	3670	3150	3360	3090	-
Nickel	mg/kg	HL Cell#4	SVL	7.65	5.75	6.27	5.61	150
Sodium	mg/kg	HL Cell#4	SVL	74.3	65.5	64.2	58.1	-
Zinc	mg/kg	HL Cell#4	SVL	43.7	38.4	44.9	44.0	300
Mercury	mg/kg	HL Cell#4	SVL	<0.033	<0.033	<0.033	<0.033	2
pH	pH	HL Cell#4	SVL	8.21	8.15	8.37	8.25	
Cyanide (WAD)	mg/kg	HL Cell#4	SVL	<0.500	<0.500	<0.500	<0.500	25
Cyanide (total)	mg/kg	HL Cell#4	SVL	<0.50	<0.50	<0.50	<0.50	
Cyanide (free)	mg/kg	HL Cell#4	SVL	<1.00	<1.00	<1.00	<1.00	
Chloride	mg/kg	HL Cell#4	SVL	2	3.3	<2.0	7.1	-
Nitrate	mg/kg	HL Cell#4	SVL	0.87	2.40	<0.50	0.84	-
Sulfate SO₄	mg/kg	HL Cell#4	SVL	11	14	5.2	9.5	-
Solid residue	%	HL Cell#4	SVL	98.8	99		99.1	-
Arsenic	mg/kg	HL Cell#4	SVL	59.7	76.1	<2.5	3.6	6
Northern pond of heap leach								
Cadmium	mg/kg	North of the HL PLS Pond	SVL	<0.20	<0.20	<0.20	<0.20	3
Calcium	mg/kg	North of the HL PLS Pond	SVL	8180	7940	13500	9180	-
Chromium	mg/kg	North of the HL PLS Pond	SVL	31.6	34.0	32.5	25.2	150
Copper	mg/kg	North of the HL PLS Pond	SVL	22.2	23.5	21.6	17.4	100
Iron	mg/kg	North of the HL PLS Pond	SVL	25800	24400	25500	21200	-
Lead	mg/kg	North of the HL PLS Pond	SVL	12	11.8	10.5	9.28	100
Magnesium	mg/kg	North of the HL PLS Pond	SVL	7360	6380	6610	5190	-
Nickel	mg/kg	North of the HL PLS Pond	SVL	25	22.9	22.5	15.8	150
Sodium	mg/kg	North of the HL PLS Pond	SVL	148	142	139	108	-
Zinc	mg/kg	North of the HL PLS Pond	SVL	58.3	59.8	56.0	47.8	300
Mercury	mg/kg	North of the HL PLS Pond	SVL	<0.033	<0.033	<0.033	<0.033	2
pH	pH	North of the HL PLS Pond	SVL	7.73	7.58	7.63	7.53	
Cyanide (WAD)	mg/kg	North of the HL PLS Pond	SVL	<0.500	<0.500	<0.500	<0.500	25
Cyanide (total)	mg/kg	North of the HL PLS Pond	SVL	<0.50	<0.50	<0.50	<0.50	
Cyanide (free)	mg/kg	North of the HL PLS Pond	SVL	<1.00	<1.00	<1.00	<1.00	
Chloride	mg/kg	North of the HL	SVL	28.3	13.6	10.9	8.3	-

		PLS Pond						
Nitrate	mg/kg	North of the HL PLS Pond	SVL	15.7	13.6	16.8	12.3	-
Sulfate SO₄	mg/kg	North of the HL PLS Pond	SVL	40.9	43.5	36.4	33.8	-
Solid residue	%	North of the HL PLS Pond	SVL	95.6	94.1	94.8	90.3	-
Arsenic	mg/kg	North of the HL PLS Pond	SVL	29.9	23.3	19.3	17.7	6

Test results show the leach dam soil parameters slightly vary depending on season, weather, and composition of leaching rocks. Although soil is slightly alkali with high grade of calcium and magnesium, it is advantageous to prevent from creating prussic acid with cyanide hydrolysis. According to results of soil tests, the content of cyanide ion is many times lower than the maximum standard level which indicates that use and consumption of cyanide is significantly concern in plant operation.

Contents of heavy elements except for arsenic are relatively lower than standard levels in all samples while naturally occurring arsenic content fluctuates between 6.5-95.2 mg/kg which is 1.08-15.87 times higher than standard level. The Boroo gold deposit is located in the Boroo-Zuunmod ore district in the Northern Khentii gold metallogenic region with the natural arsenic content metallogenic regionalization. This region's gold mineralization had gold-arsenic, gold-silver and gold-antimony combinations, thus the content of arsenic in soil of areas near Boroo deposit is found to be higher than the baseline value of other areas.

Large concentration of arsenic is related to existence of minerals such as pyrite and arsenopyrate in small particles gold in the ore as mill operation technology does not use arsenic in processing.

6.1.3. Water pollution monitoring

The plant has monitoring wells outside the leach pad with the purpose to define dam leak and parameters of water composition and assess detoxification process. (image.6.2).



Image.6.2. Monitoring wells near heap leach pad and sampling process

Average depth of monitoring wells is 54-63 m, static level is 38.2-42.9 m, and discharge is 0.02-0.76 l/sec. Samples are taken on a monthly basis from the wells and tested at Central Geological Laboratory. This study used data from samples from these wells taken in 2012, and the results are compared with MNS 6148:2010 standard and analyzed (Table 6.3).

Table 6.3. Monitoring well water composition and parameters

Element	UOM	Lab	HL1	HL2	HL4	HL5	HL6	MNS 6148:2010
K	mg/l	CGL	3.43	2.72	2.16	3.83	2.29	-
Na	mg/l	CGL	54.5	110	54.4	184	36.4	-
NH4	mg/l	CGL	0.1	0.1	0.1	0.1	0.3	3.0
Ca	mg/l	CGL	149.3	229.46	100.2	82.16	53.11	-
Mg	mg/l	CGL	94.16	101.45	60.75	108.14	23.09	-
Cl	mg/l	CGL	154.92	159.17	111.31	209.16	25.52	350
SO₄	mg/l	CGL	423.02	805.72	237.85	454.29	67.48	500
NO₂	mg/l	CGL	0.01	0.01	0.02	0.01	0.01	1.0
NO₃	mg/l	CGL	4.06	6.5	0.1	9.25	4.7	50
CO₃	mg/l	CGL	<1.5	<1.5	<1.5	<1.5	<1.5	-
HCO₃	mg/l	CGL	241.01	241.01	241.01	292.88	262.37	-
pH	pH	CGL	7.55	7.68	7.76	7.77	7.75	6.5-8.5
H₂SiO₃	mg/l	CGL	13.98	16.38	6.51	13.79	13.07	-
TDS	mg/l	CGL	1058	1626	702	1248	368	-
COD	mg/l	CGL	3.68	4.08	4	5.6	0.6	-
hardness	mg-equiv.l	CGL	15.2	19.8	10	13	4.55	10
CN total	mg/l	CGL	<0.002	<0.002	<0.002	<0.002	<0.002	0.1

CN free	mg/l	CGL	<0.002	<0.002	<0.002	<0.002	<0.002	0.05
CN WAD	mg/l	CGL	<0.05	<0.05	<0.05	<0.05	<0.05	-
Ag	mg/l	CGL	<0.05	<0.05	<0.05	<0.05	<0.05	-
Al	mg/l	CGL	0.035	<0.025	<0.025	<0.025	0.032	0.5
As	mg/l	CGL	0.01	<0.01	<0.01	<0.01	<0.01	0.01
B	mg/l	CGL	0.05	0.04	0.03	0.42	0.06	1.0
Ba	mg/l	CGL	<0.05	<0.05	<0.05	<0.05	<0.05	2.0
Cd	mg/l	CGL	<0.003	<0.003	<0.003	<0.003	<0.003	0.003
Co	mg/l	CGL	<0.01	<0.01	<0.01	<0.01	<0.01	-
Cr	mg/l	CGL	<0.02	<0.02	<0.02	0.04	<0.02	0.07
Cu	mg/l	CGL	0.02	0.03	0.02	0.02	0.02	1.0
Fe	mg/l	CGL	0.04	0.03	0.18	0.04	0.05	0.3
Mn	mg/l	CGL	0.01	0.01	0.21	0.01	<0.01	0.1
Mo	mg/l	CGL	<0.03	<0.03	<0.03	<0.03	<0.03	0.04
Ni	mg/l	CGL	<0.01	<0.01	<0.01	<0.01	<0.01	0.1
Pb	mg/l	CGL	<0.01	<0.01	<0.01	<0.01	<0.01	0.05
Se	mg/l	CGL	<0.05	<0.05	<0.05	<0.05	<0.05	0.04
Sr	mg/l	CGL	1.27	1.85	0.96	1.05	0.47	-
V	mg/l	CGL	0.12	0.15	0.09	0.13	0.04	
Zn	mg/l	CGL	0.03	0.01	<0.01	0.02	0.01	5.0
Th	mg/l	CGL	<0.05	<0.05	<0.05	<0.05	<0.05	
Hg	mkg/l	CGL	<1.0	<1.0	<1.0	<1.0	<1.0	0.002

Note: HL-1,2,4,5,6 are monitoring wells near heap leach pad

According to test results, underground water quality meets MNS 6148:2010 standard requirements.

In order to detect whether there is any pollution spreading through water from plant operations, the test results are compared with test data from the time when the wells are first built. The water composition of the time of building the wells is shown in the below table (Table 6.4).

Table 6.4. Results of tests of the USA laboratories on samples taken from HL-4, HL-5, HL-6 wells at request of BGC

#	Elements	UOM	HL-4 well water contents	HL-5 well water contents	HL-6 well water contents
1	A/SUM	mg-equiv.l	9.93	12.5	6.58
2	ALK	mg/l	231	204	243
3	C/ABAL	%	7.91	3.63	-1
4	C/SUM	mg-equiv.l	11.6	13.4	6.45
5	CO3	mg/l	<1.0	<1.0	<1.0
6	COND	Umhos/cm	1000	1300	630
7	HCO3	mg/l	231	204	243
8	pH	unit	7.81	7.98	7.87
9	TDS	mg/l	670	810	340
10	TDS c	mg/l	586	759	387
11	TSS	mg/l	180	250	78
12	Ca	mg/l	96.5	117	34.7
13	Cl	mg/l	46.2	130	15.4
14	CN	mg/l	<0.01	<0.01	<0.01
15	CN-E	mg/l	<0.1	<0.1	<0.1
16	CN-WAD	mg/l	<0.01	<0.01	<0.01
17	K	mg/l	27	5.14	3.93
18	Mg	mg/l	50.3	42.4	20
19	Na	mg/l	42.1	85	67.5
20	SO4 S	mg/l	60.7	68.2	17.1
21	SO4 ;hg, So4	mg/l	182	204	51.3
22	Ag	mg/l	<0.005	<0.005	<0.005
23	Al	mg/l	2.67	1.66	0.23
24	As	mg/l	0.0185	0.011	0.00605
25	As+3	mg/l	<0.003	0.003	0.00377
26	As+5	mg/l	0.0185	0.011	<0.003
27	B	mg/l	0.056	0.117	0.152
28	Ba	mg/l	0.0389	0.0666	0.0107
29	Cd	mg/l	<0.002	<0.002	<0.002
30	Co	mg/l	<0.006	<0.006	<0.006
31	Cr	mg/l	0.103	0.0076	<0.006
32	Cu	mg/l	0.01	<0.01	<0.01
33	Fe	mg/l	13.1	2.14	0.195
34	Hg	mg/l	<0.0002	<0.0002	<0.0002
35	Mn	mg/l	0.198	0.0858	0.129
36	Mo	mg/l	0.0103	0.0087	0.0107
37	Ni	mg/l	0.016	<0.01	<0.01
38	Pb	mg/l	0.0149	0.0228	<0.0075
39	Se	mg/l	<0.04	<0.04	<0.04
40	Si	mg/l	9.81	8.33	5.22
41	V	mg/l	0.0056	<0.005	<0.005
42	Zn	mg/l	0.0336	0.0206	0.0238
43	TOC	mg/l	31.6	15.0	49.3
44	N in NH3	mg/l	<0.03	<0.03	<0.03
45	NO2+ NO3	mg/l	3.05	6.85	3.11

Comparison of initial and current composition showed they are quite close, sulfate ion content is slightly higher, which could have been resulted from seasonal weather and groundwater composition and dynamics. This compared test results indicate that there is no water pollution at any level caused by BGC operations.

6.1.4. Ways of pollution spreading

If above-mentioned pollutants are spread at doses and amounts that may cause negative impact through certain ways, it may cause actual impact to human health. Although content of chemical substance is high but there is no way for transmission, this will not cause risks.

When soil and water test results are compared, the content of arsenic is higher than standards in the stacked material but it is within the standard level in the water. This is a form to protect from any impact on human and environment through water by settling dissolved arsenic in the mill plant. In other words, it is blocking main ways of spreading. Although stacked ore has high content of arsenic, it is impossible to issue a conclusion based on comparison of this value with standard levels because the dust in this area is very low (0.076 gr/m³) thus unlike to spread in air, it will not be lost outside in any way from the stacked ore, and after the gold leaching is completed, the stockpile will be covered with top soil and reclaimed. Thus the arsenic is buried back into the ground and will not cause harm to human health and environment.

In other words, the ways of spread of pollution are limited.

However, content of arsenic in soil sample taken from heap leach area is 8.6 mg/kg and it can harm human and pollute environment in 3 ways such as through polluted soil, polluted soil through skin and inhaling fine dust of polluted soil.

The potential link between the chemical pollution, its ways of transmission and affected persons are shown in the below table (Table 4.4).

Table 6.4 Exposure ways of health risk assessment

Pollutant	Activity that may cause pollution	Transmission mechanism	Transmission environment	Transmission way	Person exposed
As	Main leaching process	Through soil	Soil air	Inhale Touch	Employees, population
SO ₄ ⁻² Ca ⁺² Mg ⁺²	Main leaching and detoxification process	Through water	Water	Drinking, household	Employees, population

6.1.5. Assessment of impact on human health

Assessment of exposure impacts on health of employees of heap leach area has been prepared in accordance with the “Methodology to assess risks of toxic and hazardous chemicals” approved by Annex #2 of the Joint Decree #A-50/378/565 of the Minister of Nature, Environment and Green Development, Minister of Health and Chairman of the National Emergency Management Agency, dated October 25, 2012, and the daily accepted dose of each substance is expressed in number compared to the person’s body weight. Calculation has been made at highest risk scenario assuming the worst case, and soil and water results with highest pollutant indicators. Tables 6.5-6.8 show assessment of exposure to risks to harm human health with parameter values.

D3 and LE parameters in the following equations are substances that cause cancer, thus these two parameters are excluded when calculating substance that do not cause cancer.

Table 6.5. Dosage to be transmitted with water

$$D_w = \frac{IR \times C_w \times AF_{GIT} \times D_1 \times D_2 \times D_3}{BW \times LE}$$

IR (l/day)	C _{water} (mg/l)	AF _{GIT}	D1	D2	D3	BW (kg)	LE	D _{water} (mg/kg-day)
1.5	229.46 – Calcium	1	5	26	-	70	-	1.75
1.5	108.14 – Magnesium	1	5	26	-	70	-	0.825
1.5	805.72 – Sulfate	1	5	52	-	70	-	6.15

Comment: mg/kg-day: Daily dose of one adult per day

Based on above calculations, conclusion is made that in case of using the monitoring well water for drinking and household purposes or when the well water flows into the rivers and is used by the population for drinking, the daily receipt of calcium is 1.75 mg/kg-day, magnesium 0.825 mg/kg-day, and sulfate 6.15 mg/kg-day.

Table 6.6. Dosage transmitted with soil

$$Dose_{soil\ ingestion} = \frac{(C_s \times IR \times AF_{GIT} \times D_{Days} \times D_{Weeks} \times D_{Years})}{BW \times LE}$$

IR (kg/day)	C _{soil} (mg/kg)	AF _{GIT}	D1	D2	D3	BW (kg)	LE	D _{soil\ ingestion} (mg/kg day)
0.00002	(As) 94.5	1	5	26	5	70	60	4.00·10 ⁻⁷

Table 6.7. Dose transmitted with inhaling of fine dust particles from polluted soil

$$D_{inhal-soil} = \frac{(C_s \times P_{Air} \times IR_A \times AF_{Inh} \times D_{Hours} \times D_{Days} \times D_{Weeks} \times D_{Years})}{BW \times LE}$$

IR _A (m ³ /h)	C _s (mg/kg)	P _{air} (g/m ³)	AF _{Inh}	D1	D2	D3	D4	BW(kg)	LE	D _{inhal-soil} (mg/kg day)
0.66	(As) 94.5	0.076	1	8	5	26	5	70	60	1.61·10 ⁻⁸

Table 6.8. Transmission of polluted soil through skin

$$D_{DermalContact} = \frac{(C_s \times SA_h \times SL_h \times AF_{Skin} \times EF \times D_{Days} \times D_{Weeks} \times D_{Years})}{BW \times 365 \times LE}$$

C _{soil} (mg/kg)	SA _h (cm ²)	SL _h (kg/cm ² event)	AF _{skin}	EF (event/day)	D1	D2	D3	BW (kg)	LE	D _{DermalContact} (mg/kg day)
(As) 94.5	890	10 ⁻⁴	0.03	5	5	26	5	70	60	5.35·10 ⁻⁴

Above calculations are compiled, and total amount of arsenic to be received by one person per day:

$$D_{\text{total}}(\text{As}) = 4.00 \cdot 10^{-7} + 1.61 \cdot 10^{-8} + 5.35 \cdot 10^{-4} = 5.354 \cdot 10^{-4} \text{ mg/kg-day}$$

6.1.7. Assessment of toxicity to cause harm to human health

The toxicity depends on physical and chemical parameters and chemical reaction with living organisms. Toxicity is expressed in number in order to assess the risk to human health, and is used for comparing toxicity of various compounds, and calculating health risks and expressing them in numbers.

6.1.8. Determining human health risks

Determination of human health risks used each substance separately and substances that cause and not cause cancer have been separated as well.

. Arsenic, a substance that causes cancer:

Slope factor is 1.5 mg/kg-day and accumulated cancer risk for the entire lifetime (ILCR) is calculated as follows:

$$\text{ILCR} = 5.354 \cdot 10^{-4} \cdot 1.5 = 8.031 \cdot 10^{-4}$$

It falls into a category “risky” when compared with risk level.

(ILCR $1 \cdot 10^{-5}$ no risk, $1 \cdot 10^{-5} < \text{ILCR} < 1 \cdot 10^{-4}$ very low risk, or probable there is no risk, $\text{ILCR} > 1 \cdot 10^{-4}$ risky)

b. Substances such as Ca^{+2} , Mg^{+2} , SO_4^{-2} that do not cause cancer:

Toxicity and hazard coefficient is compared with toxicity reference level and estimated with equation $H = \frac{D}{T}$.

Table 6.9. Risk estimate of substances with benchmark (do not cause cancer)

$H = \frac{D}{T}$				
Pollutant	D _{total} (daily dose) mg/kg-day	TRV (Toxicity reference value)	HQ (Hazard coefficient)	Risk level
Calcium ion	1.75	Unclear	Unclear	Unclear
Magnesium ion	0.825	Unclear	Unclear	Unclear
Sulfate ion	6.15	Unclear	Unclear	Unclear

Comment: $HQ < 0.2$ no risk, $0.2 > HQ > 10$ very low risk, i.e. probable there is no risk, $HQ > 10$ risky.

6.2. ENVIRONMENTAL RISK ASSESSMENT

6.2.1. Definition of affected ecological components

Affected ecological component: Selection as representatives should be rare or endangered or similar type of species that live in the same food chain with economic value.

Based on results of studies, one species of each food chain is selected as representative of affected wildlife.

Table 6.10. Representatives of wildlife to be affected

Type	Animal name	Feed	Protection status
Small terrestrial mammals	<i>Cricetulus barabensis</i>	Seeds and leaves of all species of grassy plants, insects. Prepares winter feed reserve.	About 9% of land where <i>Cricetulus barabensis</i> is spread is in specially protected areas.
Terrestrial predators	<i>Vulpes corsac</i>	Mammal of predator family. Mostly fed by small mammals.	Regional assessment: Probably to become rare ³
Terrestrial birds	<i>Buteo hemilasius</i>	Rodents and small mammals.	Registered in CITES II Annex

6.2.2. Environmental exposure assessment

. Dose to be transmitted with water:

Estimate of the dose to be transmitted with water:

$$D_{\text{water}} = C_{\text{water}} \times I_{\text{water}}$$

$$I_w = \frac{0.099(B)^{1.9}}{B}$$

Table 6.11. Dose to be transmitted to animals through water

Animal	BW	I _{water}	D _{water} (mg/kg-day)		
			Ca ⁺²	Mg ⁺²	SO ₄ ⁻²
<i>Cricetulus barabensis</i>	0.023 kg	0.144≈ l/kg	33.04	15.57	116.02
<i>Vulpes corsac</i>	2.4 kg	0.09≈ /kg	20.65	9.73	72.51
<i>Buteo hemilasius</i>	1.05 kg	0.099≈ /kg	22.72	10.71	79.77

Comment: I_{water} – Water consumption amount
 BW – Body mass

3 EmmaL. Clark, S.Dulamtsere, Mongolian red list of mammals, 2006

. Dose to affect through soil:

Daily dose of transmission through soil is calculated with below equation.

$$D_{\text{soil}} = C_{\text{soil}} \times I_{\text{soil}}$$

Herein: I_{soil} is amount to be absorbed in soil which is calculated as follows.

$$I_s = 0.025 \cdot I_f$$

$$I_f = \frac{0.0 (B)^{0.8}}{B} \quad (\text{mammals})$$

$$I_f = \frac{0.5 (B)^{0.6}}{B} \quad (\text{birds})$$

Table 6.12. Dose to affect animals through soil

Animal	BW kg	I_f g/kg-day	I_{soil} mg/kg-day	D _{soil} (mg/kg-day)
				As
<i>Cricetulus barabensis</i>	0.023	0.1344	$3.36 \cdot 10^{-6}$	$3.18 \cdot 10^{-4}$
<i>Vulpes corsac</i>	2.4	0.059	$1.47 \cdot 10^{-6}$	$1.39 \cdot 10^{-4}$
<i>Buteo hemilasius</i>	1.05	0.572	$14.3 \cdot 10^{-6}$	$1.35 \cdot 10^{-3}$

6.2.3. Determining environmental risks

Risk assessment of specie to be affected at heap leach area has been made based on comparison of exposure dose with toxicity reference values.

$$H = \frac{D}{T}$$

Table 6.13. Environmental risk assessment

	Chemical	<i>Cricetulus barabensis</i>	<i>Vulpes corsac</i>	<i>Buteo hemilasius</i>
Estimated dose, mg/kg-day (D_{total})	Ca ⁺²	33.04	20.65	22.72
	Mg ⁺²	15.57	9.73	10.71
	SO ₄ ⁻²	116.02	72.51	79.77
	As	$3.18 \cdot 10^{-4}$	$1.39 \cdot 10^{-4}$	$1.35 \cdot 10^{-3}$
Toxicity reference value, mg/kg-day (TRV)	Ca ⁺²	Unclear	Unclear	Unclear
	Mg ⁺²	Unclear	Unclear	Unclear
	SO ₄ ⁻²	Unclear	Unclear	Unclear
	As	$3 \cdot 10^{-4}$	$3 \cdot 10^{-4}$	$3 \cdot 10^{-4}$
Hazard coefficient (HQ)	Ca ⁺²	Unclear	Unclear	Unclear
	Mg ⁺²	Unclear	Unclear	Unclear
	SO ₄ ⁻²	Unclear	Unclear	Unclear
	As	1.06 (very low risk)	0.46 (no risk)	4.5 (very low risk)

Comment: HQ 1 – no risk: no change from baseline estimate, 1<HQ 10 – very low risk, highly probable there is no risk, HQ>10 - risky

Ways of Risk mitigation

1. According to risk assessment results, contents of calcium, magnesium and sulfate ions in the water in monitoring wells are exceeding the standard levels. However, calculation with these indicators shows there is no risk to human health or environment.
2. The content of arsenic in soil near heap leach area is above the standard levels, and with risk assessment it falls into a category of “very low risk, i.e. probable to have no risk”. The plant has monitoring program that is implemented on regular basis and this monitoring should be continued.
3. Although arsenic level in stacked ore is high, its spreading is limited. When leaching finishes and in case reclamation work is properly conducted, arsenic will not cause risks to human health or environment.

6.3. ACCIDENT AND HAZARD RISK ASSESSMENT

6.3.1. Potential accident risk assessment

Potential risk assessment for accidents and hazards due to Heap leach facility operations has been made for each frequency index of potential occurrence of accidents and hazards and their consequence indexes and expressed in risk metrics.

Consequence index estimate has been listed in the order of intensity of impacts on impacted subjects such as human, environment and certain object.

Table 6.14. Potential risk log

#	Name	Potential risk ⁴	Cause of occurrence	Possibility to predict occurrence (1=possible to predict, 5=impossible to predict)	Potential worst case consequence	Protective measures	Occurrence frequency
Chemical substance, solution							
1.1	Chemical transportation	Spill due to unreliability of containers, release to environment, fire, explosion	Breach of storage and transportation safety procedures	3	Damage to human health, environment, project operations	Strict compliance with chemical transportation, storage safety procedures, occupational safety procedures	Rare
1.2	Chemical storage	Chemical evaporation, spill due to improper storage	Breach of storage safety procedures	2	Destruction of soil microorganisms in the area, fatality	Strict compliance with safe operating procedures on chemicals and technological guidelines	Rare
1.3	Chemical use	Chemical evaporation, consequent spill, explosion	Breach of safety procedures, internal work place procedures	2	Migration of wildlife, destruction of soil microorganisms in the area, fatality	Strict compliance with safe operating procedures on chemicals and technological guidelines	Rare
1.4	Loading and unloading chemicals	Chemical spill	Breach of chemical transportation, loading, unloading safety procedures	3	Employees poisoning with chemicals, environmental pollution	Compliance with loading, unloading safety procedures, use PPE, take measurements	Rare
2.1	Solution pond leakage, spill	Spill of solution containing toxic substances	Dam crack	4	Major soil pollution	Protective fastening and lining to be done at high quality	Rare
2.2	Fuel station and solution pipes break	Crack of transmission pipes causing release of toxic and hazardous chemicals to nature	Transmission pipes freeze, wear out	3	Impact on air and soil quality in the area with spill of toxic and hazardous chemicals, harm to health of employees working in the area	Regularly check pipes, insulate according to standards, regular monitoring, immediate repair of damaged pipes	1-2 per year
3.1	Evaporation from	Surrounding air quality	Weather conditions	5	Air quality degradation,	Ensure pH of attenuated	Almost never

⁴ BGC HL project DEIA report, page 137

#	Name	Potential risk ⁴	Cause of occurrence	Possibility to predict occurrence (1=possible to predict, 5=impossible to predict)	Potential worst case consequence	Protective measures	Occurrence frequency
	heap and solution pond	degradation			employees poisoning	solution and pregnant solution not below 10-10.5	
Natural disaster							
4.1	Leach pad, pond, equipment, machinery to be flooded	Heap leach pad, solution pond to be flooded	Flood	5	Soil pollution due to overflow of flood pond	Regularly check the flood dam, ensure reliable operations of pumps, install flood protection	Once in 100 years ⁵
5.1	Crack of solution pipe, collapse of buildings and facilities	Heap to fall apart, solution pond to break, crusher equipment to break, cyanide spill/leak due to pipes crack at welding stitches	Natural disaster, earthquake	5	Pipe damage releases cyanide to and pollutes environment, fatality	Install liners at high quality, ensure stability of crusher equipment	Once in 500 years
6.1	Processing unit, chemical storage, fuel station, solution transmission pipes	Fire caused by breach of fire safety procedures	Fire, thunder	3	Fire starts, causes explosion, fatality	Prevent from fire, take protective actions, install lightning rods	Unclear

Table 6.15. Index of consequences of hazards to human health

Name	Consequence seriousness index				
	(A) Very low	(B) Low	(C) Moderate	(D) High	(E) Very high
Damage to project activities	<1 mln ₺	1-10 mln ₺	10-50 mln ₺	>50-100 mln ₺	100 mln ₺
1.1 Spill due to unreliability of containers, release to	Small amount of substance starts leaking	Amount of leaking substance increases,	Leaking solution starts disturbing living and	Leaking solution increases, breaks down buildings and	Harm to human health, damage environment and

⁵ Addendum to BGC HL project DEIA report, Chapter 2, page 10

	environment, fire, explosion		becomes noticeable to families along the way and employees	working conditions of families along the way	facilities along the way, harms many people	project operations
1.2	Evaporation and spill of chemicals	Chemical spill not felt by surrounding people	Chemicals smelled by sensitive people	Dizziness, nausea	Unconsciousness, red eye, skin burn	Fatality
1.3	Chemical spill, fire, explosion	Smoke is not felt by surrounding people	Smoke smelled by surrounding people, explosion sounds heard	Explosion vibration felt by employees	Explosion, fire smoke poisoning, unconsciousness	Explosion, fire caused fatality
1.4	Spill of chemicals during loading and unloading	Dizziness	Headache, nausea	Vomiting	Vomiting, unconsciousness	Major poisoning of employees with chemicals
3.1	Surrounding area air quality degradation	Dizziness	Headache, nausea	Vomiting	Vomiting, unconsciousness	Unconsciousness
5.1	Cyanide spill	It is possible to immediately find cyanide leak source and stop the hazard	Headache, nausea	Poisoning of employees with cyanide	Risk to employees health, severe poisoning with cyanide	Damaged pipes release cyanide to nature, pollute it, cause employees fatality
6.1	Fire	Smoke starts to be smelled	Sensitive people feel dizzy and nausea	Fire starts, but fire can be promptly extinguished by removing flammable materials away	Flammable materials explode causing burn of employees	Fire starts, burns surrounding items, causes explosion, employees get injured, fatality

Table 6.16. Index of environmental hazard

Name		Consequence seriousness index				
		(A) Very low	(B) Low	(C) Moderate	(D) High	(E) Very high
Damage to project activities		<1 mln ₺	1-10 mln ₺	10-50 mln ₺	>50-100 mln ₺	100 mln ₺
Ecological health (died animals)		<10	11-25	26-50	51-100	100<
1.2	Evaporation and spill of chemicals	No change in soil and air quality	Small amount of soil pollution	Landscape contour to be damaged, possible to reclaim	Landscape special features damaged, impossible to reclaim	Native and rare species of the area die, get damaged, migrate, landscape is destroyed
1.3	Chemical spill, fire, explosion	No change in soil and groundwater quality	Small area to be affected with fire	Fire will start but can fully be extinguished	Fire starts and burns plants and facilities in the area	Large fire starts and causes major damage to environment
2.1	Spill of solution containing toxic chemicals	No change in soil quality	Small amount of soil is polluted	Small amount of soil pollution	Major soil pollution, air and soil quality affected	Large soil pollution causing impossibility to neutralize chemicals
2.2	Release of toxic and hazardous chemical to environment due to damage in transmission pipes	Small amount of chemical has been spilled but prompt action can be taken	Chemical will be smelled in the area	Soil pollution	Major pollution of soil, air, groundwater	Pollution on large area of land, death of animals, degradation of soil and air quality
3.1	Flooding of heap leach pad and solution pond	No change in soil quality	Soil pollution can be removed	Polluted soil can be reclaimed shortly	Soil reclamation will take longer term	Flood pond overflow causes significant pollution and makes reclamation impossible
4.1	Heap leach stack failure, damage of solution pond, stockpile failure, crusher equipment breakage	Cyanide can fully be absorbed in sand	Pollution increases, pollution can be reduced	Cause impact to environment	Impact air and soil quality	Pipe is damaged, cyanide released to nature, soil microorganisms die, animals die

Table 6.17. Matrix of potential human health risk assessment

Occurrence frequency index		Frequency index of human health and safety consequences				
Occurrence/year	Repetition index explanation	Unknown	B Low	C Moderate	D High	E Very high
>1	5-occur always					
1/10 –1	4-from time to time					
1/100–1/10	3-Occasional			1.1, 1.2	1.3	
1/1000–1/100	2-very rare		6.1	5.1	1.43.1	
1/10000–1/1000	1-Almost never					
	Unknown risks					
	Tolerable risks					
	Risk to undertake mitigation actions when necessary					
	Risk with required mitigation action					

According to index frequency of hazardous condition to human health, there has been 1 case of rare occasion of low risks, 2 cases of occasional moderate risk, 1 case of very rare moderate risk, 1 case of occasional high risk and 2 cases of very rare high risks.

Table 6.18. Potential environmental impact assessment matrix

Occurrence frequency index		Frequency index of environment and safety consequences				
Occurrence/year	Repetition index explanation	Unknown	B Low	C Moderate	D High	E Very high
>1	5-occur always					
1/10 –1	4-from time to time					
1/100–1/10	3-Occasional			1.2, 2.1	1.32.2	
1/1000–1/100	2-very rare			5.1	4.1	
1/10000–1/1000	1-Almost never					
	Unknown risks					
	Tolerable risks					
	Risk to undertake mitigation actions when necessary					
	Risk with required mitigation action					

Assessment of environmental risk matrices show 2 cases of occasional moderate risk, 1 case of very rare, 2 cases of occasional high risks and 1 case of very rare high risk.

Table 6.19. Risk level and probability

#	Risk	Potential worst consequence	Risk level				Probability				
			Low I	Moderate II	High III	Harmful IV	Rare/ almost never	Probable	Definite	Unclear	
1.1	Substance spill during transportation due to insufficiency of packaging	Pollution created near spill area, poisoning of drivers and injury		■					■		
1.2	Substance evaporation or leak during storage of chemicals	Spill of toxic and hazardous chemicals, poisoning of people and animals		■					■		
1.3	Violation of chemicals use procedure and substance spills	Serious poisoning of employees, even death, air and soil quality degradation		■					■		
1.4	Chemical spill or leak during loading, unloading chemical substances	Poisoning of employees with chemicals, pollution of the environment			■			■			
2.1	Solution pond overflows and leaks	Pollution of air and soil of the area		■					■		
2.2	Pumping and solution transmission pipes break	Spill and leak of hazardous chemicals to environment and pollution of soil and air with cyanide			■				■		
3.1	HL stockpile and solution pond have evaporation	Air quality degradation in the area, poisoning of employees nearby			■			■			
4.1	Flood	Overflow of flood water pond, pollution of soil and groundwater reserves			■			■			
5.1	HL stockpile cracks, fails, solution pond is damaged	Damage to pipes cause leak of cyanide to environment, cause pollution, cause death of employees		■				■			
6.1	Fire	Fire causes explosion, employees' death	■					■			
Total number			1	5	4			5	5		
Total percentage (%)			10	50	40			50	50		

Conclusion:

Based on above results, 40% of HL operational risks are high, 50% - moderate and 10% - low. The risks based on occurrence probability is 50% - rare/almost never, 50% - highly probable to occur. Therefore, the Boroo HL project has **moderate risk, with very low probability of risk occurrence.**

6.3.2. Risk assessment of earthquake in the region of the Boroo gold mine

Boroo Gold Company’s Heap leach pad at the boundary between Bayangol and Mandal soums of Selenge aimag is in M48-129 nomenclature plot.

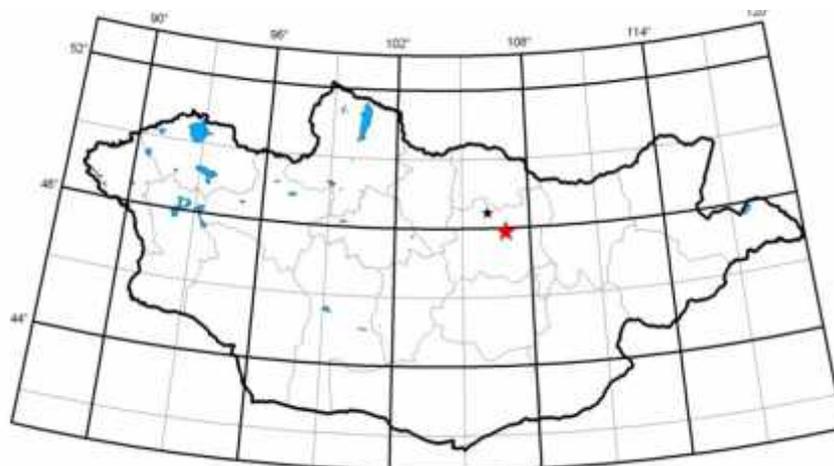


Image.6.2. Project location

Earthquake region

The territory of Mongolia is in the zone of Indian-Eurasian plate from the south and the Lake Baikal Rift Zone from the north. Thus, western and central western parts of Mongolia are referred to a region with high earthquake activity, and major strong earthquakes have been registered in these areas in the past.

Table 6.20 Registration of earthquakes near Boroo

Name	Date	Magnitude	Distance
Mogodiin	1967.01.05	7.0	170 km to north west
Buteeliin Nuruunii	1989.05.13	6.5	220 km to the west
Khustain	200-250 years ago	Strong	Unclear
Derengiin	1998.09.24	5.0	250-300 km

According to seismic station records on vibrations registered in areas near the Boroo mine, most of vibrations are with weak intensity. These weak vibrations will not cause significant harm to buildings and facilities in the region. Also due to Baikal Rift Zone activity in about 300 km to the north, moderate weak earthquakes are common. In the past century, about 5000 weak and moderate intensity vibrations have been detected in the radius of 300 km in this region.

This region is in the active zone of earthquakes of 7 magnitudes with Mongolia’s earthquake activity zone and it is considered one major earthquake is probable to occur on average in 500-600 years based on duration to accumulate earthquake energy and intensity amount. Thus, it is appropriate to develop designs of buildings and facilities in the nearby area of the Boroo gold mine to be tolerant to 7.0 magnitude earthquake.

The Boroo gold mine area is located in about 600 km from the north western part of Khangai mountain range which is considered to be the most active earthquake region in Mongolia. Also, it is in 800-1000 km from the earthquake activity of the Govi Altai and Mongol Altai mountain

ranges, thus it can be considered as earthquake has relatively low effect in the Boroo mine area. However, the eastern and north eastern edges of the Khangai mountain range and the Baikal Rift Zone effects show a probability of moderate intensity earthquake in this region. It is located in 250-300 km from the zone with moderate intensity earthquake activity which occurs in central southern Mongolia, which leads to a conclusion that occasional moderate weak earthquakes that occur in such zones will have relatively low impact to the region around the Boroo gold mine. One of the main examples is Derengiin earthquake of 5 magnitude in its epicenter /1998-09-24/.

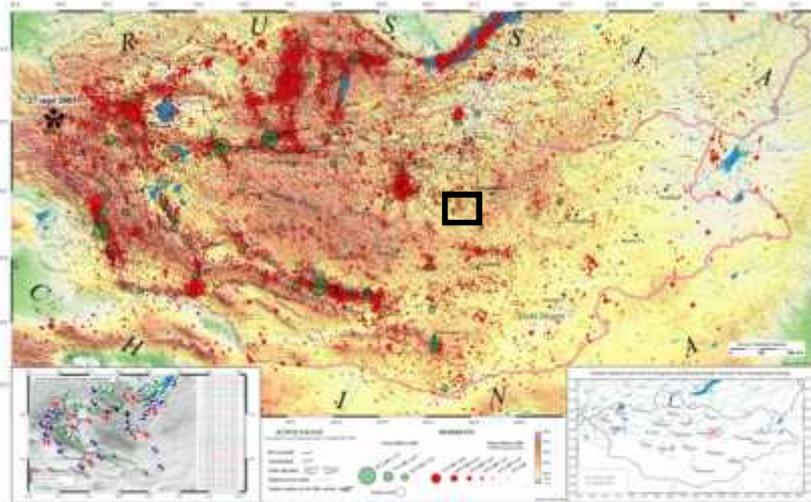


Image 6.3 century earthquakes and vibrations in Mongolia

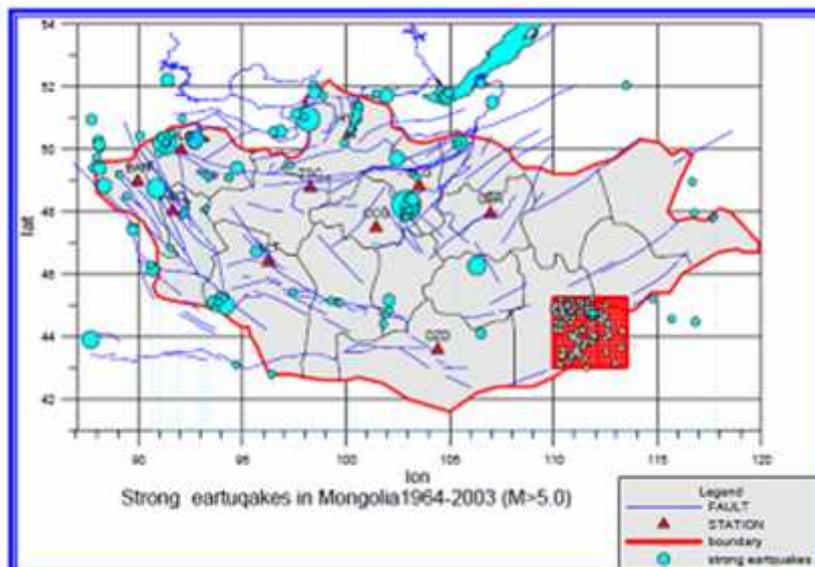


Image 6.4 1964-2003 major earthquakes in Mongolia

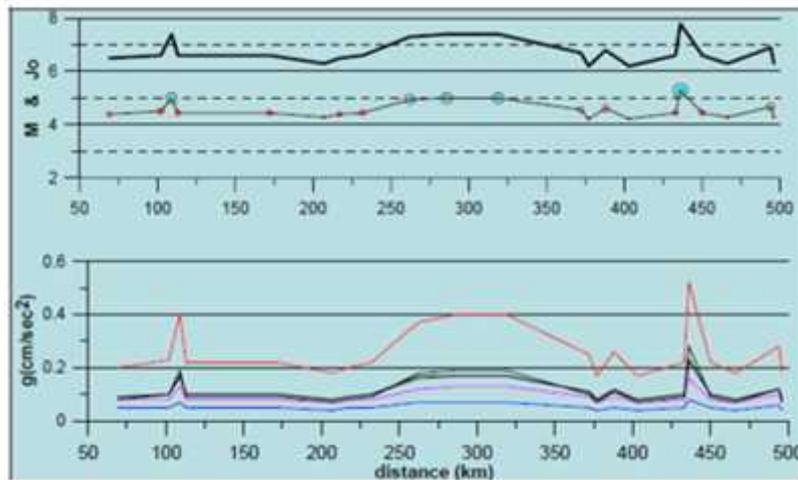


Image 6.5 Changes depending on distance

Eastern part of Mongolia is considered as a region with relatively low activation, thus, it can be said there is very low impact, i.e. almost none.

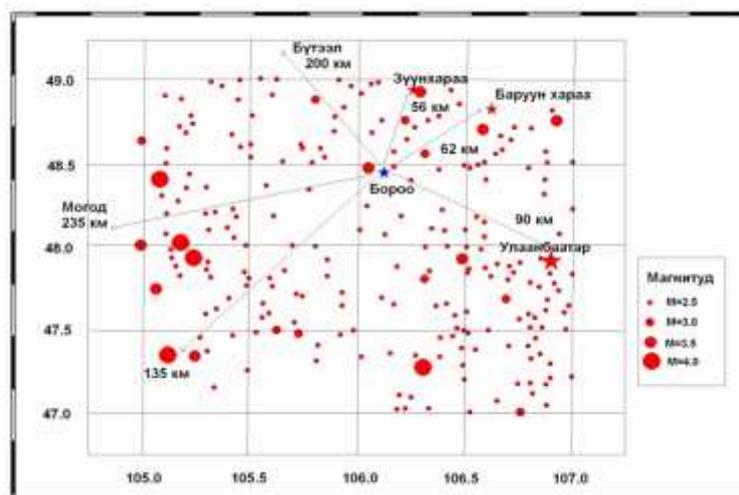


Image 6.6 Epicenters near the Boroo gold mine

According to this image, there is no strong earthquake epicenter near Boroo mine but there are several weak epicenters, the closest is in 75-135 km to the south west from the deposit.

Accordingly, in case of a 7 magnitude earthquake near the Boroo gold mine it may create 7 points effect, but it is not considered as significant hazard to affect buildings and facilities.

Earthquake hazard study

The study on hazards of earthquake in the region near the project site has been conducted by Golder Associates Company. Earthquake vibration impact study has been conducted with certain and authentication (PGA-Peak Ground Acceleration) methods. According to this study the earthquake evaluation is 0.22g. The model hazard assessment of specific authenticated earthquake on land showed the same results using 5% spectral method with 2 cycles and estimate is 475 years (10% probability ±50 years) and 2475 years (2% probability ±50 years) . 475 year cycle has been selected as it is commonly used in some regional building structure

coding for some buildings /e.g. China’s construction standard code GB 50011-2001/. PGA rocks and selected spectrum acceleration are shown in Table 6.21.

Table 6.21 Spectrum acceleration value

Cycle (years)	PGA (rock) g	Sa (0.2 sec)g	Sa (0.2 sec) g
475	0.13	0.14	0.02
2475	0.26	0.27	0.04

According to general conclusion of Golder Associates Company, there is no active earthquake fault that should be a concern in terms of engineering in the region and ground surface near the Boroo gold mine. However, due to effects of active faults in other remote areas, it has been concluded there is very small probability for weak differential movement of ground surface near Boroo gold mine.

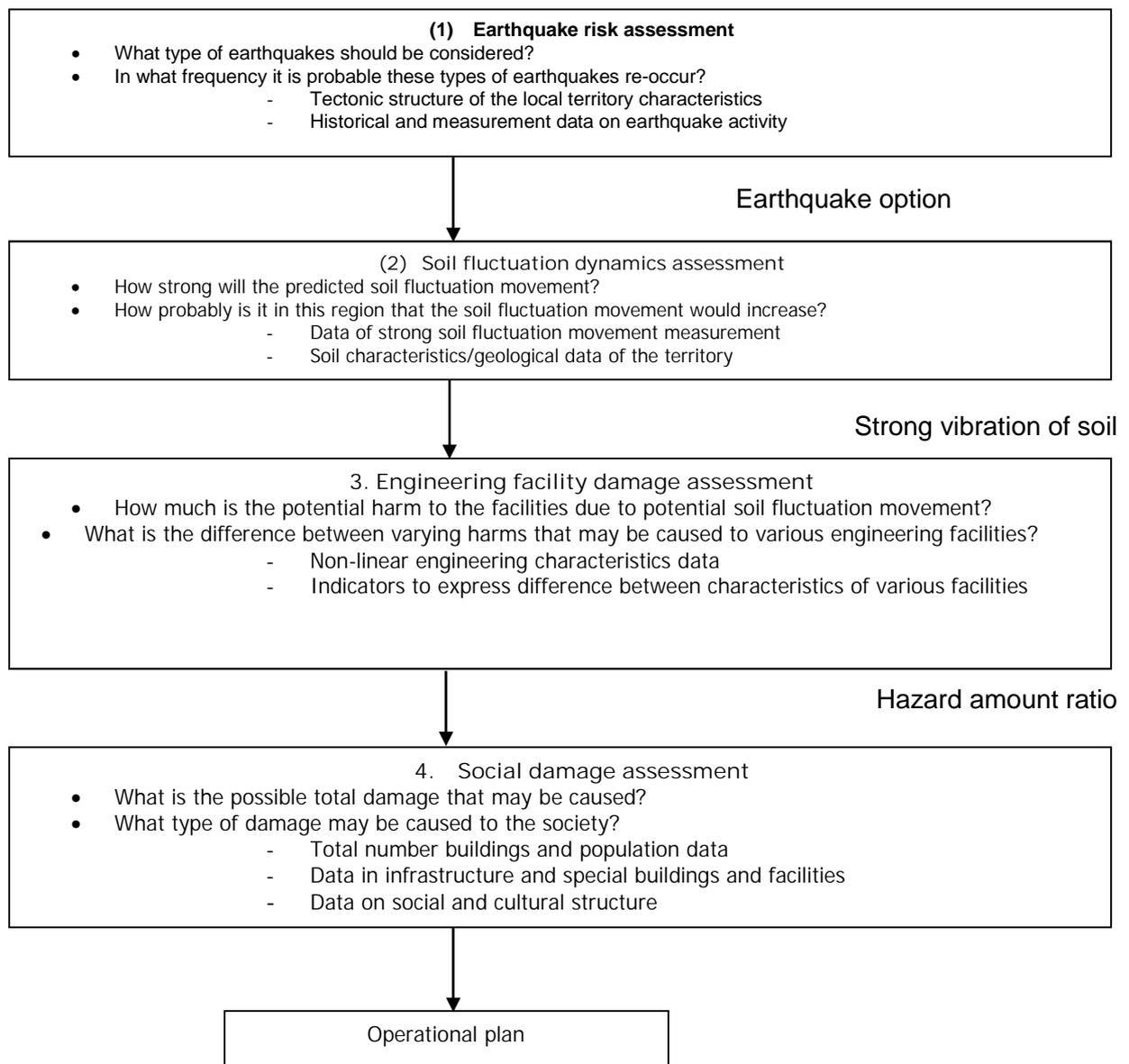


Image.6.7. Chart to assess effects of earthquakes

Authentication study

While considering sliding movement of soil and earthquake intensity effect with the purpose to define building and facility risks due to earthquakes, it should be taken into account the value of earthquake intensity that depend on soil characteristics. This report considered main values of soil slide (PGA-Peak Ground Acceleration, PGV-Peak Ground Velocity).

Out of two methods to determine soil movement authentication method has been used and results are issued. This method uses and analyzes the statistical data of earthquake registry and data of strong earthquakes recorded in the history only as written in published documents and materials, and determines soil movement. It can be combined with several analytical methods such as:

1. A statistical method to use peak value distribution based on probability, i.e. repetition distribution,
2. A method to estimate peak value distribution using probability modeling.

These two methods both have advantages and disadvantages, however, due to lack of data required for using the second method, it has been considered that it is possible to use the first method in the region near the Boroo gold mine.

Initially required data is a registration and list of earthquakes that includes earthquake statistical data such as dates of registered earthquakes, their magnitude, and location of their epicenters. Further it is required to obtain more detailed information. Also registration of statistical data during earthquakes that covers as long period as possible is useful to make the statistical data analysis as close to the reality as possible. The only realistic information that project team has been able to obtain for its study is a list of earthquakes registered for 37 years, 1957-1993.

In order to calculate the soil fluctuation movement with final value, the soil fluctuation intensity must be known. The equation to preliminarily estimate the soil maximum values is called soil movement disperse curve. But it is impossible to preliminarily determine soil movement intensity. This depends on the characteristics of the earthquake and the soil in that region. Basically, the disperse curve of the soil fluctuation movement is considered to depend on earthquake magnitude () and distance of epicenter R (distance till the epicenter). In some cases, these parameters have variable coefficients depending on the soil characteristics.

The disperse curve of soil fluctuation varies from the region and such difference depends on characteristics of earthquakes such as the coefficient of energy absorption during wave spreading process and soil conditions where the soil movement disperse curve is to be made. It is appropriate to use a soil fluctuation movement disperse curve in the Boroo area based on research at one spot nearby. It has been decided to use the disperse curve developed by Goto and others (1984) in order to estimate the potential risk in the region near the Boroo gold mine. As an example disperse curves for 3 different magnitude values developed by Goto and others are shown.

First of all, probable maximum values of strong soil fluctuation, one of the factors that define hazard levels, is considered. Limit value distribution is distribution of maximum values registered in one unit of time (e.g. 1 year) estimated based on earthquake registration. The limit value distribution directly expresses the content of earthquake registry while it is not certain whether or not the defined probability modeling that is based on earthquake registration data can express the actual probability that is the main factor to define the limit maximum value. Therefore, it is required to find the number of years of repetition cycle in the modeling with maximum limit value numbered as i and N number limit value. Thus, Hazen method has been used as one of standard methods. This is expressed with $Q_X(x_i)$ probability and has the following equation.

$$Q_X(x_i) = 1 - \frac{2i - 1}{2N} \tag{1}$$

Probability will be defined with $1 - Q_X(x_i)$ to $P_X(x_i)$, cycle with $\frac{1}{P_X(x_i)}$.

This condition will be based on the equation of Goto and others (1984) expressed with relation of fluctuation disperse. With this equation, it has been noticed that when distance to epicenter is relatively big, the moderate intensity earthquake soil fluctuation value tends to be excessively high. This does not always give assuring results to define the maximum value that soil fluctuation may have at the time of high cycle value estimated from insufficient data of earthquake registration.

However when extra-polarization has been made on correlation value of probability defined on Japan conditions based on earthquake activity data of 37 years, at repetition of 500 years in Goto and others' equation, the maximum acceleration of potential soil fluctuation (PGA) during an earthquake could have been 220 cm/sec^2 .

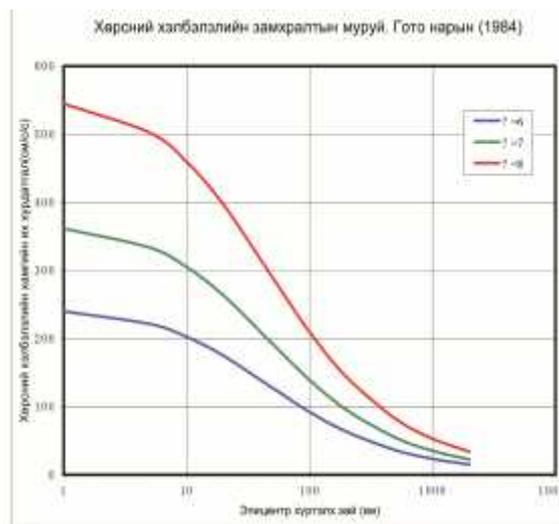


Image 6.8. Subsiding relations proposed by Goto and others (1984)

Table 6.21 Hazard of earthquake estimated based on data of 1957-1993 earthquake log

	Latitude	Longitude	Magnitude	Distance from epicenter (km)	Soil acceleration value (/c.)	Qi	Pi	Repetition (year)
1	48,20	102,90	6,9	220,0	120,40	0,986	0,014	74,00
2	45,10	99,40	8,1	710,2	65,20	0,959	0,041	24,67
3	47,34	106,74	4,5	150,3	53,20	0,932	0,068	14,80
4	48,70	102,90	6,1	307,7	50,95	0,905	0,095	10,57
5	50,17	105,34	5,8	195,0	116,50	0,878	0,122	8,22
6	43,20	104,40	6,7	559,1	44,98	0,851	0,149	6,73
7	48,39	103,15	5,6	282,4	43,72	0,824	0,176	5,69
8	50,95	98,17	6,7	690,5	38,45	0,797	0,203	4,93
9	46,70	103,50	5,3	289,3	38,10	0,770	0,230	4,35
10	48,81	103,67	5,0	257,6	36,12	0,743	0,257	3,89
11	45,77	104,10	5,2	319,5	34,44	0,716	0,284	3,52
12	47,84	103,03	5,0	288,1	33,78	0,689	0,311	3,22
13	47,85	102,91	5,0	297,0	33,16	0,662	0,338	2,96
14	44,10	106,50	5,5	425,6	32,64	0,635	0,365	2,74
15	50,17	91,23	7,0	1 169,1	31,68	0,608	0,392	2,55
16	49,42	109,02	4,5	229,5	31,51	0,581	0,419	2,39
17	51,76	104,61	5,5	457,3	31,21	0,554	0,446	2,24
18	49,78	102,47	5,2	384,1	30,76	0,527	0,473	2,11
19	49,54	104,68	4,5	242,2	30,53	0,500	0,500	2,00
20	48,07	103,05	4,7	286,4	29,98	0,473	0,527	1,90
21	48,04	102,93	4,5	295,2	27,12	0,446	0,554	1,80
22	48,40	102,93	4,5	298,7	26,93	0,419	0,581	1,72
23	46,08	104,00	4,5	299,7	26,87	0,392	0,608	1,64
24	45,00	104,00	4,8	392,8	25,75	0,365	0,635	1,57
25	44,98	106,81	4,5	326,9	25,49	0,338	0,662	1,51
26	41,90	104,90	5,6	687,0	25,14	0,311	0,689	1,45
27	49,08	101,20	4,8	439,1	24,03	0,284	0,716	1,40
28	44,40	101,80	5,0	553,9	22,54	0,257	0,743	1,35
29	52,33	106,53	4,8	491,3	22,40	0,230	0,770	1,30
30	45,76	111,18	4,5	406,5	22,29	0,203	0,797	1,25
31	51,62	106,88	4,5	411,6	22,12	0,176	0,824	1,21
32	46,71	95,67	5,5	857,5	20,93	0,149	0,851	1,17
33	52,20	96,90	5,5	857,8	20,93	0,122	0,878	1,14
34	51,93	105,36	4,5	459,3	20,66	0,095	0,905	1,10
35	52,27	106,43	4,5	485,1	19,96	0,068	0,932	1,07
36	51,80	102,30	4,5	542,8	18,60	0,041	0,959	1,04
37	49,50	97,31	4,5	725,5	15,47	0,014	0,986	1,01

Assessment of earthquake tolerance of heap leach facility of the Boroo gold mine

Analysis has been made on amount of leakage from heap leach pad. Vibration analysis in relatively stable condition has been made based on the results of heap leach stockpile acceleration and spread of hydraulic conditions. Also, three types of seismic waves have been inserted as data and dam safety factors have been considered. The results show that 1 magnitude increase of the earthquake intensity reduces safety factor with 0.3-0.4 points. These results aimed at show assessment of heap leach facility leakage and dynamic stability.

Engineering conditions

The heap leach pad foundation is made of compressed slay layer and geomembrane liner.

The ore to be leached has pipelines where the leach solution flows in with its own weight, and this will ensure minimal amount of solution on upper part of the stacked ore reducing risks of solution leak.

Amount of solution application to ore is on average 0.2 l/min/m². This can be increased by 30% in the short time. Gold-bearing pregnant solution is collected with dripping system on the polyethylene liner into the pond in the north east of the pad.

Attenuated solution is taken out of the processing unit through HDPE pipes with double liner with diameter of 300 mm, transferred through 300 mm pipe with single liner along the edge of the stockpile and ii applied onto the heap in drops through 150 mm double insulated steel sprinkler.

In summer time the sprinkler pipes are placed on the heap. In winter time they are installed in 2.0 m depth from the heap surface and sprinkled into the ore through installed sprinklers.

Sprinkles has intervals adjusted to solution speed of 0,012 m³/hour/m². Sprinkler point diameter is 16 mm, and interval is estimated to be 30 minutes at dripping speed of 7,6 l/hour (2 gr/hour).

Calculation method⁶

Theory to calculate limited elements' infiltration area

The leak in two directions in varying type of soil and anisotropy soil with estimate of water and soil pressure is defined by Darcy Law.

$$\begin{cases} \frac{\partial}{\partial x} (T \frac{\partial H}{\partial x}) + \frac{\partial}{\partial y} (T \frac{\partial H}{\partial y}) = 0, & \text{in } \Omega \\ H = H_b(x, y) & \text{on } \Gamma_1 \\ T \frac{\partial H}{\partial x} \cos(n, x) + T \frac{\partial H}{\partial y} \cos(n, y) = q & \text{on } \Gamma_2 \end{cases} \quad (1)$$

Herein, Ω - calculation zone, Γ_1, Γ_2 – boundary conditions, H_b – water level in first boundary condition, n – normal direction outwards in secondary boundary condition, internal flow is positive and vice versa. With use of Galerkin method, the road condition (H_{xy}) is defined with use of water level in zone :

$$\bar{H}(x, y) = \sum_{l=1}^n N_L H_L \quad (2)$$

Herein, N_L is element based fundamental function, H_L is water level in such element and n is number of nodes. Fundamental function has been considered as weight function, and when it is replaced with end function, \bar{H} is equal to remaining 0, and weight function remaining value is expressed in the following form

⁶ Analysis on Stability of Tailing Dam under Earthquake, 579

$$\int_{\Omega} N_L (\hat{H} - f) d\Omega = \sum_{e=1}^M \int_{\Omega_e} N_L (L(\hat{H}) - f) d\Omega = 0 \quad (3)$$

Above equation 3 determines linear system equation form upon combining all node integrals in all zones. Each node water level can be determined with systematic equation.

Static analysis

Static analysis is useful to define initial pressure conditions for early static pressure and dynamic analysis of the heap leach facility. The equation is as follows.

$$[K]\{u\} = \{p\} \quad (4)$$

Herein, K is total value of stability of the heap leach facility, ;p and u are load vector and node transition. Pressure vector of each element is deducted from load along each node movement.

Dynamic analysis

With regard to heap leach facility dynamic analysis, limited element method is suitable. One systematic dynamic loading equation is as follows for the limited element.

$$[M]\{\ddot{\alpha}\} + [C]\{\dot{\alpha}\} + [K]\{\alpha\} = \{F\} \quad (5)$$

Herein, [M], [C] and [K] mass, waste and hardening matrices [F] will be the highest loads. Also , and are acceleration, acceleration vector and node movements.

Effective pressure with no water-diversion method is widely used in dynamic analysis and after an earthquake, it estimates that water settled in pores would be removed and there would be no pore pressure. Linear modeling to calculate it is as follows.

$$G_{max} = k(\sigma'_m)^n \quad (6)$$

Here G is the maximum dynamic elasticity module (under effect of dynamic power for certain time), k and n are fixed, " is initial average effective normal pressure.

For the case the water is not diverted, total duration time can be divided into several intervals. Maximum dynamic elasticity module is excluded from equation 6 which will make vibration analysis the same as approximate effective pressure analysis.

Stability analysis

Heap leach facility dynamic stability factor can be estimated with limited element method based on vibration analysis. Also, minimum safety factor Fmin can be estimated in connection with slide surface. Fmin is an index to express dam stability and it is expressed with division of slide friction and total slide power (equation 7).

$$F = \frac{\sum_{i=1}^n (\sigma_i f_i + c_i) \Delta l_i}{\sum_{i=1}^n \tau_i \Delta l_i} \quad (7)$$

$f_i = \tan \phi'$; σ_i , τ_i , Δl_i , ϕ' and c_i

Herein: $f_i = \tan \phi'$; σ_i , τ_i , Δl_i , ϕ' and c_i is average normal pressure, average elastic pressure, σ_i , τ_i length, viscosity degree, and adhesion, i.e. viscosity pressure on certain part and n is sliding surface multiple. Sliding surface *ist* element pressure components will be in FEM estimate.

Selection of earthquake waves

According to building's earthquake vibration code (GB50011-2001) and China's earthquake vibration zoning (GB18306-2001), the earthquake magnitude has been selected as 7, 8 and 9, and focus has been on earthquake power. The calculation has been based on main accelerations 0.10g, 0.20g and 0.40g, and calculations used EL-Centro main acceleration of earthquake history with certain adjustment made to meet dam practical conditions. Acceleration amplitude has been estimated at 0.10g, 0.20g and 0.40g, and duration is calculated for 20 seconds according to below 4 equations.

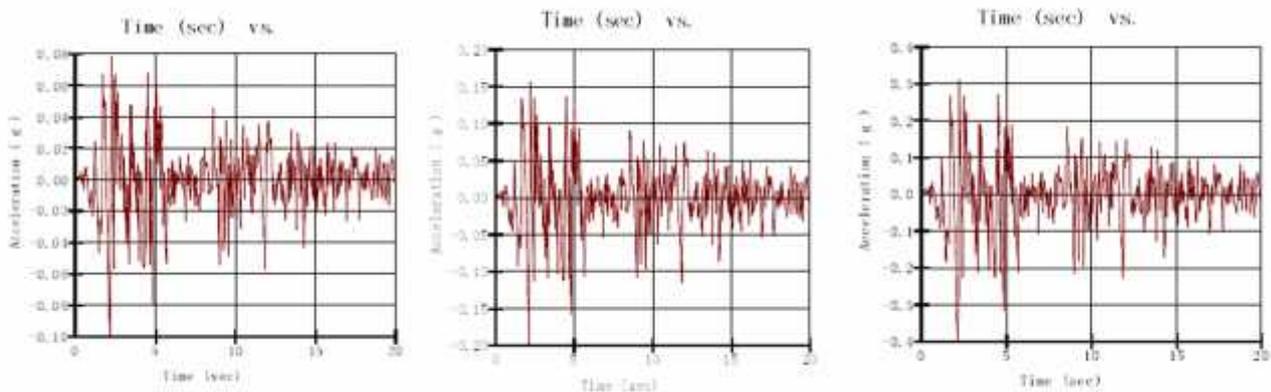


Image 6. Vibration intensity during 10, 11, 12 magnitude earthquakes

Calculation and analysis results

The calculation used the length of southern part of the heap leach facility as 500 m, did not estimate pressure area but used leakage area with initial value. Initial static pressure of the heap leach facility is highly influential to stability to tolerate vibration, thus, the initial static pressure of the dam has been estimated with linear elastic method. Observations of test work data and parameters of static stability estimates are shown in Table 6.22, movement, acceleration and elasticity pressure for all knots has been estimated with linear method in case of earthquake vibration considering dynamic timing and results are shown in Table 6.23.

Table 6.22 Static calculation parameter values

Material	Weight (kN/m3)	Pressure module (mPa)	Poisson ratio	Leakage factor (m/s)
Tsa	18.5	8	0.3	6.2E-5
Tsi	22	10	0.28	4E-5
Sic	21	12.6	0.32	2.5E-5
RFD	25	20	0.28	2.1E-4

Table 6.23 Dynamic parameter values

Material	Weight (kN/m3)	Dynamic elasticity module (mPa)	Poisson ratio
Tsa	18.5	53	0.43
Tsi	22	77	0.41
Sic	21	98	0.4

RFD	25	110	0.36
-----	----	-----	------

Analyzing of leach area⁷

Water level distribution and flow speed are shown in Image 4.9. According to these results, the saturation line along the X coordinate indicates 232-400 m which is very close to the dam slope line. The saturation line drops significantly near the initial heap leach stockpile which is related to condensed rocks and gravel, thus the saturation line is smaller. Water level distribution in the leak area is considered as stable flow condition and the results are shown in Image 4.10.



Image 6.13 Saturation line level in the dam

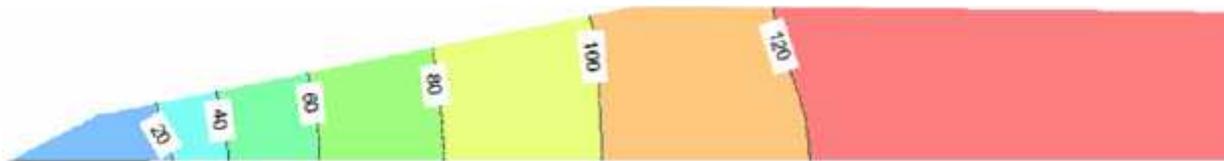


Image 6.14 Isocline of water level in heap leach stockpile

Pressure and absorption analysis

Dynamic analysis of Heap leach facility has been based on leakage analysis. After earthquake, the absorption zone distribution is shown in below images. According to the diagram, the absorption mostly occurs in dam body at the pond level and near initial dam which is related to saturation line located quite low.

Absorption zone during earthquake of magnitude of 7 can grow up to 674-893 m along the X coordinate, at 8 – 674-927 m, and at 9 – 666-995 m. As shown in images, the depth of absorption increases with increase of earthquake intensity. During operations the saturation line depth must be monitored and absorption must be prevented from which is significant for safe operations of the heap leach facility.



Image 6.15 Spread of absorption zone at 7 magnitude earthquake



Image 6.16 Spread of absorption zone at 8 magnitude earthquake

⁷ Analysis on Stability of Tailing Dam under Earthquake,

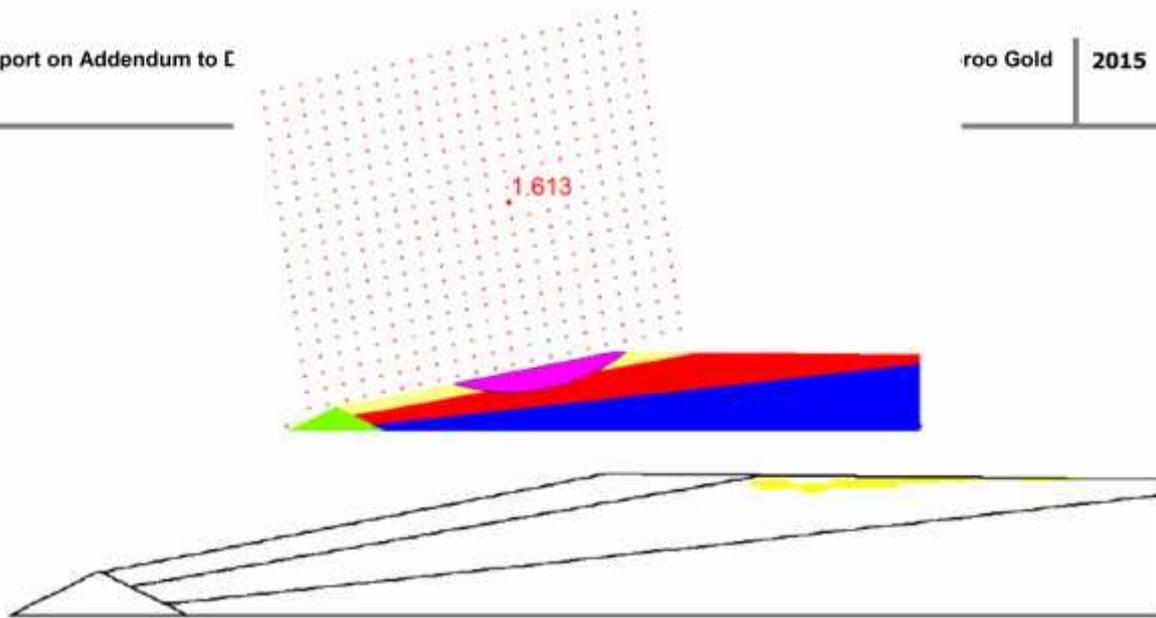


Image 6.17 Spread of absorption zone at 9 magnitude earthquake

Determining dynamic safety factors⁸

The dynamic safety factor of heap leach facility has been estimated in three conditions of earthquake vibration, and with dynamic estimate, its values are 1.613, 1.218 and 0.910. Safety factor values at magnitude of 7 and 8 are above 1.05 and in these cases, the dam is relatively safe. At magnitude of 9 it is below 1.05 thus the heap leach facility may collapse, also with increase of vibration intensity with one magnitude, the safety factor will reduce by 0.4%. Calculation parameters are in Table 6.24 and results are in images 6.18-20.

Table 6.24 Stability estimate parameters

Material	Weight (kN/m3)	Resistance pressure C(kPa)	Viscosity degree (°)
Tsa	18.5	16	26
Tsi	22	21	28
Sic	21	30	23
RFD	25	8	32

Image 6.18 Facility's minimum safety indicator spread at 7 magnitude earthquake

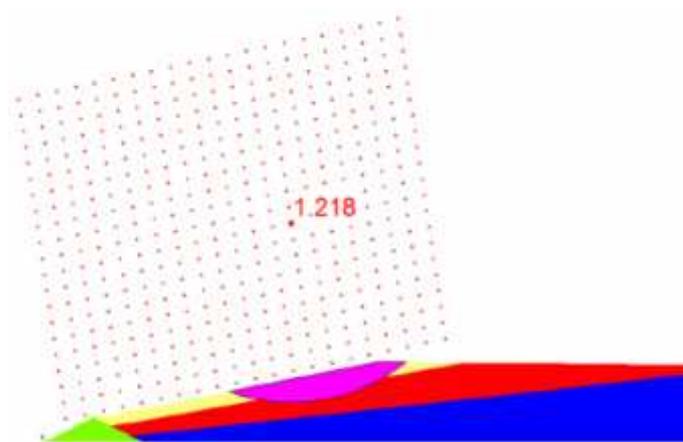


Image 6.19 Facility's minimum safety indicator spread at 8 magnitude earthquake

⁸ Analysis on Stability of Tailing Dam under Earthquake,

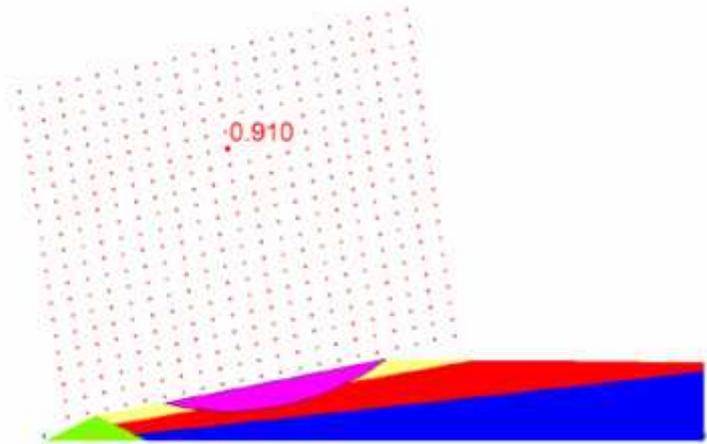


Image 6.20 Facility's minimum safety indicator spread at 9 magnitude earthquake

The following are the conclusions based on result of this study:

1. After an earthquake, it is possible for the heap leach facility area to experience absorption of vibration and its depth and width will increase depending on earthquake intensity. This might cause impact on dam safety. Thus control line changes must be constantly monitored and depth must be measured to ensure heap leach facility safety.
2. The heap leach facility's dynamic safety indicator has been estimated based on results of dynamic analysis with regard to 7-8-9 magnitude intensity earthquake. The results have been 1.613, 1.218 and 0.910 respectively and the safety indicator is higher at 7 by 0.395 from 8, and by 0.395 from 9 magnitude which indicates the indicator decreases by 0.3-0.4 with earthquake intensity increase by 1.
3. The region around the Boroo gold mine is in the region of moderate intensity earthquake activity of Mongolia and planning of engineering facilities should be made to tolerate 7 magnitude earthquake. This region's earthquake activity repetition is once in 500-600 years and the earthquake hazard and risk can be concluded as moderate.

6.3.3. Fire

According to natural disaster and vulnerability assessment of Mongolia, probability of forest-steppe fire is 1-5 times per year but due to careless human act it is possible that fire happens anytime, therefore, it should be prevented in any possible way and it is required to be cautious from being affected with potential fire at all times.

6.3.4. Lightning, thunder

Depending on environmental-weather conditions of the year, sometimes there are heavy rains and thunder storms in some years, thus machinery, equipment and human activities and labor conditions may be affected with temporary difficulties and consequently hazards may be caused.

6.3.5. Flood hazard

Maximum runoff: According to the "Norms and rules to calculate hydrologic specifications" (2.01.14-86) and verbal surveys precipitation flood in summer time is more intense than spring flood in the study region, thus the maximum daily precipitation has been calculated. In

order to calculate the maximum runoff of precipitation flood, the maximum precipitation study has been conducted.

Maximum daily precipitation and its supply: In order to carry out statistical analysis on maximum precipitation per day, data (maximum daily precipitation) from Baruunkharaa weather station located in river basin has been used. Observation

Observation included statistical processing with momentum method, supply curve has been made, and maximum precipitation has been calculated with 1% supply per day, and it resulted in 72.5 mm in Baruunkharaa.



Image 6.21 Zoning of maximum daily precipitation with 1% supply

As mentioned in “Climatic and geophysical indicators to be used in buildings” (1994), page 136, image 29, used in construction calculations in the past years, the amount of daily maximum precipitation with 1% supply is estimated at $1\% = 120 \text{ mm}$ which has been used in further calculations.

Maximum runoff calculation: The river basins are in the region with intense flood of Mongolia, thus this region is specific with its speedy flood due to short but intense rain. Therefore, the estimate of maximum runoff of rain water flood in un-studied river basins (rivers, streams, dry riverbeds) has been made based on following methods. Maximum runoff of flood in rivers, streams and riverbeds with watershed less than **200 km²** has been estimated by precipitation intensity method as specified in “Norms and rules to calculate hydrologic specifications” (2.01.14-86.).

$$Q_{1\%} = q_{1\%} * \{ H_{1\%} * u * \% * F$$

- Here: $Q_{1\%}$ - high flood runoff $m^3/s/$
 $q_{1\%}$ - high flood runoff module $l/s \text{ km}^2/$
 $\{$ - flood runoff coefficient
 $H_{1\%}$ - maximum daily precipitation with 1% supply $/mm/$
 \dagger - pond, forest, marsh coefficient
 $\}%$ - 1% supply turnover coefficient
 F - water collection area $/\text{km}^2/$

Riverbed morphologic specification (r) required to define maximum runoff module ($q_{1\%}$) has been calculated with the below equation.

$$r = 1000 * L / K_r * J_r * F^{1/4} * (\{ * H \})^{1/4}$$

Here: r - Riverbed morphologic specification

L - length of riverbed to cross /km/

K_r - riverbed and holm roughness coefficient (to be taken from Annex #15 of "Norms and rules to calculate hydrologic specifications" (2.01.14-86/2)

J_r - average inclination of the river

Slope morphological specification ($\{$) required to define the time of flood flow (t) along the slopes of water collection area has been calculated with below equation.

$$\{ = (1000 * L)^{1/2} / n * J^{1/4} * (\{ * H \})^{1/2}$$

Here: $\{$ - slope morphological specification

L - average length of slopes of water collection area /km/

J - average inclination of slopes

n - slope roughness coefficient (to be taken from Annex #23 of "Norms and rules to calculate hydrologic specifications" (2.01.14-86)

Flood flow coefficient is defined with following equation.

$$\{ = \alpha_2 * \{_0 / (F+1)^{n_6} * (Jc * 50)^{n_5}$$

Here: α_2 -empirical coefficient (in forest zone 1.3, in other zones 1.2)

$\{_0$ – runoff coefficient at $F=10$, $J = 50\%$ (to be taken from Annex #21 of "Norms and rules to calculate hydrologic specifications" (2.01.14-86)

n_5 - soil structure coefficient (to be taken from Annex #21 of "Norms and rules to calculate hydrologic specifications" (2.01.14-86)

n_6 – climatic region coefficient (in forest zone 0.07, in other zones 0.11)

Maximum ordinary runoff module equation:

$$Q_{1\%} = q_{1\%} * F = B_{1\%} / (F+1)^{0.4} * u_1 * u_2 * F$$

Here: $Q_{1\%}$ - flood high runoff with 1% supply

$q_{1\%}$ - module of flood high runoff with 1%

$q_{1\%}$ - high ordinary runoff module with 1% supply

$u_1 u_2$ - pond, forest, marsh coefficient

F – water collection area

The below table shows the results of above calculations.

F	L_r	J_r	l_0	J		$H_{\%}$		t	r	$q_{1\%}$	$Q_{1\%}$	$Q_{5\%}$	$Q_{10\%}$
km ²	(km)	(‰)	(km)	(‰)		(mm)		(min)		l/sec. km ²	m ³ / sec	m ³ / sec	m ³ / sec
2.176	2.210	164.0	0.98	40.9	0.48	57.89	10.87	200.0	11.1	0.0850	2.14	1.88	1.54

Above result shows that flood water flow in the ditch next to the heap leach pad is 1,54-2,14 m³ per second. The flood water diversion channel built before commencing this project has the

capacity to transmit the flood water at this rate. However, the channel should be cleaned and eroded areas reclaimed.

6.4. RISK ASSESSMENT OF TOXIC AND HAZARDOUS CHEMICALS

Following supplementary materials are used for heap leach project operation of Boroo mine of Boroo Gold LLC situated at Bayangol and Mandal soums territory of Selenge aimag. (Table 6.25).

Table 6.25 List of auxiliary materials to be used for heap leach project

#	Substance	Chemical formula	CAS #	Consumption kg/tand l/t	Usage
1	Sodium cyanide	NaCN	143-33-9	0.2kg/t	Leach gold from ore
2	Burnt lime		1305-78-8	2.5kg/t	Adjust solution
3	Antiscalent	-	-	0.003 l/m ³	Prevent solution transmission pipelines from residues
4	Alkali	NaOH	1310-73-2	0.01kg/t	For desorption
5	HDPE Geomembrane-high density geomembrane cover	-	-	-	Lining of solution pond and leaching area
6	Diesel fuel	C ₁₆ H ₃₄	544-76-3	-	Heavy duty equipment and light vehicle
7	Activated carbon	C=C	7440-44-0 ⁹	0.001kg/t	Adsorption
8	Hydrogen peroxide	H ₂ O ₂	7722-84-1	575 kg/year	Used as additional oxidation component for detoxification of attenuated cyanide solution delivered as waste from desorption section
9	Hydrochloric acid	HCL	7647-01-0	0.007 l/ton	For desorption

The purpose of risk assessment of toxic and hazardous chemicals is to define potential risks of given chemical, its toxic and hazardous characteristics based on guidelines of manufacturer and supplier before the project commencement, define actions to prevent potential risks and prepare appropriate emergency response actions and define required amount of cost to decrease loss, detoxification and disposal of waste.

Occupational exposure

Most common exposures at workplace are through respiratory system and skin. Almost no case of exposure through mouth i.e. swallowing chemicals occurs when workplace hygienic monitoring is good and worker is specialized and skilled.

Therefore, to assess occupational exposure, it is important to define in detail potential number of workers to be exposed to outspread of toxic chemicals, intensity, frequency and duration of the exposure, personal protective equipment and monitoring methods to mitigate and eliminate the impact. Based on above mentioned, worst scenario should be defined.

Actions to avoid and mitigate the risks should be taken in accordance with relevant procedures. Herein:

⁹Carbon CAS number

-
- Accustom to constantly wear personal protective equipment and devices,
 - Prepare emergency response plan with guideline of immediate action in case of accident (fire, explosion, spill of toxic chemicals and etc.),
 - First aid substances and materials (solutions to neutralize acidity or alkalinity, fresh water and medications) should be in place and employees should be provided with first aid training.

(MSDS-SODIUM CYANIDE, HYDROGEN CYANIDE, BURNT LIME, CAUSTIC SODA, HYDROGEN CHLORIDE, SLAKED LIME, ANTISCALENT, DIESEL FUEL, HDPE GEOMEMBRANE LINER, ACTIVATED CARBON)

SODIUM CYANIDE¹⁰¹¹

Chemical name: SODIUM CYANIDE

Other names: Hydrocyanic acid sodium salt, Prussic acid sodium salt

International name: Sodium Cyanide, Hydrocyanicacid, Sodium salt, Cyanogran

CAS : 143-33-9

UN : 1689

Molecular formula: NaCN

PHYSICAL AND CHEMICAL CHARACTERISTICS

on the outside: White, crystal or pill shape with a faint bitter-almond like odor.

Boiling point (BP): 1496 C	Molecular weight (MW): 49.01	Lower explosive level (LEL): undefined
Melting point (MLT): 564°	vapor pressure (VP): 1.0 (817°)	Upper explosive level (UEL): undefined
Fire point FP: undefined	Vapor density (VD): undefined	Density: 1.6 (25°C)

TOXICITY AND HAZARD INFORMATION

Ignition category: 0 – Weak	Laboratory protective devices: glove, glasses, face protection, laboratory clothing, drawer	Storage color code: Blue (Very toxic)
Health impact category: 3 – strong (poison)	Toxicity symbol: Very toxic, toxic to environment	
Reaction category: 2 – moderate	 	
Contact category: 3 – strong (Fatal)	Risk sign issue from EU: R 26/27/8 R32, R50/53	
Specific property (NFPA Sp. Inst.): undefined		

HAZARDOUS CHEMICAL REACTION

Sodium cyanide is stable in dry condition. In combination with acid, sodium cyanide forms very toxic and combustible hydrogenous gas. Gets into strong reaction with strong acidic substance when heated. In limited area forms very hazardous hydrogenous cyanide gas in reaction with water or low alkaline substance. When wet, gradually decomposes releasing toxic hydrogenous cyanide and ammonia.

STORAGE

Should be stored in dry, well-ventilated and protected area with proper sign in proper container. It is prohibited to store in one container with acid, acidic salt, weak alkaline and oxidation substances. It is prohibited to eat or smoke cigarettes in cyanide storage or exploitation area. People working with the substance should attend specific training and guidelines should be given on emergency response actions. It is prohibited to store with combustible and flammable substances. Cyanide may run off when fire is put out by water. Should not be stored under shower systems.

¹⁰ http://www.mne.mn/chemical/images/content/uploaded/143-33-9_4ae7ace774eb8.htm

¹¹ Hazard evaluation and chemical hazard handbook for chemicals registered in Mongolia, page 803

POISONING LIMIT		
OSHA ¹²	NIOSH ¹³	(Related Information)
Permissible maximum level (8 working hours or week average) (PEL-TWA) ppm: undefined	Permissible maximum level (8 working hours or week average) (PEL-TWA) ppm: undefined	AIHA Emergency Response Planning Guidelines - ERPG-1/ERPG-2/ERPG-3: undefined
Permissible maximum level (8 working hours or week average) (PEL-TWA) mg/m ³ : 5	Permissible maximum level (8 working hours or week average) (PEL-TWA) mg/m ³ : undefined	
Permissible maximum level (average of 15 minutes) (PEL-STEL) ppm: undefined	Permissible maximum level (average of 15 minutes) (PEL-STEL) ppm: undefined	
Permissible maximum level (average of 15 minutes) (PEL-STEL) mg/m ³ : undefined	Permissible maximum level (average of 15 minutes) (PEL-STEL) mg/m ³ : undefined	
Permissible maximum level (any time) (PEL-C) ppm: undefined	Permissible maximum level (any time) (PEL-C) ppm: 4.7	
Permissible maximum level (any time) (PEL-C) mg/m ³ : undefined	Permissible maximum level (any time) (PEL-C) mg/m ³ : 5	
Skin Notation: No	Skin Notation: No	
	Notes: maximum level 10 minutes	
	Immediately dangerous to life and health ppm: undefined	
	Immediately dangerous to life and health ppm mg/m ³ : 25	
	Immediately dangerous to life and health ppm notes: undefined	
NIOSH RESPIRATOR RECOMMENDATIONS		
Personal protection and sanitation (NIOSH/OSHA): at 25 mg/m ³ : SA/SCBAF/SAF : SCBAF : PD, PP/SAF : PD, PP : ASCBA Escape: GMFAGHiE/SCBAE		
Exposure Routes: inhalation, skin absorption, ingestion, skin and/or eye contact		
SYMPTOMS		
Irritation eyes, skin; asphyxia; lassitude (weakness, exhaustion), headache, confusion; nausea, vomiting; increased resp rate; slow gasping respiration; thyroid, blood changes		
TARGET ORGANS		
Eyes, skin, cardiovascular system, central nervous system, blood		
Sodium cyanide is a fast-acting poison. It can be fatal even in a short period of time. Could be poisoned by evaporation exhausted from cyanide gas, dust or liquid. Extremely hazardous in case of long contact with skin, especially on open injures damaged skin and mucous organs.		

REQUIRED SPECIFIC DEVICES
Full face respirator with P2 filter, PVC rubber clothing, PVC rubber glove with bands, PVC tape, PVC

¹²UN Occupational health and Safety

¹³US Occupational health and safety administration

rubber boots

EMERGENCY RESPONSE GUIDEBOOK¹⁴**Guide Number: 157****157 substances – Toxic/corrosive (Non-combustible/water-sensitive)****POTENTIAL HAZARDS****HEALTH**

- VERY TOXIC: inhalation, ingestion or contact (skin, eyes) with vapors, dusts or substance may cause severe injury, burns or death
- Reaction with water or moist air may release toxic, corrosive or flammable gases.
- Reaction with water may generate much heat that will increase the concentration of fumes in the air..
- Fire will produce irritating, corrosive and/or toxic gases.
 - Runoff from fire control or dilution water may be corrosive and/or toxic and cause.

FIRE OR EXPLOSION

- Non-combustible, substance itself does not burn but may decompose upon heating to produce corrosive and/or toxic fumes.
- Vapors may accumulate in confined areas (basement, tanks, hopper/tank cars etc.).
- Releases toxic substance in reaction with water.
- Substance may react with water (some violently), releasing corrosive and/or toxic gases and runoff.
- Contact with metals may evolve flammable hydrogen gas.
- Containers may explode when heated or if contaminated with water.

PUBLIC SAFETY

- Immediately call 105 in case of emergency.
- As an immediate precautionary measure, isolate spill or leak area in all directions for 50-100 meters.
- Keep unauthorized personnel away.
- Stay upwind.
- Keep out of low areas.
- Ventilate enclosed areas.

PROTECTIVE CLOTHING

- Wear positive pressure self-contained breathing apparatus (SCBA).
- Wear chemical protective clothing. It may provide little or no thermal protection.
- Structural firefighters' protective clothing provides limited protection in fire situations ONLY; it is not effective in spill situations where direct contact with the substance is possible

EVACUATION**Spill**

- Refer to section PUBLIC SAFETY.

Fire

- If tank, rail car or tank truck is involved in a fire, ISOLATE for 800 meters in all directions; also, consider initial evacuation for 800 meters in all directions

EMERGENCY RESPONSE**FIRE**

Sodium cyanide does not burn in regular fire.

Note: Some foams will react with the material and release corrosive/toxic gases.

Small Fires

- CO_2 (except for cyanides)¹⁵ dry chemical, dry sand, alcohol-resistant foam.

Large Fires

- Water spray, fog or alcohol-resistant foam.
- Move containers from fire area if you can do it without risk.
- Use water spray or fog; do not use straight streams.
- Dike fire-control water for later disposal; do not scatter the material.

Fire involving Tanks or Car/Trailer Loads

- Fight fire from maximum distance or use unmanned hose holders or monitor nozzles.

¹⁴ Emergency Response Guidebook 2012, 252

¹⁵ It is prohibited to use CO_2 on wet cyanide. Combination releases carbon oxide that in reaction with cyanide may form hydrogenous gas.

- Do not get water inside containers.
- Cool containers with flooding quantities of water until well after fire is out.
- Withdraw immediately in case of rising sound from venting safety devices or discoloration of tank.
- ALWAYS stay away from tanks engulfed in fire.

SPILL OR LEAK

- ELIMINATE all ignition sources (no smoking, flares, sparks or flames in immediate area).
- All equipment used when handling the product must be grounded.
- Do not touch damaged containers or spilled material unless wearing appropriate protective clothing.
- Stop leak if you can do it without risk.
- A vapor suppressing foam may be used to reduce vapors.
- DO NOT GET WATER INSIDE CONTAINERS.
- Use water spray to reduce vapors or divert vapor cloud drift. Avoid allowing water runoff to contact spilled material.
- Prevent entrance of used water run-off to spilled material.
- Prevent entry into waterways, sewers, basements or confined areas.
- Spilled material should be collected by shovel and put in specific container. Spill areas should be showered by sodium hypochlorite or calcium hypochlorite to terminate cyanide
- In case of large spills, in accordance with Boroo Gold emergency response plan, mine heavy duty machinery should be used to collect spill and transport to tailings dam and should be terminated under supervision of environmental and chemical engineers.

Small Spills

- Cover with DRY earth, DRY sand or other non-combustible material followed with plastic sheet to minimize spreading or contact with rain.
- Use clean non-sparking tools to collect material and place it into loosely covered plastic containers for later disposal.

Liquid:

- Infiltrate the spill by sand with lime and alkaline substance to maintain safe environment by keeping the area over 10 pH.

FIRST AID

- Move victim to fresh air
- Call emergency medical service.
- Give artificial respiration if victim is not breathing

Do not use mouth-to-mouth methods if victim ingested or inhaled the substance; give artificial respiration with the aid of a pocket mask equipped with a one-way valve or other proper respiratory medical device.

ADDITIONAL NOTE: When poisoned by cyanide, first aid should be provided the victim and before emergency team arrives.

Sodium cyanide (spill into water) 30 m 160 m 320 m 90 m 965 m 2575 m

ERG 2004: Toxic to inhale gas (HCN) formed from contact with water

EMERGENCY RESPONSE

Non-fire Spill Response: ELIMINATE all ignition sources (no smoking, flares, sparks or flames in immediate area). Prevent entry into waterways, sewers, basements or confined areas. Use water spray to reduce vapors or divert vapor cloud drift. Avoid allowing water runoff to contact spilled material. Water used for fire extinguishing releases poisonous gases in reaction with water.

Ground spill: Dig hole or channel and put spilled material to prevent from further spreading. plastic sheet to minimize contact with rain or water.

Water spill: Add NaOH. Add Ca(ClO)₂. Neutralize water pH (pH=7) (AAR, 1999).

Firefighting: Fire Fighters should wear self-contained breathing apparatus and adequate protective clothing. Do not expose body parts. Take common firefighting measures. . Fight fire from maximum distance. If safe to do so, remove containers from area of fire. Dike for later disposal. Water can be used to take down fire. **SMALL FIRE:** CO₂ (except for Cyanides), dry chemical, water sprinkle, alcohol-resistant foam. **LARGE FIRE:** Water spray, fog or alcohol-resistant foam.

Reactivity: WATER AND AIR REACTION: Deliquescent. Soluble in water. Slowly decomposed by water and very rapidly by acids to give off hydrogen cyanide, a flammable poison gas. **CHEMICAL PROFILE:** A white powder, a deadly human poison by ingestion. Upon contact with acids, even very weak acids , e.g., carbon dioxide (soda, pop) it will produce deadly and flammable hydrogen cyanide gas. It reacts violently with fluorine, magnesium, nitric acid, nitrates and nitrites [Sax, 9th ed., 1996, p. 2958]. (REACTIVITY,

1999).

First Aid

Warning: Heart palpitations may occur within minutes after exposure. Caution is advised. Effects may be delayed.

Signs and Symptoms of Acute Sodium Cyanide Exposure: Signs and symptoms of acute exposure to sodium cyanide may include hypertension (high blood pressure) and tachycardia (rapid heart rate), followed by hypotension (low blood pressure) and bradycardia (slow heart rate). Cardiac arrhythmias and other cardiac abnormalities are common. Cyanosis (blue tint to the skin and mucous membranes) and cherry-red or bloody mucous membranes may occur. Tachypnea (rapid respiratory rate) may be followed by respiratory depression. Pulmonary edema and lung hemorrhage may also occur. Headache, vertigo (dizziness), agitation, and giddiness may be followed by combative behavior, dilated and unreactive pupils, convulsions, paralysis, and coma. Sodium cyanide is irritating to the skin and mucous membranes. Lacrimation (tearing) and a burning sensation of the mouth and throat are common. Increased salivation, nausea, and vomiting are often seen.

Emergency Life-Support Procedures: Acute exposure to sodium cyanide may require decontamination and life support for the victims. All exposed persons should be transported to a health care facility as quickly as possible. Emergency personnel should wear protective clothing appropriate to the type and degree of contamination. Air-purifying or supplied-air respiratory equipment should also be worn as necessary. Rescue vehicles should carry supplies such as plastic sheeting and disposable plastic bags to assist in preventing spread of contamination.

Inhalation Exposure:

1. Move victims to fresh air. Emergency personnel should avoid self-exposure to sodium cyanide.
2. Evaluate vital signs including pulse and respiratory rate, and note any trauma. If no pulse is detected, provide CPR. If not breathing, provide artificial respiration. IMMEDIATELY begin administering 100% oxygen to all victims. Monitor victims for respiratory distress. Warning: To prevent self-poisoning, avoid mouth-to-mouth breathing; use a forced-oxygen mask. Direct oral contact with sodium cyanide-contaminated persons or their gastric contents may result in self-poisoning.
3. RUSH to a health care facility!
4. Obtain authorization and/or further instructions from the Localized hospital for administration of an antidote or performance of other invasive procedures.

Dermal/Eye Exposure:

1. Remove victims from exposure. Emergency personnel should avoid self-exposure to sodium cyanide.
2. Evaluate vital signs including pulse and respiratory rate, and note any trauma. If no pulse is detected, provide CPR. If not breathing, provide artificial respiration. IMMEDIATELY begin administering 100% oxygen to all victims. Monitor victims for respiratory distress.

Warning: To prevent self-poisoning, avoid mouth-to-mouth breathing; use a forced-oxygen mask. Direct oral contact with sodium cyanide-contaminated persons or their gastric contents may result in self-poisoning.

3. RUSH to a health care facility!
4. Remove contaminated clothing as soon as possible.
5. If eye exposure has occurred, eyes must be flushed with lukewarm water for at least 15 minutes.
6. Wash exposed skin areas twice with soap and water.
7. Obtain authorization and/or further instructions from the Localized hospital for administration of an antidote or performance of other invasive procedures.

Ingestion Exposure:

1. Evaluate vital signs including pulse and respiratory rate, and note any trauma. If no pulse is detected, provide CPR. If not breathing, provide artificial respiration. IMMEDIATELY begin administering 100% oxygen to all victims. Monitor victims for respiratory distress.

Warning: To prevent self-poisoning, avoid mouth-to-mouth breathing; use a forced-oxygen mask. Direct oral contact with sodium cyanide-contaminated persons or their gastric contents may result in self-poisoning.

2. Do not ingest anything through throat.
3. RUSH to a health care facility!
4. DO NOT induce vomiting. Ipecac is not recommended for ingestion of sodium cyanide.
5. Obtain authorization and/or further instructions from the Localized hospital for administration of an

antidote or performance of other invasive procedures.

6. Activated charcoal may be administered if victims are conscious and alert. Use 15 to 30 g (1/2 to 1 oz.) for children, 50 to 100 g (1-3/4 to 3-1/2 oz.) for adults, with 125 to 250 mL (1/2 to 1 cup) of water.

7. Promote excretion by administering a saline cathartic or sorbitol to conscious and alert victims. Children require 15 to 30 g (1/2 to 1 oz.) of cathartic; 50 to 100 g (1-3/4 to 3-1/2 oz.) is recommended for adults. (EPA, 1998)

TRANSPORTATION¹⁶

Hazard category: 6.1

UN: UN 1689¹⁷

Packaging group: 1

MECHANISMS OF CYANIDE DEGRADATION IN THE NATURAL ENVIRONMENT

As a result of cyanidation, a variety of cyanide related compounds are formed in solution including thiocyanate, cyanate and ammonia. The presence of thiocyanate ([SCN]⁻) in cyanidation solutions results from the reaction of cyanide with unstable sulfur atoms, either during pre-aeration or during leaching. The thiocyanate ion and cyanide can form insoluble ionic salts with silver, mercury, lead, copper and zinc. Thiocyanate is chemically and biologically degradable, with the metabolic byproducts being ammonium ion, carbonate and sulfate. The primary environmental concerns associated with thiocyanate are its breakdown products (i.e., ammonia), which may be toxic if present in sufficient levels.

Chemical hazard

Many oxidants (chlorine, ozone, oxygen and hydrogen peroxide) convert cyanide to cyanate. Under acidic conditions, cyanate slowly hydrolyzes to ammonia and carbonate. At room temperature, cyanide and thiocyanate react slowly with water to form ammonia, formate ion, and/or carbonate. The reaction rate increases with temperature.

Occupational exposure limits set by the International Programme on Chemical Safety (IPCS) are¹⁸:

- TLV: (as CN) 5 mg/m³; (Ceiling value); (skin); (ACGIH 2003);
- MAK: (Inhalable fraction) 2 mg/m³; Peak limitation category: II(1); skin absorption (H); and,
- Pregnancy risk group: C; (DFG 2004).

World bank permissible concentration levels for cyanide in the tailings pond is 50 ppm and >1 ppm cyanide in the free water of Boroo's tailings dam

¹⁶ Brief introduction to imported sodium, page 2

¹⁷ Emergency Response Guidebook 2012, page 35

¹⁸ http://www.ilo.org/public/english/protection/safework/cis/products/icsc/dtasht/_icsc11/icsc11118.htm

Cyanide Geochemistry¹⁹

Ores, rocks, and soils contain silicates, aluminosilicates, clay minerals, sulfides, carbonates, and oxides (e.g. iron and manganese more commonly) as mineral phases, plus organic matter, water, and gases. These are potential reactants with the cyanide solutions in slurry leaching, in the tailings storage or in the soils and aquifer materials. The solid components can control the solution's chemistry with regard to alkalinity or acidity (pH control), buffering capacity, and degree of oxidation or reduction (redox potential), resulting in ion exchange absorption or a chemical reaction in the cyanide solution (i.e., precipitation of insoluble species).

There are eight mechanisms of cyanide degradation in natural environments, including:

1. Complexation;
2. Cyanide complex precipitation;
3. Absorption;
4. Oxidation to cyanate;
5. Volatilization;
6. Biodegradation;
7. Formation of thiocyanate; and,
8. Hydrolysis/saponification.

Complexation:

Twenty eight elements are capable of forming complexes with cyanide, with a total of seventy-two metal cyanide complexes possible. Some of these compounds are not very stable and will decompose, releasing free cyanide. The toxicity of metal cyanide complexes is generally due to the dissociation of the complex into free cyanide.

Metal cyanide complexes are also intermediates to the formation of more stable compounds that remove free cyanide from the environment.

The environmental significance of complex/chelation of cyanide with transition metals is that it is relatively rapid and occurs wherever soluble species of these metals are present, such as in soils and ores. It reduces the toxicity of free cyanide and acts as an intermediary to reduce cyanide mobility via adsorption on organic and inorganic surfaces, or precipitation of ferrocyanide metal salts.

Cyanide Complex Precipitation

The ferrocyanide ion ($\text{Fe}(\text{CN})_6^{-4}$) and the ferricyanide ion ($\text{Fe}(\text{CN})_6^{-3}$) form insoluble salts with iron, copper, nickel, manganese, lead, zinc, cadmium, tin, and silver. Typically within the soil environment, the oxidation potential would result in the formation of ferrocyanide precipitates. In addition, the iron-cyanide complexes can react with thiocyanate to form an even more stable complex.

¹⁹ From BGC Boroo Gold Project Environmental Impact Assessment Report, section 5, JEMR, 2000.

Absorption

Absorption is another mechanism that attenuates cyanide in soils. Soils with a high anion exchange capacity attenuate cyanide. These soils typically contain kaolin clay, chlorite, gibbsite clay, and/or iron and aluminum oxides.

Organic materials will absorb or react with cyanide. The presence of copper, cadmium, zinc, or nickel ions in solution results in the formation of metal cyanide complexes, which enhance the absorptive capacity of carbon.

Oxidation of HCN and CH^-

Oxidation of HCN produces hydrogen cyanate. The oxidation of either HCN or CH^- is generally restricted to the upper, oxidized portions of the tailings storage. Cyanide can be converted to cyanate according to the following simplified reaction:



The direct oxidation of CH^- requires a mineralogical, bacteriological, or photochemical (sunlight) catalyst, and produces cyanate ions (CHO^-).



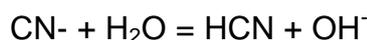
Hydrogen cyanate and cyanate ions are significantly less toxic than HCN. Within the storage environment, HCNO and CHO^- readily hydrolyze to form ammonia and carbon dioxide, which evolve from the system as gases, as illustrated by following reaction:



The ammonia can either form ammonia compounds or be oxidized to form nitrates, depending upon the pH. In this manner, oxidation of HCN or CH^- lowers the overall cyanide content of the system.

Volatilization

Hydrogen cyanide (HCN), also known as hydrocyanic acid, is a colorless gas or liquid with a boiling point of 25.7° C and a vapor pressure of 100 kPa at 26° C. The equilibrium hydrolysis reaction between a cyanide ion and water occurs according to the following reaction:



At a pH of 9.36, which is the pK value, the concentrations of the HCN and CN^- ion are equal. At lower pH values and at 20°C, the majority of cyanide exists as HCN (i.e., 69.6% at pH 9; 95.8% at pH 8, and greater than 99% at pH 7).

The process has an operational pH of approximately 10.5. In tailings, there will be a gradual decrease in pH over time because of a neutralization of the alkaline

environment, which is due to the infiltration of rain water and carbon dioxide uptake. Thus, at a neutral pH, most of the free cyanide will be in the form of HCN

Molecular hydrogen cyanide (HCN) has a high vapor pressure level and rapidly volatilizes into a gas. This volatilization process is moderately sensitive to temperature. The HCN produced by the hydrolysis of CN^- is thus readily volatilized into a gas and is continuously evolved from the tailings environment through dissipation, or destroyed by oxidation as discussed below. The net results are thus a loss of cyanide from the system.

Lime may buffer the hydrolysis reaction by keeping the pH above 9.36, which will temporarily prevent hydrolysis and the production of HCN. Over time, infiltration of water and carbon dioxide into the storage will neutralize the lime. The storage is then no longer buffered at an elevated pH, and hydrolysis of CN^- to HCN will take place.

Biodegradation

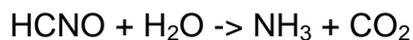
There are two types of biodegradation, including aerobic and anaerobic.

Aerobic Biodegradation of HCN

Under aerobic conditions within the upper oxidized portions, biological processes may consume hydrogen cyanide and generate hydrogen cyanate, as shown in the following equation:



The hydrogen cyanate is in turn hydrolyzed into ammonia and carbon dioxide.



Anaerobic Biodegradation

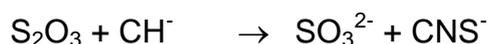
Anaerobic biodegradation of cyanide and hydrogen cyanide is restricted to the moderately to strongly reduced portions of the tailings environment, and can only occur if HS^- or $\text{H}_2\text{S}(\text{aq})$ are present. (The sulfur species present will depend on pH. At a lower pH, $\text{H}_2\text{S}(\text{aq})$ will be present). The following equations illustrate the anaerobic biodegradation of cyanide:



The HCNS will then hydrolyze to form NH_3 , H_2S and CO_2 .

Formation of Thiocyanate

Thiocyanate ions (CNS^-) can be formed by the reaction between cyanide and any sulfur species such as sulfide, hydrogen sulfide, or thiosulfate. Thiocyanate is a common cyanide species in sulfidic ore. Examples of thiocyanate forming reactions include the following equations:



In oxidized portions of the tailings storage environment, the SO_3^{2-} formed in the second equation above will be reached with oxygen to form sulfate (SO_4^{2-}).

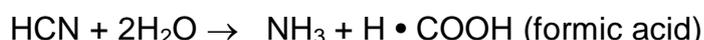
Thiocyanate is a relatively stable and less toxic form of cyanide, and thiocyanate formation is an effective way of removing cyanide from the tailings environment.

Hydrolysis/saponification of HCN

As the pH in the system falls, HCN can be hydrolyzed by a different route to form formate, either formic acid or ammonium formate by:



or



The system pH will determine the extent of the formation of each compound, a lower pH favoring the formation of formic acid. This form of hydrolysis has been referred to as "saponification".

HYDROGEN CYANIDE²⁰

Chemical name: Hydrogen Cyanide

Other names: Formonitrile, Hydrocyanic acid, prussic acid,

International name: Hydrogen Cyanide, Formonitrile; Hydrocyanic acid; Prussic acid

CAS : 74-90-8

UN No: 1613

Formula: CHN

NFPA Reactivity Rating: Undefined	EU risk label: R12, R26/27/28, R50/53, S1/2, S16, S36/37, S38, S45, S53, S59, S61
NFPA Sp. Inst.: Undefined	

TOXICITY		
OSHA	NIOSH	Related Information
Permissible maximum level (8)	Permissible maximum level (8)	AIHA Emergency Response

²⁰http://www.mne.mn/chemical/images/content/uploaded/74-90-8_4ae6aa22eb2bc.htm

working hours or week average) (PEL-TWA) ppm: 10	working hours or week average) (PEL-TWA) ppm: Undefined	Planning Guidelines - ERPG-1/ERPG-2/ERPG-3: undefined/10 ppm/25 ppm
Permissible maximum level (8 working hours or week average) (PEL-TWA) mg/m ³ : 11	Permissible maximum level (8 working hours or week average) (PEL-TWA) ppm: Permissible maximum level (8 working hours or week average) (PEL-TWA) mg/m ³ : undefined	
Permissible maximum level (average of 15 minutes) (PEL-STEL) ppm: undefined	Permissible maximum level (average of 15 minutes) (PEL-STEL) ppm: 4,7	Storage color:
Permissible maximum level (average of 15 minutes) (PEL-STEL) mg/m ³ : undefined	Permissible maximum level (average of 15 minutes) (PEL-STEL) mg/m ³ : 5	
Permissible maximum level (any time) (PEL-C) ppm: undefined	Permissible maximum level (any time) (PEL-C) ppm: undefined	
Permissible maximum level (any time) (PEL-C) mg/m ³ : undefined	Permissible maximum level (any time) (PEL-C) mg/m ³ : undefined	carcinogenicity: undefined
Skin Notation: yes	Skin Notation: yes	
Notes: undefined	Notes: undefined	
	Immediately dangerous to life and health ppm: 50	
	Immediately dangerous to life and health ppm mg/m ³ : undefined	
	Immediately dangerous to life and health ppm notes: undefined	

Personal Protection/Sanitation	First Aid
<p>Skin: Prevent skin contact. Wear appropriate personal protective clothing to prevent skin contact.</p> <p>Eyes: Prevent eye contact. Wear appropriate eye protection to prevent eye contact.</p> <p>Wash skin: The worker should immediately wash the skin when it becomes contaminated.</p> <p>Remove: Work clothing that becomes wet should be immediately removed due to its flammability hazard</p> <p>Change: No recommendation is made specifying the need for the worker to change clothing after the work shift.</p> <p>Provide: Eyewash fountains should be provided in areas where there is any possibility that workers could be exposed to the substances; this is irrespective of the recommendation involving the wearing of eye protection. Facilities for quickly drenching the body should be provided within the immediate work area for emergency use where there is a possibility of exposure. [Note: It is intended that these facilities provide a sufficient quantity or flow of water to quickly remove the substance from anybody areas likely to be exposed. The actual determination of what constitutes an adequate quick drench facility depends on the specific circumstances. In certain</p>	<p>Eye: If this chemical contacts the eyes, immediately wash (irrigate) the eyes with large amounts of water, occasionally lifting the lower and upper lids. Get medical attention immediately.</p> <p>Skin: If this chemical contacts the skin, immediately flush the contaminated skin with water. If this chemical penetrates the clothing, immediately remove the clothing and flush the skin with water. Get medical attention promptly.</p> <p>Breath: If a person breathes large amounts of this chemical, move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible.</p>

instances, a deluge shower should be readily available, whereas in others, the availability of water from a sink or hose could be considered adequate.]
Respirator Recommendations
NIOSH/OSHA 47 ppm: SA 50 ppm: SA:CF/SCBAF/SAF : SCBAF:PD,PP/SAF:PD,PP:ASCBA Escape: GMFS/SCBAE
Poisoning
Inhale, skin, swallow, eye, body contact
Symptoms
asphyxia; lassitude (weakness, exhaustion), headache, confusion; nausea, vomiting; increased rate and depth of respiration or respiration slow and gasping; thyroid, blood changes
Target organs
central nervous system, cardiovascular system, thyroid, blood

DOT Emergency response guide²¹
<p>Guide Number: 154 154 Toxic and corrosive (Non-combustible) POTENTIAL HAZARDS HEALTH</p> <ul style="list-style-type: none"> • TOXIC; inhalation, ingestion or skin contact with material may cause severe injury or death. • Contact with molten substance may cause severe burns to skin and eyes. • Avoid any skin contact. • Effects of contact or inhalation may be delayed. • Fire may produce irritating, corrosive and/or toxic gases. • Runoff from fire control or dilution water may be corrosive and/or toxic and cause pollution. <p>FIRE OR EXPLOSION</p> <ul style="list-style-type: none"> • Non-combustible, substance itself does not burn but may decompose upon heating to produce corrosive and/or toxic fumes. • Some are oxidizers and may ignite combustibles (wood, paper, oil, clothing, etc.). • Contact with metals may evolve flammable hydrogen gas. • Containers may explode when heated. <p>PUBLIC SAFETY</p> <ul style="list-style-type: none"> • CALL EMERGENCY RESPONSE Telephone Number on Shipping Paper first. If Shipping Paper not available or no answer, refer to appropriate telephone number listed on the inside back cover. • As an immediate precautionary measure, isolate spill or leak area in all directions for at least 50 meters (150 feet) for liquids and at least 25 meters (75 feet) for solids. • Keep unauthorized personnel away. • Stay upwind. • Keep out of low areas. • Ventilate enclosed areas. <p>PROTECTIVE CLOTHING</p> <ul style="list-style-type: none"> • Wear positive pressure self-contained breathing apparatus (SCBA). • Wear chemical protective clothing that is specifically recommended by the manufacturer. It may provide little or no thermal protection. • Structural firefighters' protective clothing provides limited protection in fire situations ONLY; it is not effective in spill situations where direct contact with the substance is possible. <p>EVACUATION Spill See Table Initial Isolation and Protective Action Distances for highlighted materials. For non-highlighted</p>

²¹ Emergency Response Guidebook 2012,

materials, increase, in the downwind direction, as necessary, the isolation distance shown under "PUBLIC SAFETY".

Fire

If tank, rail car or tank truck is involved in a fire, ISOLATE for 800 meters (1/2 mile) in all directions; also, consider initial evacuation for 800 meters (1/2 mile) in all directions.

FIRE EMERGENCY RESPONSE

Small:

- Dry chemical, CO2 or water spray

Large

- Dry chemical, CO2, alcohol-resistant foam or water spray.
- Move containers from fire area if you can do it without risk.
- Dike fire-control water for later disposal; do not scatter the material.
- Fight fire from maximum distance or use unmanned hose holders or monitor nozzles.
- Do not get water inside containers.
- Cool containers with flooding quantities of water until well after fire is out.
- Withdraw immediately in case of rising sound from venting safety devices or discoloration of tank.
- ALWAYS stay away from tanks engulfed in fire.

SPILL OR LEAK

- ELIMINATE all ignition sources (no smoking, flares, sparks or flames in immediate area).
- Do not touch damaged containers or spilled material unless wearing appropriate protective clothing.
- Stop leak if you can do it without risk.
- Prevent entry into waterways, sewers, basements or confined areas.
- Absorb or cover with dry earth, sand or other non-combustible material and transfer to containers.
- DO NOT GET WATER INSIDE CONTAINERS.

FIRST AID

- Move victim to fresh air.
- Call emergency medical service.
- Give artificial respiration if victim is not breathing.
- Do not use mouth-to-mouth methods if victim ingested or inhaled the substance; give artificial respiration with the aid of a pocket mask equipped with a one-way valve or other proper respiratory medical device.
- Administer oxygen if breathing is difficult.
- Remove and isolate contaminated clothing and shoes.
- In case of contact with substance, immediately flush skin or eyes with running water for at least 20 minutes.
- For minor skin contact, avoid spreading material on unaffected skin.
- Keep victim warm and quiet.
- Effects of exposure (inhalation, ingestion or skin contact) to substance may be delayed.
- Ensure that medical personnel are aware of the material(s) involved and take precautions to protect themselves.

Non fire response (CAMEO Data)

ELIMINATE all ignition sources (no smoking, flares, sparks or flames in immediate area). Do not touch damaged containers or spilled material unless wearing appropriate protective clothing. Stop leak if you can do it without risk. Prevent entry into waterways, sewers, basements or confined areas. Absorb or cover with dry earth, sand or other non-combustible material and transfer to containers. DO NOT GET WATER INSIDE CONTAINERS. (ERG, 2012)

FIRE:

Small fire:

- Dry chemical, CO2 or water spray.

Large fire:

- Dry chemical, CO2, alcohol-resistant foam or water spray. Move containers from fire area if you

can do it without risk. Dike fire-control water for later disposal; do not scatter the material.

- Move containers from fire area if you can do it without risk.
- Dike fire-control water for later disposal; do not scatter the material.

Fire involving tanks or car/trailer loads:

- Fight fire from maximum distance or use unmanned hose holders or monitor nozzles.
- Do not get water inside containers.
- Cool containers with flooding quantities of water until well after fire is out.
- Withdraw immediately in case of rising sound from venting safety devices or discoloration of tank.
- ALWAYS stay away from tanks engulfed in fire.

Reactivity: CHEMICAL CHARACTERISTICS: Weak acid with faint odor of almonds, lethal. Cyanide dissolved in water bears HCN. In reaction with acid and heating forms lethal hydrocyanic acid. (REACTIVITY, 1999)

First aid:

Eye: If this chemical contacts the eyes, immediately wash the eyes with large amounts of water, occasionally lifting the lower and upper lids. Get medical attention immediately. Contact lenses should not be worn when working with this chemical.

Skin: If this chemical contacts the skin, immediately flush the contaminated skin with water. If this chemical penetrates the clothing, immediately remove the clothing and flush the skin with water. Get medical attention promptly.

Breathing: If a person breathes large amounts of this chemical, move the exposed person to fresh air at once. If breathing has stopped, perform mouth-to-mouth resuscitation. Keep the affected person warm and at rest. Get medical attention as soon as possible.

Swallow: If this chemical has been swallowed, get medical attention immediately. (NIOSH, 1997)

ERG 2004 protective action distances				
	From a small package or small leak from a large package		From a large package or from many small packages	
	First ISOLATE in all Directions	Then PROTECT persons Downwind during Day Night	First ISOLATE in all Directions	Then PROTECT persons Downwind during Day Night
	30.5 m	160.9 m 160.9 m	122.0 m	482.7 m 1287.2 m
Hydrogen cyanide is a solution containing less than 20% of hydrogen cyanide (if MSDS has a sign "Toxic to inhale")				

BURNT LIME²²²³

Chemical name: Calcium oxide

Other names: Raw lime, lime powder

International name: Calcium Oxide, Burned lime; Burnt lime; Lime; Pebble lime; Quick lime; Unslaked lime

CAS : 1305-78-8

UN : 1910

Formula: CaO

PHYSICAL AND CHEMICAL PROPERTIES

Physical Description: White or gray, odorless lumps or granular powder

BP: 2847.1	MW: 56.1	LEL: undefined
FRZ/MLT FRZ:	VP:	UEL: undefined

²² http://www.mne.mn/chemical/images/content/uploaded/1305-78-8_4ae7b04081ee2.htm

²³ Risk assessment and chemical hazard guide of chemicals registered in Mongolia, page 636

2569.6 ⁰	0.001	
FP: undefined	VD: undefined	
Sp. GR: undefined	IP: undefined	

Hazard information	
NFPA Fire Rating: 0	Storage color code: Blue (hazardous to health), Yellow (easy to react)
NFPA Health Rating: 1	
NFPA Reactivity Rating: 1	
NFPA Sp. Inst.: undefined	

TOXICITY		
OSHA	NIOSH	Related Information
Permissible maximum level (8 working hours or week average) (PEL-TWA) ppm: undefined	Permissible maximum level (8 working hours or week average) (PEL-TWA) ppm: undefined	AIHA Emergency Response Planning Guidelines - ERPG-1/ERPG-2/ERPG-3: undefined
Permissible maximum level (8 working hours or week average) (PEL-TWA) mg/m ³ : 5	Permissible maximum level (8 working hours or week average) (PEL-TWA) mg/m ³ : 2	
Permissible maximum level (average of 15 minutes) (PEL-STEL) ppm: undefined	Permissible maximum level (average of 15 minutes) (PEL-STEL) ppm: undefined	
Permissible maximum level (average of 15 minutes) (PEL-STEL) mg/m ³ : undefined	Permissible maximum level (average of 15 minutes) (PEL-STEL) mg/m ³ : undefined	
Permissible maximum level (any time) (PEL-C) ppm: undefined	Permissible maximum level (any time) (PEL-C) ppm: undefined	
Permissible maximum level (any time) (PEL-C) mg/m ³ : undefined	Permissible maximum level (any time) (PEL-C) mg/m ³ : undefined	
Skin Notation: No recommendation	Skin Notation: No	
Notes: undefined	Notes: undefined	
	IDLH ppm: undefined	
	IDLH mg/m ³ : 25	
	IDLH Notes: undefined	

NIOSH Pocket Guide to Chemical Hazards	
Calcium oxide	CAS: 1305-78-8
Formula: CaO	RTECS: EW3100000
Synonyms/Trade Names: Burned lime, Burnt lime, Lime, Pebble lime, Quick lime, Unslaked lime	DOT ID & Guide: 1910 157
Exposure Limits	
Permissible maximum level (NIOSH REL): 8 working hours or week average (TWA) 1 mg/m ³	Permissible maximum level (NIOSH REL): 8 working hours or week average (TWA) 5 mg/m ³
IDLH: 25 mg/m ³	Conversion: undefined
Incompatibilities & Reactivity	

Water (liberates heat), fluorine, ethanol [Note: Reacts with water to form calcium hydroxide.]	
Measurement Methods	
NIOSH 7020, 7303, OSHA ID 121	
Personal Protection & Sanitation	First Aid
Skin: Prevent skin contact Eyes: Prevent eye contact Wash skin: When contaminated/Daily Remove: When wet or contaminated Change: Undefined Provide: Eyewash, Quick drench	Eye: Irrigate immediately Skin: Water flush immediately Breathing: Respiratory support Swallow: Medical attention immediately
NIOSH Respirator Recommendations	
NIOSH/OSHA 15 mg/m3: SA : CF/ PAPRAGHiE/ CCRFAGHiE/ GMFAGHiE/ SCBAF/ SAF : SCBAF : PD,PP/SAF:PD,PP:ASCBA Escape: GMFAGHiE/SCBAE	
Exposure Routes	
Inhale	
Symptoms	
irritation eyes, skin, upper resp tract; ulcer, perforation nasal septum; pneumonitis; dermatitis	
Target Organs	
Eyes, skin, respiratory system, teeth	

EMERGENCY RESPONSE GUIDEBOOK²⁴
Guide Number: 157
157 Substances - Water-Reactive - Corrosive
POTENTIAL HAZARDS
HEALTH
<ul style="list-style-type: none"> • TOXIC; inhalation, ingestion or contact (skin, eyes) with vapors, dusts or substance may cause severe injury, burns or death. • Reaction with water or moist air will release toxic, corrosive or flammable gases. • Reaction with water may generate much heat that will increase the concentration of fumes in the air. • Fire will produce irritating, corrosive and/or toxic gases. • Runoff from fire control or dilution water may be corrosive and/or toxic and cause pollution
FIRE OR EXPLOSION
<ul style="list-style-type: none"> • Non-combustible, substance itself does not burn but may decompose upon heating to produce corrosive and/or toxic fumes. • Vapors may accumulate in confined areas (basement, tanks, hopper/tank cars etc.). • SUBSTANCE WILL REACT WITH WATER (SOME VIOLENTLY), RELEASING CORROSIVE AND/OR TOXIC GASES. • May release large amount of heat in reaction with water increasing amount of vapor concentration • Contact with metals may evolve flammable hydrogen gas. • Containers may explode when heated or if contaminated with water.
PUBLIC SAFETY
<ul style="list-style-type: none"> • CALL 105 • As an immediate precautionary measure, isolate spill or leak area in all directions for at least 50 meters (150 feet) for liquids and at least 25 meters (75 feet) for solids. • Keep unauthorized personnel away. • Stay upwind.

²⁴ Emergency Response Guidebook 2012, page 252

- Keep out of low areas.
- Ventilate enclosed areas.

PROTECTIVE CLOTHING

- Wear positive pressure self-contained breathing apparatus (SCBA).
- Wear chemical protective clothing that is specifically recommended by the manufacturer. It may provide little or no thermal protection.
- Structural firefighters' protective clothing provides limited protection in fire situations ONLY; it is not effective in spill situations where direct contact with the substance is possible.

EVACUATION**Spill**

- See Table 1 - Initial Isolation and Protective Action Distances for highlighted materials. For non-highlighted materials, increase, in the downwind direction, as necessary, the isolation distance shown under "PUBLIC SAFETY".

Fire

- If tank, rail car or tank truck is involved in a fire, ISOLATE for 800 meters (1/2 mile) in all directions; also, consider initial evacuation for 800 meters (1/2 mile) in all directions.

EMERGENCY RESPONSE**FIRE**

Note: Most of foam fire extinguishers may react with the substance and release toxic gases.

Small:

- Dry chemical, CO₂, dry sand, alcohol-resistant or water spray.

Large:

- Dry chemical, CO₂, alcohol-resistant foam or water spray.
- Move containers from fire area if you can do it without risk.
- Use water spray. Avoid straight water flow
- Dike fire-control water for later disposal; do not scatter the material.

Fire involving Tanks or Car/Trailer Loads:

- Fight fire from maximum distance or use unmanned hose holders or monitor nozzles.
- Do not get water inside containers.
- Cool containers with flooding quantities of water until well after fire is out.
- Withdraw immediately in case of rising sound from venting safety devices or discoloration of tank.
- ALWAYS stay away from tanks engulfed in fire.

SPILL OR LEAK

- ELIMINATE all ignition sources (no smoking, flares, sparks or flames in immediate area).
- All equipments should have grounding
- Do not touch damaged containers or spilled material unless wearing appropriate protective clothing.
- Stop leak if you can do it without risk.
- Vapor of sprayed foam can be used decrease vapor of the substance.
- DO NOT GET WATER INSIDE CONTAINERS.
- Spray water to decrease vapor and cloud curtain
- Prevent entry into waterways, sewers, basements or confined areas.

Large spill:

- Absorb or cover with dry earth, sand or other non-combustible material and transfer to containers
- Clean using non-combustible manual tools to collect and seal in plastic container.

FIRST AID

- Move victim to fresh air.
- Call 103 or emergency medical service.
- Give artificial respiration if victim is not breathing.
- Do not use mouth-to-mouth methods if victim ingested or inhaled the substance; give artificial respiration with the aid of a pocket mask equipped with a one-way valve or other proper respiratory medical device.

Additional Emergency Response Information (CAMEO Data)

Non-fire Spill Response: Prevent entry into waterways, sewers, basements or confined areas. Store in dry place. Do not store with other substances. Ground spill: Dig a pit, pond, lagoon, holding area to contain liquid or solid material. If time permits, pits, ponds, lagoons, soak holes, or holding areas should be sealed with an impermeable flexible membrane liner. Cover solids with a plastic sheet to prevent dissolving in rain or firefighting water. Dike surface flow using soil, sand bags, foamed polyurethane, or foamed concrete.

Water spill: Use natural deep water pockets, excavated lagoons, or sand bag barriers to trap material at bottom. Remove trapped material with suction hoses. (AAR, 1999)

Firefighting: Extinguish fire using agent suitable for type of surrounding fire. (Material itself does not burn or burns with difficulty.) Cool all affected containers with flooding quantities of water. Do not use water on material itself. Keep run-off water out of sewers and water sources. Use foam, dry chemical, or carbon dioxide. (AAR, 1999)

Reactivity: AIR AND WATER REACTIONS: Temperatures as high as 800 C have been reached with addition of water (moisture in air or soil). Ignitions of sulfur, gunpowder, wood, and straw by the heat of the quicklime-water reaction have been reported (Mellor 3: 673 1946-47). CHEMICAL PROFILE: Liquid hydrofluoric acid and calcium oxide react very violently (Mellor 2, Supp. 1:129 1956). Calcium oxide or sodium hydroxide react with phosphorus pentoxide extremely violently when initiated by local heating (Mellor 8 Supp.3:406 1971). (REACTIVITY, 1999)

First Aid

Eye: If this chemical contacts the eyes, immediately wash the eyes with large amounts of water, occasionally lifting the lower and upper lids. Get medical attention immediately. Contact lenses should not be worn when working with this chemical.

Skin: If this chemical contacts the skin, immediately flush the contaminated skin with water. If this chemical penetrates the clothing, immediately remove the clothing and flush the skin with water. Get medical attention promptly.

Breathing: If a person breathes large amounts of this chemical, move the exposed person to fresh air at once. If breathing has stopped, perform mouth-to-mouth resuscitation. Keep the affected person warm and at rest. Get medical attention as soon as possible.

Swallow: If this chemical has been swallowed, get medical attention immediately. (NIOSH, 1997)

CAUSTIC SODA²⁵

Chemical name: Sodium hydroxide

Other name: Caustic soda, ash alkali

International name: Caustic soda, Lye, Sodium hydroxide, Sodium hydrate

CAS : 1310-73-2

UN : 1823

Formula: NaOH

PHYSICAL AND CHEMICAL CHARACTERISTICS

Physical description: Colorless to white, odorless solid (flakes, beads, granular form).

BP: 1390	MW: 40	LEL: undefined
FRZ/MLT: FRZ: 318	VP: 0 mm Hg	UEL: undefined
FP: undefined	VD: undefined	
Sp. GR: 2,13	IP: undefined	

²⁵Risk assessment and chemical hazard guide of chemicals registered in Mongolia, page 748

TOXICITY AND HAZARD INFORMATION	
Health impact category: 4 – very toxic (poisonous)	Storage color code: Black stripes on white (store isolated), Blue (very toxic), Yellow (stable in regular condition)
Ignition category: 0 – Safe	Toxicity symbol: Chemical burns
Reaction category: 2 – Moderate	EU risk sign: R 35 – Severe burn
Contact category: 4 – Very strong (Chemical burn)	Laboratory protective devices: glove, glasses, face protection, laboratory clothing, drawer

TOXICITY		
OSHA	NIOSH	Related Information
Permissible maximum level (8 working hours or week average) (PEL-TWA) ppm: undefined	Permissible maximum level (8 working hours or week average) (PEL-TWA) ppm: undefined	AIHA Emergency Response Planning Guidelines – (ERPG)-1/ERPG-2/ 0.5 mg/m ³ 5 mg/m ³ 50 mg/m ³
Permissible maximum level (8 working hours or week average) (PEL-TWA) mg/m ³ : 2	Permissible maximum level (8 working hours or week average) (PEL-TWA) mg/m ³ : undefined	
Permissible maximum level (average of 15 minutes) (PEL-STEL) ppm: undefined	Permissible maximum level (average of 15 minutes) (PEL-STEL) ppm: undefined	
Permissible maximum level (average of 15 minutes) (PEL-STEL) ppm: undefined mg/m ³ : undefined	Permissible maximum level (average of 15 minutes) (PEL-STEL) ppm: undefined mg/m ³ : undefined	
Permissible maximum level (any time) (PEL-C) ppm: undefined	Permissible maximum level (any time) (PEL-C) ppm: undefined	
Permissible maximum level (any time) (PEL-C) mg/m ³ : undefined	Permissible maximum level (any time) (PEL-C) mg/m ³ : 2	
Skin Notation: No	Skin Notation: No	Carcinogen Classifications: undefined
	Notes: undefined	
	IDLH ppm: undefined	
	IDLH mg/m ³ : 10	
	IDLH Notes:	

NIOSH Pocket Guide to Chemical Hazards Current through June 2006	
Sodium hydroxide	(CAS): 1310-73-2
Formula: (NaOH)	(RTECS): (WB)49000
Synonyms/Trade Names: Caustic soda, Lye, Soda lye, Sodium hydrate	(DOT ID) &(Guide): (dry solid) 1824 (liquid)
Exposure Limits	
Permissible maximum level (NIOSH REL): 8 working hours or week average 2 mg/m ³	Permissible maximum level (OSHA PEL): 8 working hours or week average 2 mg/m ³
IDLH: 10 mg/m ³	Conversion: Undefined
Incompatibilities & Reactivity	

Incompatibilities and Reactivity: Water; acids; flammable liquids; organic halogens; metals such as aluminum, tin & zinc; nitromethane Note: Corrosive to metals.]	
Measurement Methods	
(NIOSH) 7481	
Personal Protection & Sanitation	First Aid
Skin: Prevent skin contact Eyes: Prevent eye contact Wash skin: When contaminated Remove: When wet or contaminated Change: Daily Provide: Eyewash Quick drench	Eye: Irrigate immediately Skin: Water flush immediately Breath: Respiratory support Swallow: Medical attention immediately
NIOSH Respirator Recommendations	
NIOSH/OSHA 10 mg/m ³ : (SA:SF/HiEF/PAPRDM/SCBAF/SAF): (SCBAF:PD, PP/SAF:PD,PP:ASCBA) Escape: (HiEF)	
Exposure Routes	
inhalation, ingestion, skin and/or eye contact	
Symptoms	
irritation eyes, skin, mucous membrane; pneumonitis; eye, skin burns; temporary loss of hair	
Target Organs	
Eyes, skin, respiratory system	

EMERGENCY RESPONSE²⁶
Guide Number: 154
Substances – Toxic and/ or Corrosive (Non-Combustible)
Very toxic if inhaled or swallowed. Very corrosive, severely burns in contact with skin and eye. Not combustible, but releases toxic gases when heated. May release flammable or explosive hydrogenic gases when reacts with some metal.
POTENTIAL HAZARDS
HEALTH
<ul style="list-style-type: none"> • TOXIC; inhalation, ingestion or skin contact with material may cause severe injury or death. • Contact with molten substance may cause severe burns to skin and eyes. • Avoid any skin contact. • Effects of contact or inhalation may be delayed. • Fire may produce irritating, corrosive and/or toxic gases. Runoff from fire control or dilution water may be corrosive and/or toxic and cause pollution.
FIRE OR EXPLOSION
<ul style="list-style-type: none"> • Non-combustible, substance itself does not burn but may decompose upon heating to produce corrosive and/or toxic fumes. • Some are oxidizers and may ignite combustibles (wood, paper, oil, clothing, etc.). • Contact with metals may evolve flammable hydrogen gas. • Containers may explode when heated.
PUBLIC SAFETY
<ul style="list-style-type: none"> • CALL EMERGENCY RESPONSE Telephone Number on Shipping Paper first. If Shipping Paper not available or no answer, refer to appropriate telephone number listed on the inside back cover. • As an immediate precautionary measure, isolate spill or leak area in all directions for at least 60-

²⁶ Emergency Response Guidebook 2012,

80 meters.

- Keep unauthorized personnel away.
- Open enclosed area.
- Keep out of low areas.
- Ventilate enclosed areas.

PROTECTIVE CLOTHING

- Wear positive pressure self-contained breathing apparatus (SCBA).
- Wear chemical protective clothing that is specifically recommended by the manufacturer. It may provide little or no thermal protection.
- It is not effective in spill situations where direct contact with the substance is possible.

EVACUATION

Spill

- See Table Initial Isolation and Protective Action Distances for highlighted materials.
- For non-highlighted materials, increase, in the downwind direction.

Fire

If tank, rail car or tank truck is involved in a fire, ISOLATE for 800 meters (1/2 mile) in all directions; also, consider initial evacuation for 800 meters (1/2 mile) in all directions.

FIRE EMERGENCY RESPONSE

Small:

- Dry chemical, CO₂ or water spray

Large

- Dry chemical, CO₂, alcohol-resistant foam or water spray.
- Move containers from fire area if you can do it without risk.
- Dig channels around fire and fill with water
- Do not scatter the material.

Fire involving Tanks or Car/Trailer Loads

- Use efficient fire extinguisher.
- Do not get water inside containers.
- Cool containers with flooding quantities of water until well after fire is out.
- Withdraw immediately in case of rising sound from venting safety devices or discoloration of tank.

SPILL OR LEAK

- ELIMINATE all ignition sources (no smoking, flares, sparks or flames in immediate area).
- Do not touch damaged containers or spilled material unless wearing appropriate protective clothing.
- Stop leak if you can do it without risk.
- Do not touch or step over spill or leak.
- Use water to decrease vapor. Do not mix spilled substance with water.
- Do not get water inside containers.

FIRST AID

- Move victim to fresh air.
- Call emergency medical service (103).
- Give artificial respiration if victim is not breathing.
- Do not use mouth-to-mouth method if victim ingested or inhaled the substance;
- Give artificial respiration with the aid of a pocket mask equipped with a one-way valve or other proper respiratory medical device.
- Administer oxygen if breathing is difficult.
- Remove and isolate contaminated clothing and shoes.
- In case of contact with substance, immediately flush skin or eyes with running water for at least 20 minutes.
- For minor skin contact, avoid spreading material on unaffected skin.
- Keep victim warm and quiet.
- Ensure that medical personnel are aware of the material(s) involved and take precautions to protect themselves.

Required special devices:

Full face respiratory with P2 filter, coverall, PVC rubber gloves with bracelets, PVC tape, PVC rubber glove

Additional Emergency Response Information (CAMEO Data)

Non-fire Spill Response: Keep material out of water sources and sewers. Dig a pit, pond, lagoon, holding area to contain liquid or solid material. Use water fog to eliminate vapor. Cover runoff surface with earth, sand bags, and foam polyurethane solids. Use ash or powder cement to absorb liquid. Use acids. Water spill: Neutralize with dilute acid. (AAR, 1999)

Firefighting: Create for using large amount of water. Use water spray to keep fire-exposed containers

Reactivity: AIR AND WATER REACTIONS: Hydrolysis generates enough heat to ignite adjacent combustible material (Haz. Chem. Data 1966). Dissolves in water with liberation of heat, may steam and spatter. Solution is basic (alkaline).

CHEMICAL REACTION: Absorbs moisture readily forming caustic soln. which attacks aluminum and zinc. A violent polymerization of acetaldehyde results from the reactions of acetaldehyde with alkaline materials such as sodium hydroxide. Calcium oxide or sodium hydroxide react with phosphorus pentoxide extremely violently when initiated by local heating (Mellor 8 Supp.3:406 1971). Using potassium hydroxide to dry impure tetrahydrofuran, which contains peroxides, may be hazardous. Explosions have occurred in the past. Sodium hydroxide behaves in a similar way as potassium hydroxide (NSC Newsletter Chem. Soc. 1967). Mixing sodium hydroxide in equal portions with any of the following substances in a closed container caused the temperature and pressure to increase: glacial acetic acid, acetic anhydride, acrolein, chlorohydrin, chlorosulfonic acid, ethylene cyanohydrin, glyoxal, hydrochloric acid (36%), hydrofluoric acid (48.7%), nitric acid (70%), oleum, propiolactone, sulfuric acid (96%) (NFPA 1991). An extremely violent polymerization reaction of acrolein results from the contact with alkaline materials such as sodium hydroxide (Chem. Safety Data Sheet SD-85 1961). Alkali and other alkaline earth compounds such as potassium, lithium, calcium, barium, and magnesium compounds, as well as amines and other nitrogen compounds will cause explosive decomposition of maleic anhydride (MCA Case History 622 1960). Pentol, being fractionated under high vacuum, was accidentally contacted by caustic cleaning solution and a violent explosion resulted, MCA Case History 363(1964). In the manufacture of sodium salt of trichlorophenol, sodium hydroxide, methyl alcohol and trichlorobenzene were heated. During the heating process, the pressure suddenly increased rapidly and an explosion occurred (MCA Guide for Safety Appendix 3 1972). (REACTIVITY, 1999)

First Aid:

EYE: If this chemical contacts the eyes, immediately wash the eyes with large amounts of water, occasionally lifting the lower and upper lids. Get medical attention immediately. Contact lenses should not be worn when working with this chemical.

SKIN: If this chemical contacts the skin, immediately flush the contaminated skin with water. If this chemical penetrates the clothing, immediately remove the clothing and flush the skin with water. Get medical attention promptly.

BREATHING: If a person breathes large amounts of this chemical, move the exposed person to fresh air at once. If breathing has stopped, perform mouth-to-mouth resuscitation. Keep the affected person warm and at rest. Get medical attention as soon as possible.

SWALLOW: If this chemical has been swallowed, get medical attention immediately. (NIOSH, 1997)

HYDROGEN CHLORIDE²⁷²⁸

Chemical name: Hydrogen Chloride

Other names: Hydrogen Chloride anhydrate, water solution of hydrogen chloride (hydrochloric acid)

International name: Hydrogen Chloride

CAS : 7647-01-0

UN No: 1789

Formula: HCl

²⁷ Handbook of toxic and hazardous chemicals 2010

²⁸ Risk assessment and chemical hazard guide of chemicals registered in Mongolia, page 496

PHYSICAL AND CHEMICAL PROPERTIES		
Physical description: Colorless to slightly yellow gas with a pungent, corrosive, irritating odor.		
BP: -85°C	MW: 36.5	LEL: undefined
FRZ/MLT: FRZ: -1140°	VP: 40.5	UEL: undefined
FP: undefined	VD: 1.27	Sol: 67%
Sp. GR: undefined		IP: 12.74 eV

TOXICITY	
NFPA Fire Rating: 0	Storage color code: Black stripes on white (store isolated), Blue (very toxic), Yellow (stable in regular condition)
NFPA Health Rating: 3	Toxicity symbol:: Very toxic, chemical burn
NFPA Reactivity Rating: 0	EU risk sign: R 35 – severe chemical burn
NFPA Sp. Inst.: undefined	

POISONING LIMIT		
OSHA	NIOSH	Related Information
Permissible maximum level (8 working hours or week average) (PEL-TWA) ppm: undefined	Permissible maximum level (8 working hours or week average) (PEL-TWA) ppm: undefined	AIHA Emergency response guideline - ERPG-1/ERPG-2/ERPG-3: 3ppm/ 20 ppm/ 150 ppm
Permissible maximum level (8 working hours or week average) (PEL-TWA) mg/m ³ : undefined	Permissible maximum level (8 working hours or week average) (PEL-TWA) mg/m ³ : undefined	
Permissible maximum level (average of 15 minutes) (PEL-STEL) ppm: undefined	Permissible maximum level (average of 15 minutes) (PEL-STEL) ppm: undefined	
Permissible maximum level (average of 15 minutes) (PEL-STEL) mg/m ³ : undefined	Permissible maximum level (average of 15 minutes) (PEL-STEL) mg/m ³ : undefined	
Permissible maximum level (any time) (PEL-C) ppm: 5	Permissible maximum level (any time) (PEL-C) ppm: 5	
Permissible maximum level (any time) (PEL-C) mg/m ³ : 7	Permissible maximum level (any time) (PEL-C) mg/m ³ : 7	
Skin Notation: no		
Notes: undefined	Notes: undefined	Hazard label: Toxic, corrosive
	IDLH ppm: 50	
	IDLH mg/m ³ : undefined	
	IDLH Notes: undefined	

NOISH Pocket Guide to Chemical Hazards	
RTECS: MW4025000	DOT ID & Guide: 1050 125 (anhydrate) 1789 157 (solution)
Poisoning limit	

Permissible maximum level (NOISH REL) TWA: 8 working hours or week average :5 ppm (7 mg/m ³)	Permissible maximum level (OSHA REL) TWA: 8 working hours or week average :5 ppm (7 mg/m ³)
IDLH: 50 ppm	Convention: 1ppm=1.49 mg/m ³
Material to be stored separately	
Hydroxides, amines, alkalis, copper, brass, zinc [Note: Hydrochloric acid is highly corrosive to most metals.]	
Measurement methods	
NOISH 7903; OSHA ID 174SG	

<p>Emergency response guide</p> <p>154 Toxic and corrosive</p> <p>POTENTIAL HAZARDS</p> <p>HEALTH</p> <ul style="list-style-type: none"> • Inhalation results burning sensation. Cough. Labored breathing. Shortness of breath. Sore throat. • Contact with skin results in redness, irritation, injure and burn • Eye: Pain. Blurred vision. Severe deep burns. • Swallowed: feel sick, burn of digestive organs, diarrhea • Non-combustible • Runoff from fire control or dilution water may be corrosive and/or toxic and cause pollution. <p>FIRE OR EXPLOSION</p> <ul style="list-style-type: none"> • Non-combustible, substance itself does not burn but may decompose upon heating to produce corrosive and/or toxic fumes. • Some are oxidizers and may ignite combustibles (wood, paper, oil, clothing, etc.). • Containers may explode when heated. <p>PUBLIC SAFETY</p> <ul style="list-style-type: none"> • CALL EMERGENCY RESPONSE Telephone Number on Shipping Paper first. If Shipping Paper not available or no answer, refer to appropriate telephone number listed on the inside back cover. • As an immediate precautionary measure, isolate spill or leak area in all directions for at least 50 meters • Keep unauthorized personnel away. • Stay upwind. • Keep out of low areas. • Ventilate enclosed areas. <p>PROTECTIVE CLOTHING</p> <ul style="list-style-type: none"> • -2 mark respiratory device, -4 isolation mask, container, -67 muzzle. • -1 and -5 protective cloth, wrapper. • Glasses and face protection mask. • Enter only when completely equipped with protective clothing. <p>EVACUATION</p> <p>Spill See Table Initial Isolation and Protective Action Distances for highlighted materials. For non-highlighted materials, increase, in the downwind direction, as necessary, the isolation distance shown under "PUBLIC SAFETY".</p> <p>Fire If tank, rail car or tank truck is involved in a fire, ISOLATE for 800 meters (1/2 mile) in all directions; also, consider initial evacuation for 800 meters (1/2 mile) in all directions</p> <p>FIRE EMERGENCY RESPONSE</p> <p>SPILL OR LEAK</p> <ul style="list-style-type: none"> • ELIMINATE all ignition sources (no smoking, flares, sparks or flames in immediate area).

- Do not touch damaged containers or spilled material unless wearing appropriate protective clothing.
- Stop leak if you can do it without risk.
- Prevent entry into waterways, sewers, basements or confined areas.

FIRST AID

- Move victim to fresh air.
- Call emergency medical service.
- Give artificial respiration if victim is not breathing.
- Let victim breath with spirit vapor
- Half sitting position
- Call medical emergency.
- Remove and isolate contaminated clothing and shoes.
- In case of contact with substance, immediately flush skin or eyes with running water for at least 15 minutes.
- If cloth is reused, thoroughly wash with large amount of water. Wash with ammonia solution and rinse.
- Rinse mouth with large amount of water.
- Rinse with soda.
- For minor skin contact, avoid spreading material on unaffected skin.
- Keep victim warm and quiet.
- Effects of exposure (inhalation, ingestion or skin contact) to substance may be delayed.
- Ensure that medical personnel are aware of the material(s) involved and take precautions to protect themselves.

SLAKED LIME²⁹³⁰

Chemical name: Calcium hydroxide

Other names: Calcium Hydroxide, Slaked lime, Milk of lime, Pickling lime, Calcium (II) hydroxide, Hydrated lime

International name: Calcium Hydroxide, Slaked lime, Milk of lime, Pickling lime, Calcium (II) hydroxide, Hydrated lime

CAS : 1305-62-0

UN :

Formula: Ca₂O

PHYSICAL AND CHEMICAL PROPERTIES

Physical description: White, odorless powder. [Note: Readily absorbs CO2 from the air to form calcium carbonate.]

BP: Decomposes	MW: 74.1	LEL: undefined
FRZ/MLT: MLT: 573.4 ° Decomposes, loses hydration	VP: <0.001 mm ³	UEL: undefined
FP: undefined	VD: undefined	Diss. (32F): 0.2%
Sp. GR: 2.24	IP: undefined	

TOXICITY

NFPA Fire Rating: undefined	Storage color code: Blue (poisonous)
NFPA Health Rating: undefined	
NFPA Reactivity Rating: undefined	

²⁹ http://www.mne.mn/chemical/images/content/uploaded/1305-62-0_4ae7b0182b673.htm

³⁰ Risk assessment and chemical hazard guide of chemicals registered in Mongolia, page 630

NFPA Sp. Inst.: undefined	
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POISONING LIMIT		
OSHA	NIOSH	Related Information
Permissible maximum level (8 working hours or week average) (PEL-TWA) ppm: undefined	Permissible maximum level (8 working hours or week average) (PEL-TWA) ppm: undefined	AIHA Emergency Response Planning Guidelines - ERPG-1/ERPG-2/ERPG-3: undefined
Permissible maximum level (8 working hours or week average) (PEL-TWA) mg/m ³ : 5	Permissible maximum level (8 working hours or week average) (PEL-TWA) mg/m ³ : 5	
Permissible maximum level (average of 15 minutes) (PEL-STEL) ppm: undefined	Permissible maximum level (average of 15 minutes) (PEL-STEL) ppm: undefined	
Permissible maximum level (average of 15 minutes) (PEL-STEL) mg/m ³ : undefined	Permissible maximum level (average of 15 minutes) (PEL-STEL) mg/m ³ : 2	
Permissible maximum level (any time) (PEL-C) ppm: undefined	Permissible maximum level (any time) (PEL-C) ppm: undefined	
Permissible maximum level (any time) (PEL-C) mg/m ³ : undefined	Permissible maximum level (any time) (PEL-C) mg/m ³ : undefined	
Skin Notation: no	Skin Notation: no	
Notes: undefined	Notes: undefined	
	IDLH ppm: undefined	
	IDLHmg/m ³ : 500	
	IDLH Notes: undefined	
NIOSH Pocket Guide to Chemical Hazards		
Calcium hydroxide		CAS: 1305-62-2
Formula: Ca ₂ O ₂		RTECS: EW2800000
Synonyms & Trade Names Calcium hydrate, Caustic lime, Hydrated lime, Slaked lime		DOT ID & Guide: undefined
Exposure Limits		
Permissible maximum level (NOISH REL) TWA: 8 working hours or week average (TWA) 5 mg/m ³ ST 2 mg/m ³	Permissible maximum level (NOISH REL) TWA: 8 working hours or week average (TWA) 15 mg/m ³ (total)	
IDLH: 500 mg/m ³	Conversion: undefined	
Noncombustible solid substance		
Incompatibilities & Reactivity		
Maleic anhydride, phosphorus, nitroethane, nitromethane, nitroparaffins, nitropropane [Note: Attacks some metals.]		
Measurement Methods		
NIOSH 7020, OSHA ID 121		

Personal Protection & Sanitation	First Aid
Skin: Prevent skin contact Eyes: Prevent eye contact Wash skin: When contaminated/Daily Remove: When wet or contaminated Change: Daily Provide: Eyewash, Quick drench	Eye: Irrigate immediately Skin: Soap flush immediately Breathing: Respiratory support Swallow: Medical attention immediately Please refer to emergency
Exposure Routes	
inhalation, ingestion, skin and/or eye contact	
Symptoms	
irritation eyes, skin, upper respiratory system; eye, skin burns; skin vesiculation; cough, bronchitis, pneumonitis	
Target Organs	
Eyes, skin, respiratory system	

RESPIRATOR RECOMMENDATIONS
Full face respirator with 2 filter, coverall, PVC rubber gloves with bracelets, PVC rubber boots

Additional Emergency Response Information (CAMEO Data)
Non-Fire Response: undefined
firefighting: undefined
Reactivity Profile: The nitroparaffins, nitromethane, nitropropane, etc. form salts with inorganic bases such as CALCIUM HYDROXIDE. The dry salts are explosive [Chem. Eng. news 30:2344 1952]. (REACTIVITY, 1999)
First aid: Eye: <ul style="list-style-type: none"> If this chemical contacts the eyes, immediately wash the eyes with large amounts of water, occasionally lifting the lower and upper lids. Get medical attention immediately. Contact lenses should not be worn when working with this chemical. Skin: <ul style="list-style-type: none"> If this chemical contacts the skin, immediately flush the contaminated skin with soap and water. If this chemical penetrates the clothing, immediately remove the clothing and flush the skin with water. If irritation persists after washing, get medical attention. Breathing: <ul style="list-style-type: none"> If a person breathes large amounts of this chemical, move the exposed person to fresh air at once. If breathing has stopped, perform mouth-to-mouth resuscitation. Keep the affected person warm and at rest. Get medical attention as soon as possible. Swallow: <ul style="list-style-type: none"> If this chemical has been swallowed, get medical attention immediately. Release large amount of heat in reaction with water. Contact with skin and eye will mix with skin moist resulting in chemical burn.

ANTISCALENT

Chemical name: Antiscalent

International name: Antiscalent

CAS : 2809-21-4

Physical and chemical properties

Physical description:

BP: 100 ⁰ C	VP: 17 mm	Diss.: 100%
: 4-5	VD: undefined	

Storage and exploitation

Stable in normal condition. Avoid extreme temperatures (extreme – colder than a freezing point).

Emergency response

Health

Long-period poisoning or multiple poisoning may cause shock.

First aid

Eye: wide open wash for 15 minute. If doesn't help, get medical help.

Skin: Take off contaminated cloth and boots and wash with soap. Before reusing clothes, clean thoroughly.

Swallow: Do not force vomit. If unconscious, do not force to drink anything. Check breathing and pulse. If noticeable, lie on stomach and get medical assistance. If conscious, rinse mouth with water. Let drink 400 ml water and continue each 10 minutes. Get medical help.

Breath: take to fresh air and turn on conditioner. If affected person remain unconscious, get medical help.

Spill

Small:

Absorb in sand, earth or sawdust, shovel into proper container and transport to designated chemical waste area. Spot on ground should be flushed with large amount of water.

Large: build earth dam to prevent leak into rainwater channel. Use proper pump and put in proper container. Transport to designated chemical waste area. Remaining spill should be cleaned in accordance with procedure.

Fire

Foam, powder, CO₂, water.

Special protection tools: special coat, glove, boots and respirator.

DIESEL FUEL

Chemical name: Diesel

International name: Diesel fuel

CAS : 544-76-3

Formula: C₁₆H₃₄

Table 6.28 Chemical composition

Chemical element	Carbon (C)	Hydrogen (H ₂)	Oxygen (O ₂)+Nitrogen (N ₂)	Sulfur (S)
Proportion, %	85.5	14.4	0.05	0.5
Mix compounded from paraffin, cycloparaffin, aromatic and olefin carbon that boils in 160 ⁰ - 400 ⁰				
CP: 60 ⁰				

Table 6.29 Characteristics of diesel fuel

#	Parameter	UOM	Amount
1	Molecular Weight	Unit	210 – 240
2	Density in 20°	Kg/m ³	P ₄ ²⁰ = 820 – 850
3	20° kinematic viscosity		2 – 6
4	Surface gravitation (boundary between fuel and air at 1013 mPa)		26 – 30
5	Heat transmission in 50°	K joule/ .h.c.	0.4
6	Heat capacity	kJ/kg	1.9
7	Dissolution on water at 20°	%	0.005
8	Radiating temperature	°	-10 – -60
9	Boiling temperature, 1013 mPa	°	180 – 360
10	Permissible level in air, theory	kg/kg	14.8 – 14.9
11	Permissible level of vapor concentration in air	Mg/m	300

Technological processes held in fuel storage area should strictly follow state standards on fire and explosion safety, sectorial norms and rules and procedures issued from State specialized inspection agency.

HDPE GEOMEMBRANE LINER

As a result of adding stabilizer substances such as carbon black and oxidation stabilizer to this material, the material is made highly resistant to weather, ultraviolet rays and any chemical substances. This HDPE liner is highly resistant to friction and has exceptional physical parameters.

Parameters:

- Chemical parameters: extremely resistant
- Heat parameters: extremely tolerant to cold weather
- Parameters on reaction with pollutant substances: extremely tolerant to filtered waste water and alkali

ACTIVATED CARBON

International name: Activated Carbon

UN : 1362

Formula: =C

EMERGENCY RESPONE ³¹
<p>Guide Number: 133 Flammable Solids</p> <p>POTENTIAL HAZARDS</p> <p>FIRE OR EXPLOSION</p> <ul style="list-style-type: none"> • Flammable/combustible material. • May be ignited by friction, heat, sparks or flames. • Some may burn rapidly with flare burning effect. • Powders, dusts, shavings, borings, turnings or cuttings may explode or burn with explosive

³¹ Emergency Response Guidebook 2012, page 204

violence.

- Substance may be transported in a molten form at a temperature that may be above its flash point.
- May re-ignite after fire is extinguished.

HEALTH

- Fire may produce irritating and/or toxic gases.
- Contact may cause burns to skin and eyes.
- Contact with molten substance may cause severe burns to skin and eyes.
- Runoff from fire control may cause pollution.

PUBLIC SAFETY

- CALL Emergency Response Telephone Number on Shipping Paper first. If Shipping Paper not available or no answer, refer to appropriate telephone number listed on the inside back cover.
- As an immediate precautionary measure, isolate spill or leak area for at least 25 meters (75 feet) in all directions.
- Keep unauthorized personnel away.
- Stay upwind.
- Keep out of low areas.

PROTECTIVE CLOTHING

- Wear positive pressure self-contained breathing apparatus (SCBA).
- Structural firefighters' protective clothing will only provide limited protection.

EVACUATION

Spill

- Consider initial downwind evacuation for at least 100 meters (330 feet).

Fire

- If tank, rail car or tank truck is involved in a fire, ISOLATE for 800 meters (1/2 mile) in all directions; also, consider initial evacuation for 800 meters (1/2 mile) in all directions.

EMERGENCY RESPONSE FIRE

Fire:

Small Fire:

- Dry chemical, CO2 sand, earth, water spray or regular foam.

Large Fire:

- Water spray, fog or regular foam.
- Move containers from fire area if you can do it without risk.

Metal painting substance, slurry

- Dry sand, graphite powder, dry sodium chloride fire extinguisher, G-1 or Met-L-X powder should be used in fire originated from aluminum.

Fire involving Tanks or Car/ Trailer Loads:

- Cool containers with flooding quantities of water until well after fire is out.
- For massive fire, use unmanned hose holders or monitor nozzles; if this is impossible, withdraw from area and let fire burn.
- Withdraw immediately in case of rising sound from venting safety devices or discoloration of tank.
- ALWAYS stay away from tanks engulfed in fire.

SPILL OR LEAK

- ELIMINATE all ignition sources (no smoking, flares, sparks or flames in immediate area).
- Do not touch or walk through spilled material.
- With clean shovel place material into clean, dry container and cover loosely; move containers from spill area.
- Wet down with water and dike for later disposal.
- Prevent entry into waterways, sewers, basements or confined areas.

First aid:

- Move victim to fresh air.
- Call 103 or emergency medical service.

- Give artificial respiration if victim is not breathing.
- Administer oxygen if breathing is difficult.
- Remove and isolate contaminated clothing and shoes.
- In case of contact with substance, immediately flush skin or eyes with running water for at least 20 minutes.
- Removal of solidified molten material from skin requires medical assistance.
- Keep victim warm and quiet.
- Ensure that medical personnel are aware of the material(s) involved and take precautions to protect themselves.

HYDROGEN PEROXIDE

Chemical name: HYDROGEN PEROXIDE

CAS #: 7722-84-1

UN No: 2014

Formula: H_2O_2

Other name: High-strength hydrogen peroxide; Hydrogen dioxide; Hydrogen peroxide (aqueous); Hydroperoxide; Peroxide

Physical parameters			
Colorless liquid with a slightly sharp odor. [Note: The pure compound is a crystalline solid below 12°F. Often used in an aqueous solution.]			
BP: 141,1 ^o	MW: 34.0	LEL: undefined	NFPA FP: undefined
FRZ: -11 ^o	VP: (30 ^o): 5 mmHg	UEL: undefined	NFPA HP: undefined
FP: undefined	VD: undefined		NFPA Reactivity Rating: undefined
Sp. GR: 1.39	IP: 10.54 eV		NFPA Sp. Inst.: undefined

POISONING LIMIT		
OSHA	NIOSH	Related Information
Permissible maximum level (8 working hours or week average) (PEL-TWA) ppm: : 1	Permissible maximum level (8 working hours or week average) (PEL-TWA) ppm: 1	AIHA Emergency response guideline - ERPG-1/ERPG-2/ERPG-3: 10 ppm/50 ppm/100 ppm
Permissible maximum level (8 working hours or week average) PEL-TWAPEL-TWA mg/m ³ : 1,4	Permissible maximum level (8 working hours or week average) REL-TWA mg/m ³ : 1,4	
Permissible maximum level (average of 15 minutes) (PEL-STEL) ppm: undefined	Permissible maximum level (average of 15 minutes) (PEL-STEL) ppm: undefined	
Permissible maximum level (average of 15 minutes) (PEL-STEL) mg/m ³ : undefined	Permissible maximum level (average of 15 minutes) (PEL-STEL) mg/m ³ : undefined	
Permissible maximum level (any time) (PEL-C) ppm: undefined	Permissible maximum level (any time) (PEL-C) ppm: undefined	
Permissible maximum level (any time) (PEL-C) mg/m ³ : undefined	Permissible maximum level (any time) (PEL-C) mg/m ³ : undefined	

Skin Notation: No	IDLH ppm: 75	
Notes: undefined	IDLH mg/m ³ : undefined	
	IDLH Notes: undefined	

NIOSH Pocket Guide to Chemical Hazards (valid until 2006)			
Hydrogen peroxide		CAS: 7722-84-1	
Formula: H_2O_2		RTECS: MX0900000	
Synonyms & Trade Names High-strength hydrogen peroxide, Hydrogen dioxide, Hydrogen peroxide (aqueous), Hydroperoxide, Peroxide		DOT ID & guide: DOT ID & Guide: 2984 140 (8-20% solution) 2014 140 (20-60% solution) 2015 143 (>60% solution)	
POISONING LIMIT			
Permissible maximum level (NIOSH REL): 8 working hours or week average: 1ppm (1,4 mg/m ³)		Permissible maximum level (OSHA REL): 8 working hours or week average: 1ppm (1,4 mg/m ³)	
IDLH: 75 ppm		Conversion: 1 ppm = 1,39 mg/m ³	
Physical Description: Colorless liquid with a slightly sharp odor. [Note: The pure compound is a crystalline solid below 12°F. Often used in an aqueous solution.]			
MW : 34,0	BP : 286F	FRZ: 12F	Diss : evenly dissolves in liquid
VP: 5 mmHg	IP : 10,54 eV	RGasD: undefined	Sp.Gr: 1,39
Fl.P: undefined	UEL : undefined	LEL: undefined	MEC: undefined
Noncombustible Liquid, but a powerful oxidizer. (See flammable and combustible liquid classes)			
Materials to store separately			
Oxidizable materials, iron, copper, brass, bronze, chromium, zinc, lead, silver, manganese. [Note: Contact with combustible material may result in SPONTANEOUS combustion.]			
Measurement method			
OSHA ID126SG			
Personal Protection/Sanitation		First aid	
Skin: Wear appropriate personal protective clothing to prevent skin contact. Eye: Wear appropriate eye protection to prevent eye contact. Wash skin: The worker should immediately wash the skin when it becomes contaminated.		Eye: If this chemical contacts the eyes, immediately wash (irrigate) the eyes with large amounts of water, occasionally lifting the lower and upper lids. Get medical attention immediately.	
Remove: Work clothing that becomes wet should be removed immediately		Skin: If this chemical contacts	

<p>Change: No recommendation is made specifying the need for the worker to change clothing after the work shift.</p> <p>Provide: Facilities for quickly drenching the body should be provided within the immediate work area for emergency use where there is a possibility of exposure. [Note: It is intended that these facilities provide a sufficient quantity or flow of water to quickly remove the substance from anybody areas likely to be exposed. The actual determination of what constitutes an adequate quick drench facility depends on the specific circumstances. In certain instances, a deluge shower should be readily available, whereas in others, the availability of water from a sink or hose could be considered adequate.]</p>	<p>the skin, immediately flush the contaminated skin with water. If this chemical penetrates the clothing, immediately remove the clothing and flush the skin with water. Get medical attention promptly.</p> <p>Breathing: If a person breathes large amounts of this chemical, move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible.</p> <p>Swallow: f this chemical has been swallowed, get medical attention immediately.</p>
<p>NIOSH Respirator recommendations</p>	
<p>NIOSH/OSHA 10 ppm: SA* 25 ppm: SA:CF* 50 ppm: SCBAF/SAF 75 ppm: SAF:PD,PP : SCBAF:PD,PP/SAF:PD,PP:ASCBA Escape: GMFS/SCBAE</p>	
<p>Exposure Routes</p>	
<p>Inhale, breath, swallow, contact with eye and skin</p>	
<p>Symptoms</p>	
<p>irritation eyes, nose, throat; corneal ulcer; erythema (skin redness), vesiculation skin; bleaching hair</p>	
<p>Target Organs</p>	
<p>Eyes, skin, respiratory system</p>	

<p>Emergency response guideline</p>
<p>Guide number: 140 140 Oxidizers POTENTIAL HAZARD FIRE OR EXPLOSION</p> <ul style="list-style-type: none"> • These substances will accelerate burning when involved in a fire. • Some may decompose explosively when heated or involved in a fire. • May explode from heat or contamination. • Some will react explosively with hydrocarbons (fuels). • May ignite combustibles (wood, paper, oil, clothing, etc.). • Containers may explode when heated. • Runoff may create fire or explosion hazard. <p>HEALTH</p> <ul style="list-style-type: none"> • Inhalation, ingestion or contact (skin, eyes) with vapors or substance may cause severe injury, burns or death. • Fire may produce irritating, corrosive and/or toxic gases. • Runoff from fire control or dilution water may cause pollution <p>PUBLIC SAFETY</p>

- CALL Emergency Response Telephone Number on Shipping Paper first. If Shipping Paper not available or no answer, refer to appropriate telephone number listed on the inside back cover.

- As an immediate precautionary measure, isolate spill or leak area in all directions for at least 10-25 meters
- Keep unauthorized personnel away.
- Stay upwind.
- Keep out of low areas.
- Ventilate closed spaces before entering.

PROTECTIVE CLOTHING

- Wear positive pressure self-contained breathing apparatus (SCBA).
- Structural firefighters' protective clothing will only provide limited protection.

EVACUATION

Large Spill

- Consider initial downwind evacuation for at least 100 meters (330 feet).

Fire

- If tank, rail car or tank truck is involved in a fire, ISOLATE for 800 meters (1/2 mile) in all directions; also, consider initial evacuation for 800 meters (1/2 mile) in all directions.

FIRE

Small Fires

- Use water. Do not use dry chemicals or foams. CO₂ or Halon® may provide limited control.

Large Fires

- Flood fire area with water from a distance.
- Move containers from fire area if you can do it without risk.
- Do not move cargo or vehicle if cargo has been exposed to heat.
- Fight fire from maximum distance or use unmanned hose holders or monitor nozzles.
- Cool containers with flooding quantities of water until well after fire is out.
- ALWAYS stay away from tanks engulfed in fire.
- For massive fire, use unmanned hose holders or monitor nozzles; if this is impossible, withdraw from area and let fire burn.

SPILL OR LEAK

- Keep combustibles (wood, paper, oil, etc.) away from spilled material.
- Do not touch damaged containers or spilled material unless wearing appropriate protective clothing.
- Stop leak if you can do it without risk.
- Do not get water inside containers.

Small Dry Spills

- With clean shovel place material into clean, dry container and cover loosely; move containers from spill area.

Small Liquid Spills

- Use a non-combustible material like vermiculite or sand to soak up the product and place into a container for later disposal.

Large Spills

- Dike far ahead of liquid spill for later disposal.
- Following product recovery, flush area with water.

FIRST AID

- Move victim to fresh air.
- Call emergency medical service.
- Give artificial respiration if victim is not breathing.
- Administer oxygen if breathing is difficult.
- Remove and isolate contaminated clothing and shoes.
- In case of contact with substance, immediately flush skin or eyes with running water for at

least 20 minutes.

- Keep victim warm and quiet.
- Ensure that medical personnel are aware of the material(s) involved and take precautions to protect themselves.

Emergency response (CAMEO Data)

Non fire spill: Keep material out of water sources and sewers. Build dikes to contain flow as necessary. Land spill: Dig a pit, pond, lagoon, holding area to contain liquid or solid material. Dike surface flow using soil, sand bags, foamed polyurethane, or foamed concrete. Dilute slowly with water. Absorb bulk liquid with fly ash or cement powder. (AAR, 1999)

Firefighting: Use water in flooding quantities as fog. Cool all affected containers with flooding quantities of water. Apply water from as far a distance as possible. (AAR, 1999)

CHEMICAL PROFILE: The hazards associated with the use of hydrogen peroxide(especially highly concentrated solutions) are well documented. There is a release of enough energy during the catalytic decomposition of 65% peroxide to evaporate all water and ignite nearby combustible materials. Most cellulose materials contain enough catalyst to cause spontaneous ignition with 90% peroxide. Contamination of concentrated peroxide causes the possibility of explosion. Readily oxidizable materials, or alkaline substances containing heavy metals may react violently. Solvents(acetone, ethanol, glycerol) will detonate on mixture with peroxide of over 30% concentration, the violence increasing with concentration. Concentrated peroxide may decompose violently in contact with iron, copper, chromium, and most other metals or their salts, and dust(which frequently contain rust).During concentration under vacuum of aqueous or of aqueous-alcoholic solutions of hydrogen peroxide, violent explosions occurred when the concentration was sufficiently high(>90%), Bretherick 2nd ed., 1979.Mixtures of alcohols with concentrated sulfuric acid and strong hydrogen peroxide can cause explosions. Example: An explosion will occur if dimethylbenzylcarbinol is added to 90% hydrogen peroxide then acidified with concentrated sulfuric acid. Mixtures of ethyl alcohol with concentrated hydrogen peroxide form powerful explosives. Mixtures of hydrogen peroxide and 1-phenyl-2-methyl propyl alcohol tend to explode if acidified with 70% sulfuric acid, Chem. Eng. News 45(43):73(1967); J, Org. Chem. 28:1893(1963). Hydrogen selenide and hydrogen peroxide undergo a very rapid decomposition, Mellor 1:941(1946-1947). (REACTIVITY, 1999)

First Aid: Move victim to fresh air. Call emergency medical care. Apply artificial respiration if victim is not breathing. Administer oxygen if breathing is difficult. Remove and isolate contaminated clothing and shoes. In case of contact with substance, immediately flush skin or eyes with running water for at least 20 minutes. Keep victim warm and quiet. Ensure that medical personnel are aware of the material(s) involved, and take precautions to protect themselves.

6.5. ACTIONS TO PREVENT AND MITIGATE POTENTIAL RISKS

6.5.3. Actions to prevent and mitigate from natural phenomena

The following actions should be taken to prevent from potential natural phenomena and accidents. Herein:

Actions to prevent from fire hazards

- Strictly follow fire safety procedure, provide with firefighting tools and equipment and provide firefighting trainings and exercises to employees,
- All employees should be provided with fire prevention instructions, prepare and follow chart plan in case of potential fire,
- Ensure permanent preparedness of fire extinguishers and allocate in proper places,
- Place fire warning signs, memos and signs at required places,
- Assign patrolling in potential fire seasons of spring and fall,
- Clean flood channels on regular basis

Self-protective actions during earthquake

Before earthquake:

- Discuss what things will broke at the workplace and camp if earthquake occurs
- To have emergency response plan,
- Pre-define most safe areas of the room and office,
- Exercise drop, cover and hold on procedure,
- Be aware of emergency exits of buildings and facilities,
- Be able to provide first aid,
- Be aware how to turn off water and electricity,
- Properly install and fix heavy furniture in the room and office,
- Separately store toxic and hazardous chemicals in designated area,
- Ensure preparedness of flashlight (with extra batteries), small radio on batteries and first aid kit and etc.,
- To know phone number list of essential organizations,
- Learn to use fire extinguisher.

What to do during earthquake?

If in the building:

- Stay calm,
- Find safe shelter (internal wall, corner, bearing column and etc.),
- When earthquake starts, drop down and cover yourself and wait,
- Duck under steady table,
- Stay away of windows,
- Do not stand under clock and ceiling lights,
- Opening the door and standing under prevents from falling objects.

If outside:

- Stay away of buildings and facilities, trees, illumination poles and power lines,
- If you are in the vehicle, stay in the vehicle until the vibration ends,

- If you are in moving vehicle, stop out of the way, move away from bridge and tunnels and find an open place,
- Do not light candle or start open fire near explosive materials.

Actions to prevent from flood

- Regularly receive and pass to others warnings, information and signals on flood prevention from newspapers and other sources of media
- Learn traditional ways to predict and prevent earthquake by observing sky, clouds, wind direction, livestock manner and etc.,
- Avoid building offices at flood way, river course, channels and ravines, dry riverbeds and floodplain and etc.,
- Build flood protection dams, channels and fences and regularly check for deficiencies,
- Warn employees about flood.

What to do during flood

- Save and protect health, life and property by traditional methods of flood prevention,
- Unplug electric devices,
- Inform relevant organizations (health care, emergency agency, local administration and etc.) and others.

What to do after flood

- Move from damaged area to safe place,
- Visit hospital if necessary,
- Flood water carries disease viruses, therefore immediately start cleaning, get assistance from specialized organization,
- Do not enter if flood water is still around the building,
- Be aware that flood water damages building fundament and building is in danger of collapse,
- Enter facility after relevant specialized organizations authorizes after examining for potential gas leakage, damages of power, heat and water lines.
- Regularly wash hands with soap.

6.5.4. Actions to prevent from risks of industrial accidents

Prevent from potential fire

Below actions should be taken to prevent from potential fire hazards. Herein:

- Take safety measures according to Law on Fire safety of Mongolia, Fire safety regulation for business entities and other fire associated decrees and resolutions by conducting fire safety trainings, instructions, monitoring works, supply of firefighting equipment, firefighting training and safety procedure to work on electric equipment and machinery,
- Senior employee of each unit should check fire extinguishing equipment on daily basis and take measures to eliminate deficiencies occurred,

- Define specific regulation for workplaces and assign smoking places, develop and strictly follow rules to work with fire, gas and electric equipment and restrict to put open fires and have scheduled patrolling,
- Build protective strip within the mine territory, at flammable and lubrication material storage and explosives magazine and prevent from human and animal entrance,
- Ensure initial firefighting and permanent equipment preparedness and take measures to immediately repair and replace deficiencies ,
- Fire extinguishing devices and materials indicated in “fire prevention procedure” should be placed at potential fire hazard areas within the mine and at excavators and dumps.

Prevent employees from different diseases, occupational illness and temporary and irreversible disability

- Stay away from and do not touch carcasses of high risk animals (birds and etc.) and immediately notify relevant specialized organization,
- Strictly follow and regularly monitor the implementation of food supply standards,
- Strictly follow and regularly monitor implementation of occupational safety regulations and procedures at workplaces with high risk to health and life, provide personal protective equipment to all employees,
- Enforce employees to follow work and rest regimen,
- Take essential technical and organizational actions to prevent from accidents and ensure occupational safety by studying and concluding mine operation hazards and accidents,
- Introduce approved occupational safety rules, regulations and procedures to all employees and particularly pay attention on implementation of these procedures during the operation,
- Assess, prepare conclusion and find the reason of occurred accidents, illness of employees and incidents.

Prevent from accidents at CIL plant

Regular and qualified maintenance of equipment should be conducted to prevent from accident. As well as plant processing should be monitored, improve technological control, strictly follow safety and technological instructions, define in detail actions to be taken in case of emergency and provide relevant training to employees.

Prevent from vehicle accidents

Below actions should be taken to prevent from any vehicle accidents. Herein:

- Install appropriate traffic signs and notices that meets related standards at required areas,
- Provide drivers and operators with refresh training,
- Take measures to mitigate dust and if required, temporarily stop operations,
- Use light reflector and flags on workers uniforms and vehicles,
- Improve illumination at work places,
- Limit vehicle speed at work areas.

Any accident occurred at work place and on roads should be immediately reported to mine manager. All accidents are investigated and preventive measures are taken to avoid same accident in future.

6.5.5. Actions to prevent and mitigate risks of use of chemicals

Actions to prevent from spill and loss of chemicals

Actions included in feasibility study:

- NaCN should be imported in accordance with laws and regulations of Mongolia and stored and used at Boroo gold mine in accordance to safety procedures. Sodium cyanide should be used based on complete providence of safety for man, nature and the environment.
- Solution of NaCN should be prepared at ore leaching area infer strict control and employees should be provided with protective equipment. Ventilation should be used to remove evaporation in indoors.
- Cyanide sensor signal should automatically give sound signal in case the content of cyanide in processing facility exceeds permissible maximum level.
- Safety shower should be placed in particular areas to use in case of emergency.
- Metal container, hose and lines for preparation of solution is sealed and the project is developed to avoid any leakage, spill and loss of chemical solution.
- Boroo Gold LLC procedures should be followed for transportation and storage of cyanide and other chemicals. 20 ton sealed containers should be used for transportation and storage.
- Transportation safety should be provided in cooperation with local police department.
- pH of the pregnant solution should stay high to prevent from evaporation. For that reason:
- Lime should be mixed to ore before stalking (with content of 0.75 kg/t). Static experiment shows that low-grade ore, has waste rock and soil of Boroo have a capacity to neutralize.
- of the solution and content of cyanide in air should be regularly measured by automatic device.
- Solution should be saturated into the ore by drip emitters placed in 2.0-2.5m depth during the winter. Droppers will be used for solutions in side surface of the heap.
- BGC employees and contractors should follow overall safety standards.
- "Blame free" policy should continuously on-go in order to provide safe, unpolluted workplace and operate with no accidents.
- Potential hazard of each heap leach workplace should be defined, employees will be provided with personal, special and public protective devices and constant monitoring will be conducted for use, storage and protection.
- Employees handling chemicals and preparing solution should familiarize with and follow safety procedures and standards, check preparedness every day and provide with protective equipment.
- Emergency response team with total of 22 members is ready for immediate response action to chemical spills and other hazardous conditions and accidents. The team is fully equipped with necessary tools and equipment, and provided with all necessary items for classroom and outdoor practices.

Actions to use and handle toxic chemicals

Project implementer should particularly pay attention to the following issues to mitigate potential impacts on human besides environmental protection:

1. Include new employees at heap leach in medical examination to get conclusion whether the person meets physical requirements of the job description,
2. Follow Law on Toxic and hazardous chemical of Mongolia in plant operation,
3. In accordance to decree A/201 issued by Minister of Health and social welfare in 1999, include employees handling and using chemicals in medical examination once in 12 months,
4. Children and pregnant women are prohibited to work in toxic and hard working condition,
5. "Regulation on organization of occupational health and safety works at business entities" should be followed in accordance to laws and regulations of Mongolia,
6. Organize chemical safety trainings and practical exercises,
7. Employees should be provided with hazard information on sodium cyanide, hydrogen cyanide and other chemicals; take protective and monitoring actions,
8. High level and step-by-step training should be provided to newly hired employees. Refresh trainings should be provided to refresh and update primary knowledge and refresh instructions are given in case of technological amendments in equipment, machinery and tools of mill and mine departments and establishment of new standards and procedure.

Each workplace with hazardous condition, i.e. handling toxic chemicals should have emergency response plan that should include the following actions:

1. Develop evacuation outline in case of emergency,
2. Call environmental, hospital and fire officers if required,
3. Include role of enterprise, services and business entities in case of different hazardous condition
4. Include role of specifically trained employees,
5. Include location and exploitation procedure of emergency equipment in training curricula
6. Introduce and provide training on first aid to all employees
7. Following information should be included in first aid training:
 - Property, amount and toxic reference of substances used at the workplace,
 - Name and phone number of specialized doctor to provide first aid,
 - Location of nearest hospital (define the distance),
 - List of vehicles to go to the hospital,
 - Contact number and office room number,
 - Basic first aid techniques.

Transportation of chemicals³²

³² Safety procedures for transportation, storage, use and disposal of sodium cyanide, Boroo Gold LLC, page 4

Transportation across the border and further transportation, storage and use of chemicals for heap leach facility of Boroo Gold LLC should follow relevant laws and regulations of Mongolia. Transportation of toxic chemicals and sodium cyanide should meet the following requirements:

1. Traffic safety for transportation of sodium cyanide between Boroo mine site and mechanic wood log loading and unloading platform of UB railroad station should be provided in cooperation with Traffic police.
2. Transportation of toxic and hazardous chemical should strictly follow instructions indicated in hazard reference,
3. Toxic and hazardous chemicals should be transported in a specifically designed vehicle (reagent transportation vehicle), that has warning and prevention signs that meets safety requirements and only by pre-established route,
4. Route for transportation of toxic and hazardous chemicals should be selected on a road with minimum traffic; inform on time and location and get permission from Selenge aimag emergency agency and traffic police in advance to ensure safety of transportation,
5. Executor of transportation, loading, unloading and disposal of toxic and hazardous material should be responsible for safety of transportation, loading and unloading process,
6. From total of 130 km between UB and Boroo mine site 120 km is paved and 10 is unpaved road. In order to prevent from fall, damage of packages and mix of chemicals during transportation, chemicals should be properly positioned as well as liquid substance should be positioned vertically with opening looking upward,
7. Toxic and hazardous chemicals classified as "A" should be loaded and unloaded only during the daylight and strictly follow instructions of hazard reference,
8. Speed of the vehicle transporting toxic and hazardous chemicals should not exceed 30km/hr. and distances between two vehicles should be at least 50m,
9. Transportation should be canceled in case packages of toxic and hazardous chemicals is damaged, vehicle in defective condition and/or documents for chemicals are violated and has no warning and precautionary signs,
10. Specialized employee should introduce hazard reference of each chemical, provide safety instructions, emergency response plan and transportation route and get signature of the driver and conveyers assigned to transport, load and unload toxic and hazardous chemicals,
11. Driver should put "**Entrance prohibited**" sign in 100m in front and back of the truck in case of emergency stop caused by damage of package seal and/or collapse of load.
12. Each truck should be equipped with tools and equipment to eliminate hazard (fire extinguisher, shovel, wrecking bar, axe and etc.) and neutralizer substance and solutions in case of emergency. Exhaust pipe should be located on radiator side of the truck,
13. Trucks loaded with toxic and hazardous chemicals are prohibited to stop and/or park in urbanized area for long period of time.
14. Include other requirement for transportation of toxic and hazardous material in technical condition and standard for transportation of hazardous materials,
15. Transporting person should strictly follow the instructions of the procedure and ensure safety of chemicals transportation,

16. It is prohibited to transport toxic and hazardous chemicals with human, animals and/or other products,
17. Following requirement should be met during the transportation of toxic and hazardous chemicals in convoy:
- Employee assigned to ensure transportation safety (chief of the convoy) will organize the convoy and lead the activities related to transportation of toxic and hazardous chemicals in accordance with approved route and traffic regulation;
 - Chief of the convoy should travel in the first vehicle of the convoy and estimate appropriate speed and distance between the vehicle considering the transported item, weather condition and condition of vehicles in the convoy.;
 - First and last vehicles in convoy should have a clear sign “**convoy**” and each vehicle in convey should have its number in line both in front and back of the vehicle that could be easily seen;
 - During the transportation of toxic and hazardous chemicals, first vehicle in convoy should be a security vehicle and last is a reserve vehicle and during the daytime front low-beam lights should be turned on.
18. Transportation of flammable liquid and compressed gas should fulfill below mentioned requirements. Herein:
- Large amount of flammable liquids and compressed gas should be transported in mechanically refilling specially designed fuel refilling cistern. Cistern could use trailer and semi-trailer and should have “**Flammable**” sign on both sides of the tank in legible bright color;
 - Small amount of flammable liquid should be transported in metal barrel and compressed gas in gas cylinder;
 - Within the city, liquefied flammable gas should be transported by roads and during the time with less traffic. In this situation, provide local government, emergency unit and traffic police with information of last and next month transportation report and obtain permission for transportation;
 - When received for transportation, gas cylinders with compressed gas or empty gas cylinders should be certified with authorized organization and painted into blue, name of the substance written by black oil paint and manufacturer name, manufactured date, cylinder number, pressure and next inspection date should be indicated on shoulder of the cylinder;
 - 2-3 wooden boards with slots with rubber absorbers should be placed along the truck body and place the gas cylinder seals looking upward and to one direction. Line in-between should be sealed with wooden bar with rubber absorbers on both sides. Cylinders should be as secure as possible;
 - Gas cylinders should be positioned looking upward, seals looking to one direction and separators should be placed between the cylinders. Horizontal wood plank with groove or

rope with at least 25mm diameter or rubber ring (2 rings for one cylinder) should be used as a separator to secure cylinders from knocking to each other;

- Gas cylinders should be secured from overheating. It is prohibited to load fuel barrel, lubricant materials and oily towels with gas cylinders;
- Due to remain of pressure, transportation of empty cylinders should follow the same instructions as cylinders with compressed gas.

Special glass container should be used for transportation of corrosive chemicals such as acid and alkali. Glass container should be secured in wooden box or woven basket. Neck (seal) of the glass container should be upward in standing position and security fixed for transportation.

Storage of chemicals

Storage of toxic and hazardous chemicals to use for heap leach project should meet the following requirements. Herein:

1. Toxic and hazardous chemicals should be received for storage with accompanying documents and hazard reference of each chemical substance from transported personnel and strictly following requirements indicated in hazard reference.
2. Package and seal of each transported chemical substance should be checked as indicated in hazard reference and measures should be taken according to chemical safety instructions in case of any damages and irregularities.
3. Warehouse should keep constant records of classification, name and amount of toxic and hazardous chemicals.
4. Depending on chemical and toxic properties, toxic and hazardous chemicals should be stored in isolation in accordance to the guideline.
5. Based on toxic and hazardous property of stored chemicals, legible warning signs and precautionary notices should be placed in a visible place inside and outside of the warehouse (For instance: warning signs such as flammable and toxic and precautionary notices such as "**Flammable solution**", "**Toxic**" and "**Corrosive**").
6. Door width or at least 1m wide pass-through tunnel should be built across the door.
7. Illumination and distance between different chemicals should be at least 0.5m.
8. It is prohibited to store chemicals above human eye level and shelves should have protective barrier to avoid slippage of chemical.
9. In case of storage of chemicals in the ground, walkway should be open and should not barricade the exit.
10. Liquid chemical should be stored in strong and unbreakable containers and temperature of the storage should meet the requirements to store the chemical.
11. All chemicals, especially flammable liquids should be stored away from heating system and with no direct sunlight.
12. It is prohibited to store chemicals with leaked or broken seal and/or package.
13. It is prohibited to star open fire and/or light matches in chemical storage.
14. It is prohibited to store or eat food products at chemical storage.

15. Flammable gas cylinders, flammable solutions and aerosols should be stored away from direct sunlight and heat sources.
16. Rubber materials should not be stored with other substances.
17. It is prohibited to park or repair vehicle and loading and unloading equipment at warehouse entrance and its area.

Warehouse of toxic and hazardous chemicals³³

Warehouse for storage of toxic and hazardous chemicals should meet the following requirements:

- Collecting container, dry and chemical fire extinguisher, neutralizer, tools to remove and other necessary devices should be placed at easily accessible places for emergency cases, spills and leakage of chemicals.,
- Any chemical stored in the warehouse should have easy access from every side for transportation and use and in case of fire, distance between the chemicals should be available to put out the fire not reaching the neighboring stored chemical,
- Warehouse should be built from material that can provide fire resistance, with floor designed to avoid loss of chemical into soil and outside (cement or tiles), strong windows and doors and have flood channels and dams,
- Chemical warehouse may consist of several sections in safe distance not to spread fire in case of fire hazard
- Small amount of toxic and hazardous chemicals (less than 50 kg) for scientific, laboratory and industrial purposes can be stored in specifically prepared area of the person to use. The room should have ventilation system and connected to water and sewage lines,
- Chemical storage should be provided with conditions to wash hands, take shower and change clothes,
- Chemical storage should be closed and locked to avoid entrance of people and particularly toxic and hazardous chemicals should be sealed by personal mark of person in charge.

Actions to undertake during chemical spill

Manufacturer and trade companies deliver action guide in case of chemical spill together with chemicals. This document is of great importance especially during transboundary transportation.

These guidelines have instructions such as to stop work, prevent run-off into waterway, sewage and enclosed areas, actions to stop leak, small spill collect in plastic container considering most of the recommendations mentioned in this section are translation of manufactures data sheet that comes along with chemicals. There are some recommendations that are issued in consideration of the chemical properties of the material.

. *Sodium Cyanide Spill:*

³³ Pre-assessment of risks, chemical warehouse, Boroo Gold LLC

Nonflammable. May evolve highly flammable and toxic hydrogen cyanide gas in reaction with air.

May react with oxidizers, acids, water and water pollutants. Therefore, should be stored separately with such materials. Nonflammable but when heated, may release corrosive and toxic gases.

If a spill of sodium cyanide occurs onto land:

- Avoid danger to yourself and others.
- Stop working.
- Evacuate the immediate area.
- Immediately alert others in the area of the danger.
- Eliminate all ignition sources (no smoking, flares, sparks or flames in immediate area).
- Stop leak if you can do it without risk.
- Use vapor eliminating extinguisher.
- Water spray should be used to decrease vapor or vapor fog.
- Prevent used water run-off to mix with spilled material.
- Prevent run-off into waterways or sewers or enclosed areas.
- Small spills: cover with dry earth and sand or non-flammable material or plastic material to prevent from further loss and from rain.
- Shovel and sweep spilled material with clean tools made of non-ignition material into a plastic container with cap.
- Prevent run-off or solid substance from further loss by building dykes around the spill.
- Solid substance should be cover to prevent from rain and water used to put out fire.
- Stay upwind if not wearing appropriate Personal Protective Equipment.
- Sodium cyanide may release toxic gases in strong chemical reactions. Therefore, avoid contact with eye, skin and clothing. If contacted, flush with water at least for 15 minute.
- Assess spill quantity and characteristics.
- Notify Management who will initiate spill-reporting procedures as outlined in the ERP.
- Prevent further loss of material if it is practical and you have full protective clothing and a self-contained breathing apparatus.
- Prevent run-off into waterways or sewers by building dykes around the spill.
- In case of potential leak into waterway, notify management who will take measures as outlined in ERP.

If sodium cyanide entered waterway:

- Avoid danger to yourself and others.
- Stop working.
- Evacuate the immediate area and notify downstream users as outlined in the ERP.
- Immediately alert others in the area of the danger.
- Prevent further loss of material if it is practical and you have full protective clothing and a self-contained breathing apparatus.

- Contain spreading and entry into waterways if it can be done safely. Remove the source of contamination as soon as possible.
- Dredge or vacuum pump bottom sediments where cyanide has entered water. Remove the recovered material to the Mine Site for appropriate disposal.
- Add NaOH and (10g) to neutralize (pH=7) if lost onto waterway.

Personal Protective Equipment:

- Coveralls, rubber glove, apron, glasses
- Positive pressure apparatus

B. Sulfuric acid spill

Sulfuric acid is corrosive, reacts with water. Sulfuric acid is extremely harmful if swallowed or inhaled. It is very corrosive, and causes severe burns to the skin and eyes and fatal. Releases corrosive and toxic gases in reaction with water, in combination with water or heating may explode the storage container. In reaction with metal releases combustible hydraulic gases.

For spills onto land:

- Avoid danger to yourself and others.
- Stop working.
- Shut off power supplies and equipment to eliminate ignition sources.
- Alert others in the area of the danger.
- Prevent damage to equipment.
- Turn off equipments in the area of danger.
- Move equipments from the area of danger.
- Stop spill if you can do it without risk.
- Cover with dry earth and sand or non-flammable material or plastic material to prevent from further loss and from rain.
- Prevent run-off into waterways or sewers.
- Isolate spill area in all directions for at least 50-100 meters.
- Build hole or pond to collect spilled acid.
- Prevent run-off into waterways or sewers by building dykes around the spill. Cover dry substance when rains.
- For small spills, shovel the spilled materials into a drum or container. Remove the recovered materials for appropriate disposal. (Do not put in aluminum container)
- For large spills, use earthmoving equipment and trucks to collect the spilled material. Use trucks to haul the spilled materials for appropriate disposal.

Spill into water:

- Remove the source of contamination as soon as possible. Dredge or vacuum pump bottom sediments where sulfuric acid has entered water. Remove the recovered material for appropriate disposal.

Personal protective equipment

- Alkali resistant cloth, rubber boots, apron, rubber gloves, respiratory apparatus.

C. Hydrochloric acid spill

Hydrochloric acid is fuming and corrosive acid with pungent odor. Should not be stored with hydroxide amine, alkalis, copper, brass and zinc. Inflames skin, mucosa and eye.

For spills onto land

- Avoid danger to yourself and others.
- Stop working.
- Shut off power supplies and equipment to eliminate ignition sources.
- Alert others in the area of the danger.
- Prevent damage to equipment.
- Stop machine operations in the area.
- Move equipment away from spill area.
- Prevent further loss of material, if practical.
- Prevent run-off into waterways or sewers by building dykes around the spill.
- Isolate spill area in all directions for at least 50-100 meters.
- Build hole or pond to collect spilled acid.

D. Lime (Calcium Oxide) Spill

Calcium Oxide is a corrosive alkaline material. Causes severe skin irritation and is harmful if swallowed. It reacts strongly with water and gives off heat. Avoid contact with acids, fluorine, chlorine, and boron trifluoride.

For spills onto land:

- Avoid danger to yourself and others.
- Stop working.
- Alert others in the area of the danger
- Prevent damage to equipment.
- Stop machine operations in the area.
- Move equipment away from spill area.
- Prevent further loss of material, if practical.
- If spill occurred from barrel or container, measures such as putting upward the container, put the lead on or seal the hole should be taken to prevent further loss.
- Assess spill quantity and characteristics
- Notify Management who will initiate spill-reporting procedures as outlined in the ERP.
- Wear protective clothing to prevent inhalation, skin and eye contact. Avoid breathing the dust.
- Prevent run-off into waterways by building dykes around the spill.
- Cover any dry spilled material if it starts raining.
- For small spills, shovel the spilled materials into a plastic container/drum (do not use aluminum) and take it for appropriate disposal.

- For large spills, use earthmoving equipment and trucks to collect the spilled material. Use trucks to haul the spilled materials for appropriate disposal.

For spills into water:

- Remove the source of contamination as soon as possible. Use the pumps or a vacuum truck from the Mine Site to dredge bottom in area of spill.
- Remove collected material for appropriate disposal.

Personal protective equipment:

- Wear coveralls, boots, goggles, gloves, dust mask or self-contained breathing apparatus if spill is in a confined space.

. Sodium Carbonate Spill

Soda Ash may irritate skin and eyes, and is harmful if swallowed. It reacts with water and gives off heat. Avoid contact with acids, aluminum, phosphorus, and fluorine oxides. Sweep up dry spills and flush the area with lots of water.

- Avoid danger to yourself and others.
- Stop working.
- Shut off power supplies and equipment to eliminate ignition sources.
- Alert others in the area of the danger.
- Prevent damage to equipment.
- Stop machine operations in the area.
- Move equipment away from spill area.
- Prevent further loss of material, if practical.
- If spill occurred from barrel or container, put the lead on or seal the hole.
- Assess spill quantity and characteristics
- Prevent run-off into waterways or sewers by building dykes around the spill.
- Isolate spill area in all directions for at least 50-100 meters.
- Build hole or pond to collect spilled acid.
- Notify Management who will initiate spill-reporting procedures as outlined in the ERP.

For spills onto land:

Decomposes and does not accumulate in soil or water. In some cases, may irritate eyes and skin.

- Avoid danger to yourself and others.
- Stop working.
- Shut off power supplies and equipment to eliminate ignition sources.
- Alert others in the area of the danger.
- Ventilate the area to limit dust dispersion.
- Prevent damage to equipment.
- Stop machine operations in the area.

- Move equipment away from spill area.
- Prevent further loss of material, if practical.
- If spill occurred from barrel or container, put the lead on or seal the hole.
- Assess spill quantity and characteristics
- Notify Management who will initiate spill-reporting procedures as outlined in the ERP

For spills onto land:

- Prevent run-off into waterways by building dykes around the spill
- Cover any dry spilled material if it starts raining.
- For small spills, shovel the spilled materials into a plastic or steel drum. Remove the recovered materials appropriate disposal.
- For large spills, use earthmoving equipment and trucks to collect the spilled material. Use trucks to haul the spilled materials for appropriate disposal.

For spills into water:

- Remove the source of contamination as soon as possible. Dredge or vacuum pump contaminated sediments. Remove contaminated materials for appropriate disposal.

Personal Protective Equipment

- Wear coveralls, goggles, gloves, cartridge respirator suitable for dust or self-contained breathing apparatus if in contact with acids, aluminum, and phosphorus or fluorine oxides in a confined space

F. Activated Carbon Spill

Activated carbon dust may form explosive mixtures in air in a poorly ventilated area. On combustion, carbon monoxide (CO) and carbon dioxide (CO₂) will be generated.

For spills onto land:

- Avoid danger to yourself and others.
- Stop working.
- Shut off power supplies and equipment to eliminate ignition sources.
- Alert others in the area of the danger.
- Prevent damage to equipment.
- Stop machine operations in the area.
- Move equipment away from spill area.
- Assess spill quantity and characteristics
- Notify Management who will initiate spill-reporting procedures as outlined in the ERP
- Wear protective clothing to prevent inhalation, skin and eye contact. Avoid breathing the dust. Ensure that there are no sparks, smoking or flames in the area
- Prevent run-off into waterways by building dykes around the spill.
- For small spills, put the spilled materials into a drum and take it to the Mine Site for appropriate disposal.

- Cover any dry spilled material if it starts raining.
- For large spills, use earthmoving equipment and trucks to collect the spilled material.
- Use trucks to haul the spilled materials back for appropriate disposal

For spills into water:

- Remove the source of contamination as soon as possible. Use the pumps or a vacuum truck to dredge bottom in area of spill. Remove collected material for appropriate disposal.

Personal Protective Equipment

- All employees should wear coveralls, gloves, goggles and a respirator in order to protect eyes, skin and breathing.

G. Antiscalent spill

Irrigates eye, skin and respiratory system. Noncombustible. However, large amount of dust may produce explosive dust fog. Heating may release toxic gases (hydrocarbons, ammonia and nitric acid).

- Avoid danger to yourself and others.
- Stop working.
- Shut off power supplies and equipment to eliminate ignition sources.
- Alert others in the area of the danger.
- Ventilate the area to limit dust dispersion.
- Prevent damage to equipment.
- Stop machine operations in the area.
- Move equipment away from spill area.
- Prevent further loss of material, if practical.
- If spill occurred from barrel or container, put the lead on or seal the hole
- Assess spill quantity and characteristics
- Notify Management who will initiate spill-reporting procedures as outlined in the ERP
- Wear protective clothing to prevent inhalation, skin and eye contact. Avoid breathing the dust. Ensure that there are no sparks, smoking or flames in the area
- Prevent run-off into waterways by building dykes around the spill.
- For small spills, put the spilled materials into a drum and take it to the Mine Site for appropriate disposal.
- Cover any dry spilled material if it starts raining.
- For large spills, use earthmoving equipment and trucks to collect the spilled material. Use trucks to haul the spilled materials for appropriate disposal

For spills onto land:

- Prevent run-off into waterways by building dykes around the spill.
- Cover any dry spilled material if it starts raining.

- Absorb spilled liquid with inert material (i.e., sand). Remove collected material for appropriate disposal. Avoid dust generation.

Requirements for temporary storage point before disposal of toxic and hazardous chemicals and their packaging

Following are the Requirements for temporary storage point before disposal of toxic and hazardous chemicals and their packaging:

- Toxic and hazardous chemical has waste, expired chemicals and chemicals that not meet the requirements and their packaging should be stored in specific temporary disposal point.
- It is prohibited to use packaging and containers of toxic and hazardous chemical for household purposes.
- Temporary disposal point should be fenced to prevent from entrance of animals and human, protective zone, channel and dam should be built around and warning signs should be installed.

Table 6.29 General recommendation to mitigate risks

#	Technological facilities	Recommendations to mitigate risks
1	Fuel farm, transmission pipes	Build water protection channels
		Make with durable quality by flexible material
		Install a lightning pole
		Provide proper operation of equipment
		Prevent and protect from fire hazards
2	Solution pond	Improve security
		Thoroughly install the protection brace and lining
		Provide proper operation of pump hose
3	Chemical storage	Improve security
		Install a lightning pole
		Position stable sealed container
4	Leaching heap	Prevent and protect from fire hazards
		Improve security
		Constantly hold pH of solution in 10-10.5
		Facility to remove flood water
5	Processing plant	Build in area with no fractures
		Protect solution freezing in winter
		Thoroughly install the lining
		Install a lightning pole
6	Flood dam	Set stable
		Prevent and protect from fire hazards
		Improve security
7	Crusher	Thoroughly install the lining
		Provide proper operation of pump hose
7	Crusher	Install a lightning pole
		Construct flood water channel

		Set stable
		Prevent and protect from fire hazards
		Improve security

6.6. GENERAL CONCLUSION OF RISK ASSESSMENT

Auxiliary materials used in the Heap Leach operations to recover gold from the Boroo hard-rock deposit ore in Bayangol and Mandal soums of Selenge aimag, are listed in the 3.1 , 6.1E, 6.3B, 6.7B, 6.8 , 9.1 of the Annex #1 of “Classification of hazardous chemicals” approved with the Joint Decree #04/04 of the Minister of Nature, Environment and Tourism and Minister of Health, of Mongolia, dated January 5, 2009.

Table 6.30 Classification of toxic and hazardous chemicals

	Substance	Toxic and hazardous substance classification					
		3.1	6.1E	6.3B	6.7	6.8A	9.1B
1	Sodium cyanide	+	+	+	+	+	+
2	Burnt lime	+	+		+	+	+
3	Antiscalent	+		+	+	+	+
4	Alkali	+	+	+	+	+	+
5	HDPE Geomembrane						
6	Diesel fuel	+	+	+	+	+	+
7	HDPE Geomembrane						
8	Diesel fuel	+	+	+	+	+	+

Comment: 3.1B flammable liquid 6.1E extremely toxic, 6.3B corrosive, 6.7 cancer causing, 6.8A reproduction/growth impacting /, 9.1B harmful to water organisms

Risks to human health and environment compiled and concluded: When heavy metals in water and soil samples have been determined, the contents of heavy metals in soil samples are lower than hazardous content specified in soil pollutant substance standards.

The monitoring well tests showed risks of some pollutants, but there is no transmission way which eliminates the creation of the risk.

Accidents/Hazards compiled and concluded: Conclusion of the risks show 10% low risk, 50% moderate risk and 40% high risk. Accordingly, Boroo mine’s Heap Leach project falls into a category of very low probability of occurrence of moderate risks.

Moreover, BGC has in place internal occupational safety procedures, chemicals safety procedure, emergency response plan in case of spill of cyanide, procedure on transportation, storage, use and disposal of cyanide, emergency response plan, implements them and constantly monitors their implementation.

Therefore, it is concluded that it is possible to operate mitigating the risks if afore-mentioned Mongolian laws, regulations, guidelines, recommendations, internal procedures and plans developed in accordance with them are strictly adhered to.

RECOMMENDATIONS ON PROJECT IMPLEMENTATION AND DETAILED STUDY OF RISK OF INFILTRATION OF CYANIDE SOLUTION CONDUCTED FOR CHEMICAL RISK ASSESSMENT

There are 3 potential risks to human and the environment in case of infiltration of cyanide solution and spread into environment. Herein:

. Pollution of rivers and streams through infiltration into underground water or carried out by snow and rain waters.

Cyanide reacts with water. Aquatic fauna is affected by cyanide, especially fishes are largely affected. In 24 hours, for some fishes, their LC50 (density that kills 50% of animals) only 40 mkg/g is free cyanide. Maximum meaning of LC50 for aquatic invertebrates is 90 mkg/l in temperature of the environment. For aquatic plants the concentration is from 30 mkg/l to several mg/l. Although cyanide decomposes in water, it releases pollutants such as ammonia and nitrate. Cyanide impacts gas exchange and pressure regulating organs of fish.

B. Hydrolysis of cyanide in water forms hydrocyanic acid and vapor of the acid lands on ground polluting flora and fauna. Although birds are mainly poisoned, there are records of domestic and wildlife poisoning. Mammals (including bats), amphibians, reptiles (snake, lizard, turtle and etc.) and insects are very sensitive to cyanide.

C. CN⁻ (cyanide) ions formed from infiltration may form complexes with metals (such as Au, Co, Cr, Cu, Fe, Fe and etc.) in soil and rock. These complexes allow cyanide to be stored in soil and gradually decompose and release free cyanide, which further poisons human through plants.

Despite the way of poisoning, the impact is same to flora and fauna. Spreading of cyanide in body depends on the kind of the cyanide.

Way of poisoning and conditions (stomach pH, existence of other food) are considered. Poisoned by metabolism, cyanide doesn't stay in the body and very quickly withdraws.

Hazard of cyanide is its rapid poisoning quality.

Cyanide connects with metal ferments that transports oxygen in cell and as a result, cells experiences oxygen shortage (Ballentyne 1987, Richardson 1992). When first aid is not provided, amount of cyanide enough to poison is breathed, swallowed or contacted with skin may kill. Small amount eaten with food will be filtrated through liver and withdrawn from body.

Cyanide does not form neoplasm, therefore not fatal doses is fully withdraws from the body. However, constant exposure within permissible level or frequent poisoning causes irreversible damage to central nervous system and initiates Parkinson's disease.

There are many methods to neutralize cyanide. Methods vary depending on specifics of processing plant, climate and structure of soil and rock. Table 1 and 2 shows methods used in Australia. Detail information is given in article "Cyanide cleaning method" of M.M.Bots published in "Environmental management" magazine issued in May 2001.

Table 6.31 Technologies to neutralize cyanide through oxidation

Technology (types)	Brief content	Common reagents	Common products
A. Oxidation			
Alkali chlorination	Oxidate to CNO and then oxidate N ₂ and CO ₃ again with Cl ₂ or ClO when pH=11	Cl ₂ /ClO ⁻ , NaOH	CNO ⁻ , CO ₂ ²⁻ , N ₂
SO ₂ /Air (C)	Oxidate to CNO with SO ₂ /air and soluble Cu catalyst;	SO ₂ , air, Cu catalyst	CNO ⁻

	INCO process		
Hydrogen peroxide (C)	Oxidate to CNO with H ₂ O ₂ and Cu ²⁺ catalyst	H ₂ O ₂	CNO ⁻ , CO ₃ ²⁻ , NH ₄ ⁺
Caro's acid (C)	Oxidate to CNO with H ₂ SO ₅	H ₂ SO ₅	CO ₃ ²⁻ , NH ₄ ⁺ , NO ₃ ⁻ , SO ₄ ²⁻
Activated carbon (C&P)	Oxidate to CNO, then partially form CO ₃ ⁻ and NH ₄ ⁺ using activated carbon and Cu catalyst	Activated carbon, air/O ₂ , Cu catalyst	CNO ⁻ , CO ₃ ²⁻ , NH ₄ ⁺
Biological decompose (B)	Oxidate to CO ₃ , then to NH ₄ and then, using endemic microorganisms, to NO ₃	Na ₂ CO ₃ , H ₃ PO ₄	CO ₃ ²⁻ , NH ₄ ⁺ , NO ₃ ⁻ , SO ₄ ²⁻
UOP catalytic oxidation	Form CO ₂ , NO ₂ and NH ₄ , then with catalyst in temperature less than 130°C and pressure over 550kPa	catalyst	CO ₃ ²⁻ , N ₂ , NH ₄ ⁺
Ozonation (C)	Form Co ₃ and N ₂ , then oxidize with O ₃	O ₃	CO ₃ ²⁻ , N ₂
Moist air oxidation (C)	Oxidate to CO ₂ and N ₂ in temperature 175-320°C and pressure 2100-20700	N/A	CO ₂ , N ₂
Photocatalytic oxidation	Form CNO using ultraviolet /visible ray and base of semiconductor (TiO ₂ , ZnO, or CdS and etc.), then form NO ₃ and then oxidize to CO ₃	N/A	CO ₂ , N ₂

Table 6.32 Technologies to neutralize cyanide through non-oxidation

Technology (types)	Brief content	Common reagents	Common products
B. Non oxidizing elements			
AVR (C&P)	Acidizer – combustible element formation, re-neutralization. After acidizing until pH is less than 3, HCN (g) becomes unstable and saturates into NaOH. Metals will precipitate after another neutralization	H ₂ SO ₄ , NaOH	HCN, SCN ⁻ ?
CYANISORB (C&P)	Similar to AVR but HCN (g) separates in high pH (5.5-7.5)	H ₂ SO ₄ , NaOH	HCN, SCN ⁻ ?
CRP (C&P)	Restoration of cyanide: similar to AVR but better separation of cyanide and precipitation of metals	H ₂ SO ₄ , NaOH	HCN, SCN ⁻ ?
SART	Sulfidizing, acidizing, re-processing, concentrating	Na ₂ S, H ₂ SO ₄	Cu ₂ S
Heat hydrolysis (C)	In high temperature turns into NH ₄ and salt of formic acid and hydrolyzes	NaOH	NH ₄ ⁺ , HCOO
Alkali hydrolysis	In 100-250°C high pH hydrolyzes with NH ₄ and salt of formic acid	NaOH	NH ₄ ⁺ , HCOO
IX – GM (C&P)	Gas cover – ion exchanger: ion exchange concentrates cyanide. After another forming, gas cover releases pure cyanide	Gum	CN ⁻
IX – AVR (C&P)	Ion exchange concentrate. Cyanide CN releases after	Gum	CN ⁻

	formation of AVR		
Amount of precipitation of prussia blue	Precipitates when FeSO ₄ and (Fe(CN ₆)) ₃ is added	FeSO ₄	Fe ₄ (Fe(CN ₆)) ₃
Release of air from full compression (P)	Remove air from full compression	Air/gas	HCN
Osmosis	Physical removal of cyanide and its compounds using semi-filtration membrane under pressure	H ₂ SO ₄ ?	CN ⁻
Flotation (P)	Absorb CN crystals precipitated in small air bubbles	FeSO ₄	Fe ₄ (Fe(CN ₆)) ₃
High speed concentrator	Quick concentration through CIP and reuse	N/A	CN ⁻

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ANNEX

1. Terms, definitions and abbreviations

Environmental risk assessment: Integrated activity to define potential health risks of ecological compounds from contact with impact and/or potential impact distributed in the environment;

Human health risk assessment: Integrated activity to define risk to human health exposed or contacted with impacts and/or potential impact in the environment;

Risk: Impact caused by certain activity or process;

Substance of potential risk: chemical substance that is spread or may spread in nature in concentration enough to impact human health and ecological components;

Exposed to risk: man or ecological component exposed to hazardous impact;

Hazard: irregular work process of system caused by flood, earthquake, fire, weather factor and other natural factors;

Accident: damage of equipment, accident, irregular work process of system caused by improper actions of employee;

Key issue: mandatory issue that should be considered in risk assessment;

Risk image: to integrate and show cases of condition that will form in relation with risk,

Hazard coefficient: portion of predicted amount of risk impact divided to average of multiple year permissible level;

cumulative risk of cancer to average life expectancy: predicted cancer cases caused by potential impact of chemicals used in project operation;

Impact threshold dose of chemical: most of the chemicals have impact threshold dose. When overdosed this threshold, it begins to impact and larger the expose to the substance, larger the impacts. Most of the chemicals that do not cause cancer have such threshold dose.

Chemicals with no threshold dose: chemicals that cause cancer and/or genetic mutation usually do not have such threshold doses. Because one molecule of such element may cause genetic mutation and self-dividing gradually forms cancer condition. Therefore, theoretically, employees exposed to such elements at heap leach area are considered as impacted and poisoned.

Toxic reference value: toxic reference value (TRV) is a numeric meaning of toxicity to use in risk estimation. For chemical with threshold dose this value is called reference dose and measured in exposure to chemicals (mg) per day for each kg of the body. TRV of chemicals with no threshold dose is defined by cancer decline factor.

Risk management plan: strategy, decision and action aimed to eliminate, mitigate and keep risk parameters within the permissible level.;

Impact: negative or unwanted outcome felt by receiver due to certain activity;

Impact: sum of several impacts;

Unclear situation: inseparable part of risk and should be considered in calculation.

2. Chemical hazard markings

1. "R" marking:

R1 Explosive when dry.

R2 Risk of explosion by shock, friction, fire or other source of ignition.

R3 Extreme risk of explosion by shock, friction, fire or other sources of ignition.

R4 Forms very sensitive explosive metallic compounds.

R5 Heating may cause an explosion.

R6 Explosive with or without contact with air.

R7 May cause fire.

- R8 Contact with combustible material may cause fire.
- R9 Explosive when mixed with combustible material.
- R10 Flammable.
- R11 Highly flammable.
- R12 Extremely flammable.
- R13 Extremely flammable liquefied gas
- R14 Reacts violently with water.
- R15 Contact with water liberates extremely flammable gases.
- R16 Explosive when mixed with oxidizing substances.
- R17 Spontaneously flammable in air.
- R18 In use, may form inflammable/explosive vapor-air mixture.
- R19 May form explosive peroxides.
- R20 Harmful by inhalation.
- R21 Harmful in contact with skin.
- R22 Harmful if swallowed.
- R23 Toxic by inhalation.
- R24 Toxic in contact with skin.
- R25 Toxic if swallowed.
- R26 Very toxic by inhalation.
- R27 Very toxic in contact with skin.
- R28 Very toxic if swallowed.
- R29 Contact with water liberates toxic gas.
- R30 Can become highly flammable in use.
- R31 Contact with acids liberates toxic gas.
- R32 Contact with acid liberates very toxic gas.
- R33 Danger of cumulative effects.
- R34 Causes burns.
- R35 Causes severe burns.
- R36 Irritating to eyes.
- R37 Irritating to respiratory system.
- R38 Irritating to skin.
- R39 Danger of very serious irreversible effects.
- R40 Limited evidence of a carcinogenic effect.
- R41 Risk of serious damage to the eyes.
- R42 May cause sensitization by inhalation.
- R43 May cause sensitization by skin contact.
- R44 Risk of explosion if heated under confinement.
- R45 May cause cancer.
- R46 May cause heritable genetic damage.
- R47 May cause birth defects
- R48 Danger of serious damage to health by prolonged exposure.

2. "R" marking combinations:

- R 14/15 - Reacts violently with water, liberating extremely flammable gases.
- R 15/29 - Contact with water liberates toxic, extremely flammable gas.
- R 20/21 - Harmful by inhalation and in contact with skin.
- R 20/22 - Harmful by inhalation and if swallowed.

- R 21/22 - Harmful in contact with skin and if swallowed.
- R 20/21/22 - Harmful by inhalation, in contact with skin and if swallowed.
- R 23/24 - Toxic by inhalation and in contact with skin.
- R 24/25 - Toxic in contact with skin and if swallowed.
- R 23/25 - Toxic by inhalation and if swallowed.
- R 23/24/25 - Toxic by inhalation, in contact with skin and if swallowed.
- R 26/27 - Very toxic by inhalation and in contact with skin.
- R 26/28 - Very toxic by inhalation and if swallowed.
- R 26/27/28 - Very toxic by inhalation, in contact with skin and if swallowed.
- R 27/28 - Very toxic in contact with skin and if swallowed.
- R 36/37 - Irritating to eyes and respiratory system.
- R 36/38 - Irritating to eyes and skin.
- R 37/38 - Irritating to respiratory system and skin.
- R 36/387/38 - Irritating to eyes, respiratory system and skin.
- R 42/43 - May cause sensitization by inhalation and skin contact.

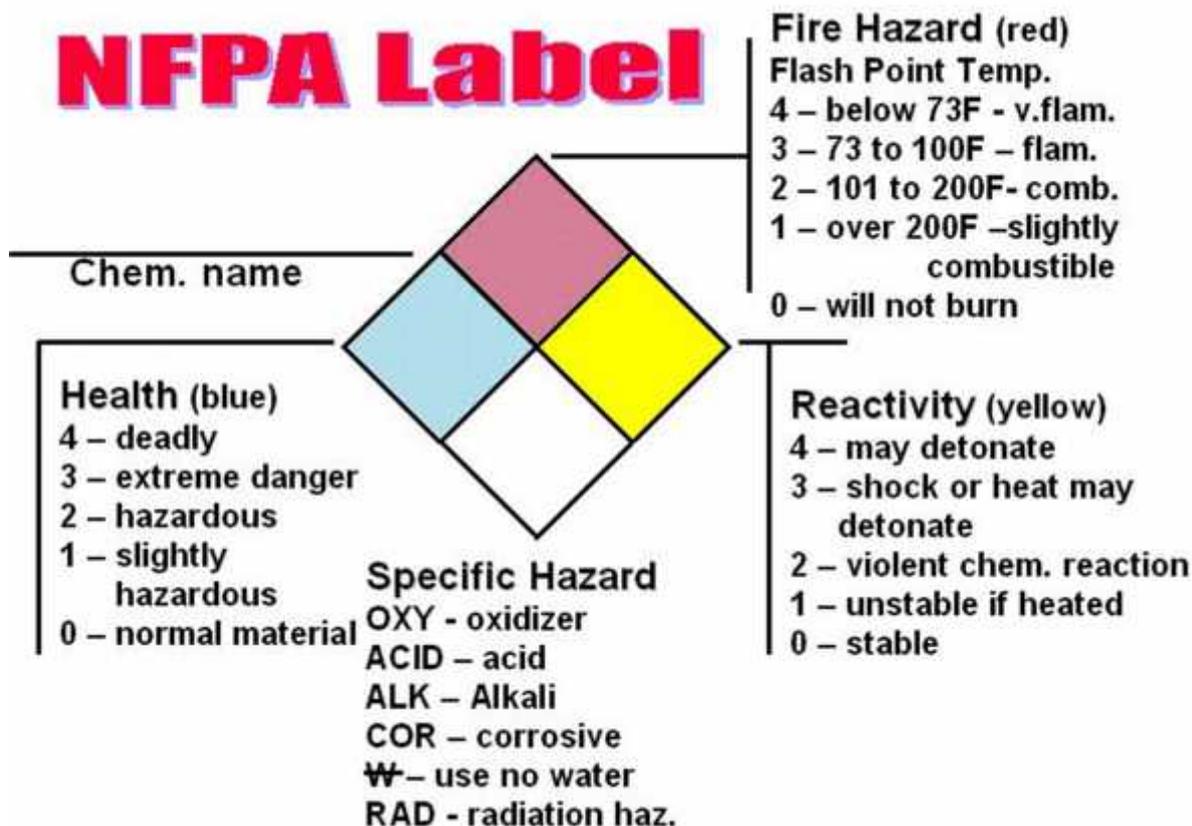
3. Chemical storage marking

1. "S" marking:

- S 1- Keep locked up
- S 2- Keep out of the reach of children
- S 3- Keep in a cool place
- S 4- Keep away from living quarters
- S 5- Keep contents under ... (appropriate liquid to be specified by the manufacturer)
- S 6- Keep under ... (inert gas to be specified by the manufacturer)
- S 7- Keep container tightly closed
- S 8- Keep container dry
- S 9- Keep container in a well-ventilated place
- S 10- Keep contents wet
- S 11- Avoid contact with air
- S 12- Do not keep the container sealed
- S 13- Keep away from food, drink and animal foodstuffs
- S 14- Keep away from ... (incompatible materials to be indicated by the manufacturer)
- S 15- Keep away from heat
- S 16- Keep away from sources of ignition - No smoking
- S 17- Keep away from combustible material
- S 18- Handle and open container with care
- S 19- Do not keep in sealed container
- S 20- When using do not eat or drink
- S 21- When using do not smoke
- S 22- Do not breathe dust
- S 23- Do not breathe gas/fumes/vapor/spray
- S 24- Avoid contact with skin
- S 25- Avoid contact with eyes
- S 26- In case of contact with eyes, rinse immediately with plenty of water and seek medical advice
- S 27- Take off immediately all contaminated clothing
- S 28- After contact with skin, wash immediately with plenty of ... (to be specified by the manufacturer)
- S 29- Do not empty into drains

- S 30- Never add water to this product
- S 31- Store separate from explosive materials
- S 33- Take precautionary measures against static discharges
- S 34- Avoid friction and electrical shock
- S 35- This material and its container must be disposed of in a safe way
- S 36- Wear suitable protective clothing
- S 37- Wear suitable gloves
- S 38- In case of insufficient ventilation wear suitable respiratory equipment
- S 39- Wear eye/face protection
- S 40- To clean the floor and all objects contaminated by this material use ... *(to be specified by the manufacturer)*
- S 41- In case of fire and/or explosion do not breathe fumes
- S 42- During fumigation/spraying wear suitable respiratory equipment *(appropriate wording to be specified by the manufacturer)*
- S 43- In case of fire use ... *(indicate in the space the precise type of fire-fighting equipment. If water increases the risk add - **Never use water**)*
- S 44- Get immediate medical advice when feel uncomfortable, show the material label.
- S 45- In case of accident or if you feel unwell seek medical advice immediately (show the label where possible)
- S 46- If swallowed, seek medical advice immediately and show this container or label
- S 47- Keep at temperature not exceeding ... °C (to be specified by the manufacturer)
- S 48- Keep wet with ... (appropriate material to be specified by the manufacturer)
- S 49- Keep only in the original container
- S 50- Do not mix with ... (to be specified by the manufacturer)
- S 51- Use only in well-ventilated areas
- S 52- Not recommended for interior use on large surface areas
- S 53- Avoid exposure - obtain special instructions before use
- 2.2. "S" marking combination:
- S 1/2- Keep locked up and out of the reach of children
- S 3/9- Keep container in a cool, well-ventilated place
- S 3/7/9- Keep container tightly closed in a cool, well-ventilated place
- S 3/14- Keep in a cool place away from ... (incompatible materials to be indicated by the manufacturer)
- S 3/9/14- Keep in a cool, well-ventilated place away from ... (incompatible materials to be indicated by the manufacturer)
- S 3/9/49- Keep only in the original container in a cool, well-ventilated place
- S 3/9/14/49- Keep only in the original container in a cool, well-ventilated place away from ... (incompatible materials to be indicated by the manufacturer)
- S 7/9- Keep container tightly closed and in a well-ventilated place
- S 7/8- Keep container tightly closed and dry
- S 20/21- When using do not eat, drink or smoke
- S 24/25- Avoid contact with skin and eyes
- S 36/37- Wear suitable protective clothing and gloves
- S 36/39- Wear suitable protective clothing and eye/face protection
- S 37/39- Wear suitable gloves and eye/face protection
- S 36/37/39- Wear suitable protective clothing, gloves and eye/face protection
- S 47/49- Keep only in the original container at temperature not exceeding ... °C (to be specified by the manufacturer)

4. NFPA704 chemical harm and hazard chart



5. Chemical storage “JT BAKER” color codes

Color on Chemical Substance label	Harm and type of hazard	Storage form
Blue	Hazardous to health.	Store separately in a secure area.
Red	Flammable.	Store separately only with other flammable chemicals.
Yellow	Reactive.	Store separate from combustible and flammable reagents.
White	Corrosive.	Store separate from combustible and flammable chemicals in warehouse made of corrosive-tolerant material.
Orange	Reagent presents no more than a moderate hazard in any category.	General chemical storage.
Green		
Above color labels with black stripes	Incompatible with other reagents of the same color code.	To be stored separately in proper warehouses

6. Photo images³⁴

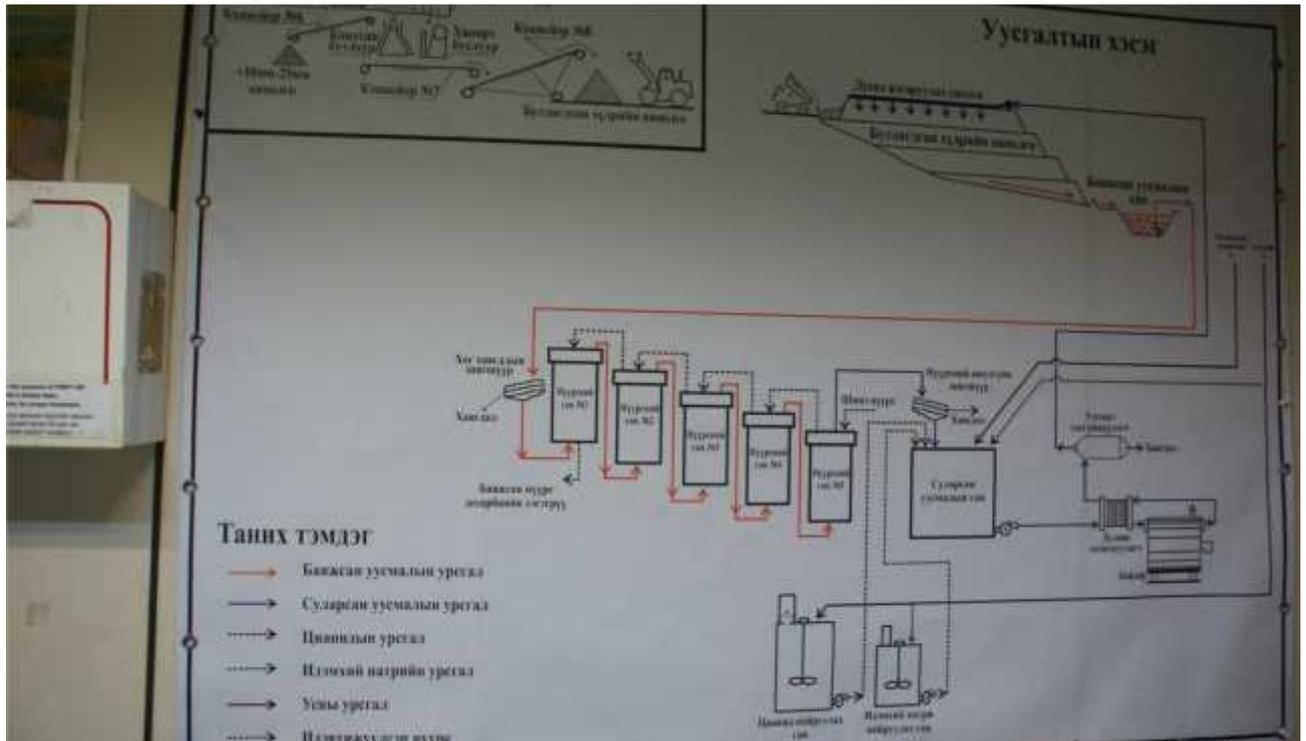


Photo image 4.1 Technology flowchart

³⁴Photographs taken during business trip, Eco Trade LLC, February 20, 2013



Photo image 4.2 Heap leach stockpile #3 (standing on its top)

Photo image 4.3 HL stockpile (view from plant building)



Photo image 4.4 Container of leach pipes on HL pad



Photo image 4.5 View of pipes inside the container





Photo image 4.6 PLS pond



Photo image 4.7 Carbon in leach unit



Photo image 4.8 Warning signs outside the unit



Photo image 4.9 HCN meter

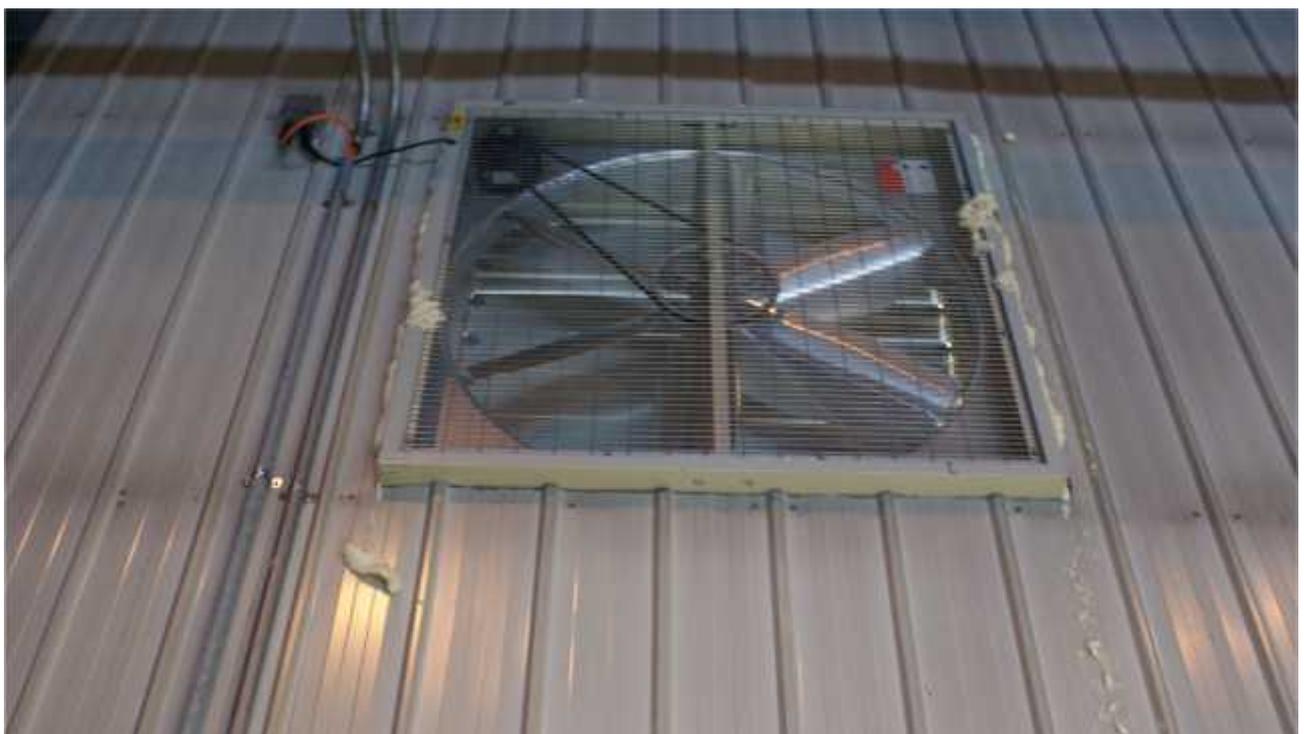


Photo image 4.10 Ventilator to operate at times of excessive cyanide in air



Photo image 4.11 Carbon columns



Photo image 4.12 Sign to wear protective gloves



Photo image 4.13 Office, employees camp

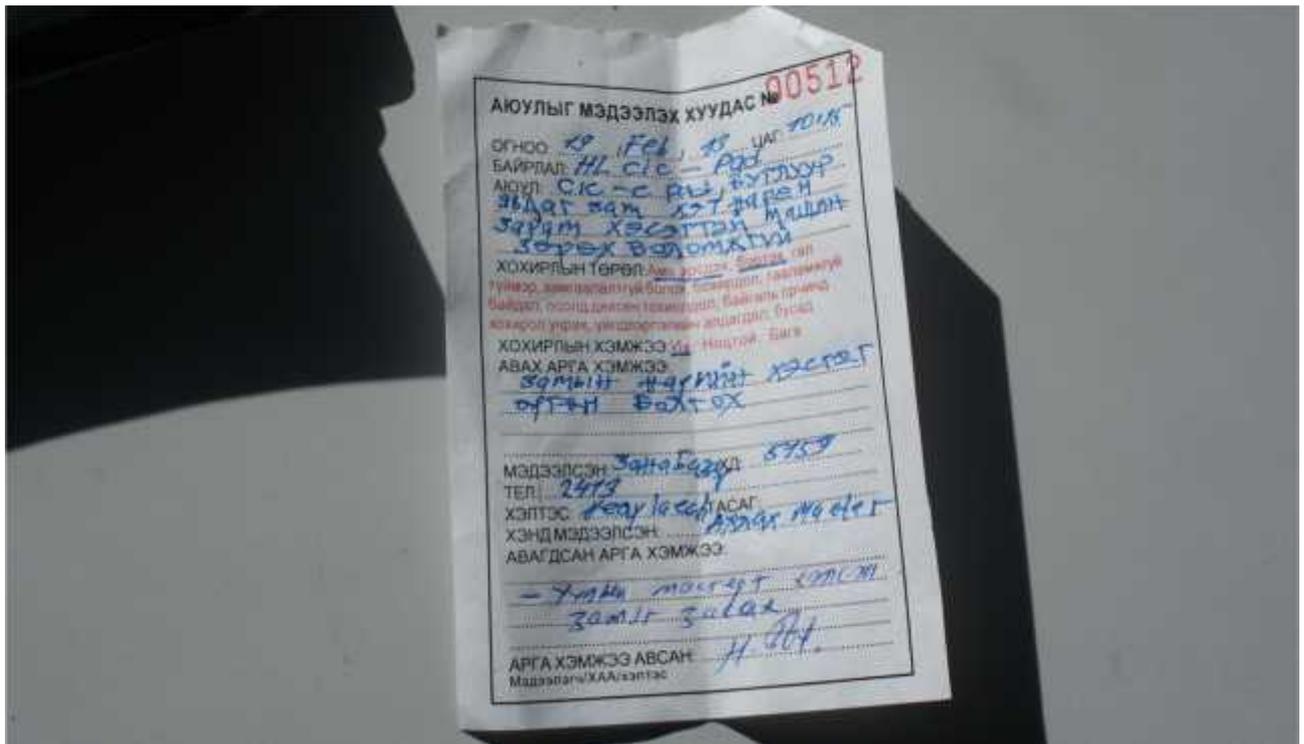


Photo image 4.14 Hazard report sheet filled out

CHAPTER SEVEN. CONCLUSION

1. "Boroo Gold" LLC has been obliged to prepare Addendum to Detailed Environmental Impact Assessment and present to relevant agencies in accordance with the act issued on August 16, 2012 by State Committee, who accepts the mine mill plant, appointed from Ministry of Mineral Resources and Energy. Also Addendum to Feasibility Study, developed by Centre for Mining Project Studies, on open pit mining of Boroo gold hard rock deposit and gold recovery by heap leaching method, located in territories of Bayangol and Mandal soum of Selenge aimag, was discussed and approved by Mineral Resources Professional Council of Mineral Authority of Mongolia on December 14, 2013. "Global Environ" LLC has performed Detailed Environmental Impact Assessment of the heap leach project to recover gold from low grade ore of Boroo gold mine in accordance with relevant legislative framework. In 2013, low grade ore reserve stockpile has been classified in 2 types including mining reserve and heap leaching reserve according to supplemental study of Boroo gold hard rock ore reserve. Mining reserve is 4,680 thousand tons and heap leaching reserve is 9,739 thousand tons. Heap leach project to process proposed to continue until 2016.
2. The proposed location for heap leaching project is within Boroo gold mine's license area of "Boroo Gold" LLC, at the distance of 2 km south east of concentrator plant, in the northern levelled foothills of mountain on fertile chernozem soil on top of clayey ground. The area is covered with natural vegetation and covers 500 m x 600 m or 30 hectare area and about 33 hectare area will be disturbed during project implementation. However, it is possible to reduce the amount of above potential disturbance area by properly using the land during heap leaching project implementation.
3. During implementation of heap leach project, natural resources such as water, coal and ore will be used.
4. Heap leach project will require to use 57,682.5 m³ of water in annual basis. Water use conclusion letter should be issued by the authority responsible for water affairs in accordance with article 26.1 of "Law on Water", prior to commencement of heap leach activity.
5. Supplemental raw materials and chemical substances including sodium cyanide, calcium oxide, Antiscalant, alkali, hydrochloric acid, calcium hydroxide, aluminum oxide, Molecular Sieve- 5, HDPE Geomembrane – high density geomembrane layer and diesel fuel will be used in heap leach project activity.
6. Main environmental impact includes soil disturbance at 33 hectare area due to establishment of heap leaching area, dust pollution generated due to movement of heavy machinery used for heap leach project, potential evaporation to air and

penetration to soil of cyanide and chemical substances from heap leaching stockpile, soil and vegetation pollution due to hydrocarbon lubricant leakage from vehicles and noise pollution from project activity and fire hazard due to carelessness and etc. These impacts can be mitigated by recommendations described in Chapter 3.

7. Heap leaching project's reclamation and environmental protection activity annual cost is **54,460,800.0** Tugriks.
8. If reclamation and environmental protection plan activity is not performed in accordance with relevant procedures the cost of **590,839,744.93** discussed in this report shall be spent on compensating ecological and economic damage imposed.
9. Impact mitigation measures discussed in this report as well as in environmental management plan should be strictly adhered and performed in accordance with relevant standards and procedures.
10. Recruiting from local residents, landscaping and carrying out reclamation on timely manner by taking into account comments and request from local community, and implementing other from local community in the mine activity would be suitable.
11. In order to mitigate and eliminate environmental impacts caused by project activities, project implementer shall strictly adhere to occupational health and safety procedures and to protect employee health and include employees to medical check-up and analysis.
12. Addendum to detailed environmental impact assessment should be development each time changes are made in equipment and technology and their capacity, production, area of possessed land and land use as well as other issues.
13. Project implementer should closely cooperate with Governor's offices of Mandal and Bayangol soums as well as Selenge aimag Governor's office, Environmental Department on the issues related with environmental protection, prevention from impacts, local development and employment of local community and etc.
14. No impacts will be imposed on surface water regime, forest and historical and cultural heritages during implementation of the project while there is positive socio-economic effect. Landscape alteration impact is high; there is risk of occurrence of disaster and accident; and pollution of air, soil, water, disturbance and impact on fauna and flora is medium while impact on groundwater and climate is low.
15. Since sodium cyanide will be used in all stages of gold leaching process, no pollution will be generated to nature and surrounding environment and human health and safety prevention issues are addressed in feasibility study and recommended measures and

rest the of requirements that could arise during project implementation period should be fully implemented.

16. According to results of risk assessment, attention should be paid to the safety of fuel station, solution transmission pipeline and solution storage tank during potential hazards and accidents such as toxic chemicals, subversive activities, flood.
17. In the conclusion: "Heap leach" project of "Boroo Gold" LLC implemented at Boroo mine tenure situated within the in territory of Bayangol soum of Selenge aimag meets the technical and ecological requirements for the implementation of such type of project. Therefore, it was concluded that it is possible to implement this project given that it doesn't destabilize the regional ecological regime of the environment to the extent it is possible and if the project performs high quality reclamation work, and if adheres and implements the measures to mitigate project impacts that are stated in environmental protection plan and environmental monitoring plan on a timely manner during project operation period and if the project complies with legislative documents of Mongolia.