Earth Observation for Monitoring and Observing Environmental and Societal Impacts of Mineral Resources Exploration and Exploitation

Project no: 244242, call 2009, Theme 6, Topic ENV.2009.4.1.3.2

Conceptual site model of Makmal gold mine, Kyrgyz Republic

Barbara Palumbo-Roe, Vanessa Banks, Ernis Kylychbaev, Claire Fleming

Public document

Conceptual site model of Makmal Gold mine, Kyrgyz Republic

Final Report
October, 2011

Barbara Palumbo-Roe, Vanessa Banks
With the collaboration of
Ernis Kylychbaev, Claire Fleming

Checked by:	**Approved by:**
Name: Christian Fischer	Name: Stephane Chevrel
Date: 29 March 2012	Date: 4th April 2012
Signature:	Signature:

Deliverable reference number and title
EO-MINERS D3.1-3
Conceptual site model of Makmal Gold mine, Kyrgyz Republic

Due date of Deliverable	**Month 6**
Actual Submission Date	**01/04/2012**
Start Date of Project	**February 1st. 2010**
Duration	**36 months**
Deliverable Lead Contractor	**BGS**
Revision	Version 1
Last Modifications	September 2011
Nature	**Report**
Dissemination level	**Public**
Public Summary enclosed	**YES**
Reference / Workpackage	DoW WP3
Digital File Name	EO-MINERS D3.1-3 V2.pdf

Keywords:	Environmental impact, conceptual site model, gold mining, cyanide.
In bibliography. this report should be cited as follows:	PALUMBO-ROE, B., BANKS, V.J., KYLYCHBAEV, E., FLEMING, C. (2011) Conceptual site model of Makmal Gold mine, Kyrgyz Republic. Earth Observation for Monitoring and Observing Environmental and Societal Impacts of Mineral Resources Exploration and Exploitation, CEC FP7 Project EO-MINERS, Deliverable D3.1-3, 45 pp

.

Summary

This report presents the work undertaken as part of the EO MINERS WP3 - project task 3.1. “Site Specific Available Data Collection” and develops a conceptual site model (CSM) for the Makmal Gold mine, Kyrgyz Republic.
The aim is: i) to present the available information regarding known apparent environmental impacts; ii) to define the environmental setting that would influence the transport of contaminants from the source to the exposed individuals or environmental receptors, through identified potential exposure pathways; iii) to describe the source-pathway-receptor interactions using a CSM.
Examining the CSM results in the identification of data gaps and information needed for a full environmental assessment of mining of the Makmal ore deposit and provides the rational for EO selection.

Contents

List of illustrations

List of tables

1. Introduction

1.1.1. Project/ Task

This document is a deliverable of EO-MINERS Task 3.1 “Site Specific Available Data Collection”, and presents a conceptual site model (CSM) for Makmal Gold Mine. The purpose of this CSM is to provide a representation of the current understanding of the status of the environmental system based on available information at this point in time. The model of the site, its hazards and its environment is achieved by identifying and analysing: i) the sources of environmental hazard that the site presents (throughout its operation and post closure); ii) the potential events and pathways by which the environment will be exposed to those hazards; iii) the potential receptors that will be impacted by those hazards; iv) the potential consequences to those receptors. Another important goal of the CSM is to identify the level of knowledge regarding the site and the level to which understanding of the environmental system cannot progress because of lack of information (data gaps). Socio-economic factors (water supply, agriculture, economical dependencies) and societal aspects (housing infrastructure, development strategies) are not covered by the CSM.

In the following sections the available information about the geographical, geological and anthropogenic framework and site specific information is organised to facilitate the identification of data and information gaps. The available information is ultimately integrated in the CSM for Makmal Gold Mine. Examining the CSM provides the rationale for EO selection.

2. Regional framework and site description

2.1. GEOGRAPHY

Kyrgyzstan is a relatively small, mountainous country in north eastern Central Asia with a total area of about 198500 km^2. The national territory extends approximately 900 km from east to west and 410 km from north to south. Kyrgyzstan is bordered on the southeast by China, on the north and west by Kazakhstan, and on the south and west by Uzbekistan and Tajikistan respectively.

The country is divided into six oblast (administrative districts): Chui, Naryn, Yssyk-Kul, Jalal-Abad, Osh and Talas (Figure 1).

The Makmal deposit is located in the Toguz-Toro district of the Jalal-Abad oblast of Kyrgyzstan, 630 km from Bishkek city and 47 km from the Kazarman village (Figure 2). The Makmal deposit is located at 2350-2800 m above sea level. The nearest railway stations are: Balykchy (c 465 km) and Djalal-Abad (c. 170 km). Highway service is carried out year round by Bishkek-Kazarman road (645 km).

Figure 1 - Kyrgyzstan map

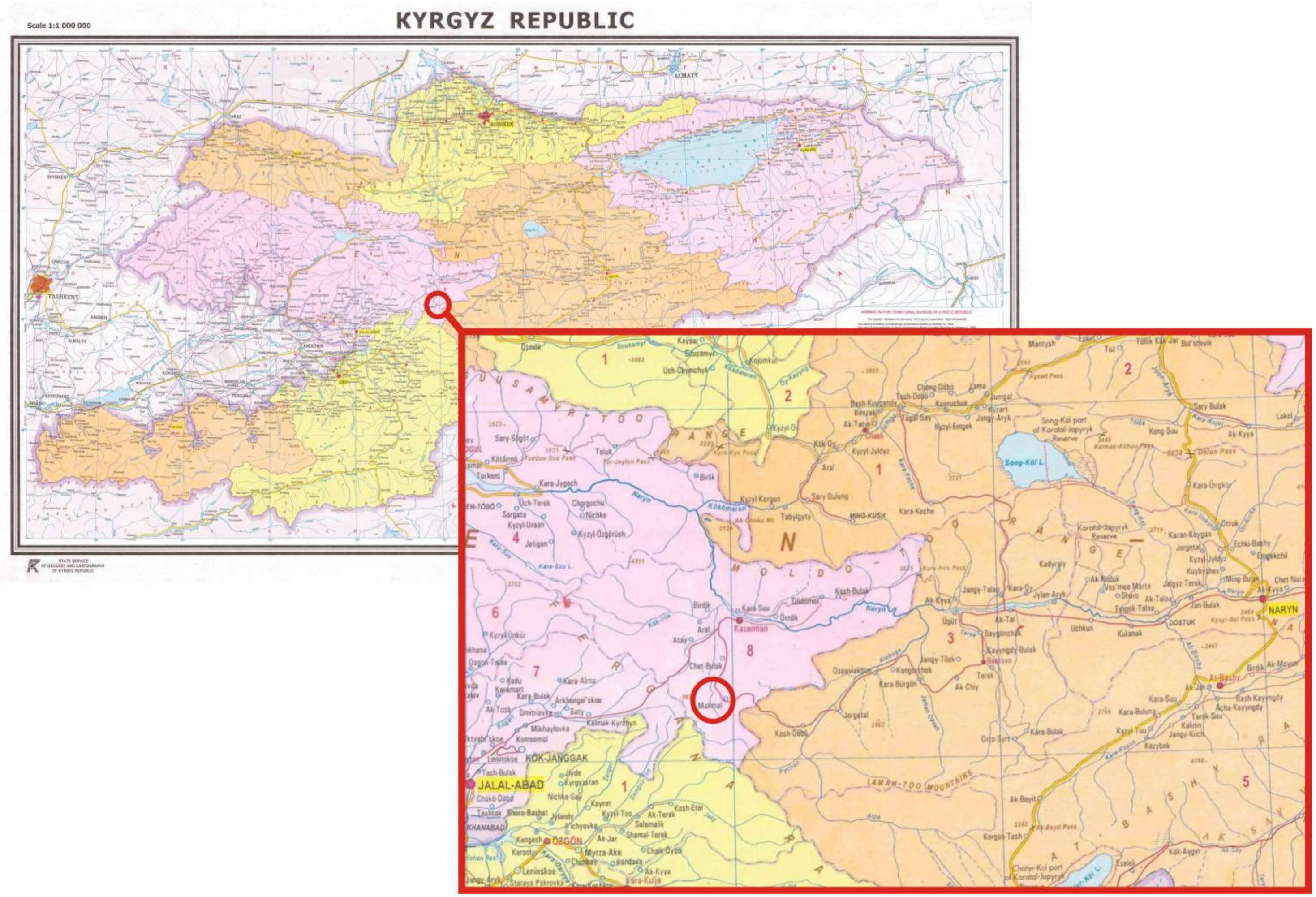

Figure 2 Administrative-Territorial division of the Kyrgyz Rebublic and details of the study area

2.2. TOPOGRAPHY

The terrain of Kyrgyzstan is dominated by the Tian Shan, Pamir and Alay mountain ranges (Figure 3). The Alay (Alai) mountains are a mountain range that extends from the Tian Shan range in Kyrgyztan in the west in an easterly direction into Tajikstan and forms part of the Pamil-Alay mountain range. The Tian Shan system dominates the southwestern crescent of the country, and, to the east, the main Tien Shan range runs along the boundary between southern Kyrgyzstan and China before extending farther east into China's Xinjiang Uygur Autonomous Region.

Kyrgyzstan's average elevation is 2750 m, ranging from 7439 m at Pik Pobedy (Mount Victory) to 394 m in the Fergana Valley near Osh. Almost 90 percent of the country lies more than 1500 m above sea level.

The distinct character of the relief is reflected in the strongly pronounced gradation of landscapes: semi desert, valley, foothill, sub-alpine, alpine, tundra, and glacial. Mountains are separated by deep valleys and glaciers. Kyrgyzstan's 6500 distinct glaciers are estimated to hold about 650 billion cubic meters of water. Only around the Chu, Talas, and Fergana valleys is there relatively flat land suitable for large-scale agriculture (Curtis, 1996).

The area of the Makmal deposit is characterised by significant rugged relief (Figure 4) with deep ravine edges that have steep slopes typically at a 50° inclination and with highly elevated drainage regions with respect to the stream network.

Figure 3- Topographic map

Figure 4- Overview of the Naryn river valley in the area of the "Makmal" deposit

2.3. CLIMATE

The country's climate is influenced chiefly by the mountains, Kyrgyzstan's position near the middle of the Eurasian landmass, and the absence of any body of water large enough to influence weather patterns. Consequently, the climate is distinctly continental, but with significant local variations (Curtis, 1996).

At the mine the average annual temperature is +6.2 ^{o}C. Average monthly temperature varies from -16.9 ^{o}C in January to +21.6 ^{o}C in July, with an average minimum temperature in January of -40 ^{o}C and an average maximum temperature in July of +42 ^{o}C. The summer season at the mine site lasts 70 days. Average annual precipitation is 800 mm, and 320 mm at the gold-extracting plant. Average depth of snow cover is 36 cm with a maximum of 59 cm. Permanent snow cover appears in the first ten days of December and remains 130-140 days depending on the altitude. Average annual relative humidity is 64%. The minimum relative humidity is in July-September (44-47%), the maximum in November-March (70-74%). Average annual cloudiness is 5-6 oktas. Fog is observed mainly during the cold period from October to March. On average, there are 30 foggy days in a year. Annual wind movement is characterised by significant recurrence of calms (61%) and by prevailing winds from the west, south west and north-west, with annual average speeds of 2.5 m/s. The location of the site relates to climate area III according to the Construction Standards and Rules 2.01.01-82.

2.4. DISTRIBUTION OF POPULATION

All mines and most mining and minerals companies are located in remote areas far from settlements and agricultural lands (Bogdetsky et al., 2001). According to the Toguz-Toro District Department of Statistics 22136 people live in the district, (11172 men and 10964 women). The district consists of five villages and 13 settlements comprising 4665 households. The nearest centres of settlement to the Makmal Mine are Kazarman to the northeast and Julalabad town to the southwest. The nearest railway stations are: Balykchy c. (465 km) and Djalal-Abad c. (170 km). Highway service is carried out year round by Bishkek-Kazarman road (645 km) [http://www.kyrgyzaltyn.kg/mzdk_en].

2.4.1. Distribution of soils and crops

According to the Toguz-Toro District Department of Statistics the district covers an area of 207967 ha; 11183 ha of this comprises arable land, 690 ha non-arable land, 1556 ha hay land, and 194538 ha pasture land. These data above indicate that the main land use is pasture. Out of 11183 ha of arable land, 2981 ha comprise irrigated land and 8202 ha non-irrigated land. These areas are mainly used for growing wheat and maize.

2.5. WATER RESOURCES

The country is dissected by more than 30000 rivers with streams emerging from glaciers and accumulations of snow. The area of glaciations extends approximately 6578 km^2. Glaciers and snow store significant quantities of fresh water.

The largest rivers in Kyrgyzstan are the Naryn, Chatkal, Sarydjaz and Talas rivers. Due to their origin, the rivers and streams are characterised by low water temperature and highly turbulent and transparent flow at the source. Downstream, while flowing through crumbly rock, the streams become turbid. In addition to the rivers, there are more than 2000 lakes covering about 7000 km^2, some located at high altitudes. The largest lake is Yssyk-Kul (“hot lake”), also one of the largest lakes of Central Asia.

There are 10 rivers and 3 canals in the Toguz-Toro District. The Naryn is a river of inter-state importance. Tributaries of the Naryn with lengths of between 11 to 42 km are located in the Naryn River basin.

The Makmal River, which is approximately 0.4 km to the east of the ore bodies, flows towards the south west, whereas the Kichi-Makmal river is 1.3 km to the west of the minefield. Both rivers merge into the Oikaian River which flows into the Kyldau River (which is itself a tributary of the Kugart River). The Makmal River is a groundwater fed river and the only perennial watercourse in the region. Average annual water flow reaches 250 l/s, with a maximum of 2000 l/s and a minimum in winter of 23 l/s. The catchment area of Makmal River is 43 km^2. In order to supply water to the administrative building of the mine, a groundwater intake structure was constructed through which water is fed to users by gravity. The water downstream of the mine is used for irrigation.

2.6. GEOLOGICAL FRAMEWORK

2.6.1. Geology of the Makmal Ore Field

The Makmal ore deposit is located close to the southwestern part of the Chaartash granitic pluton of early Permian age. The granite intrudes Lower Carboniferous carbonate rocks (Jenchuraeva et al., 1999) comprising a sequence of Tournaisian dolomite and Visean cherty-carbonate rocks. Carbonaceous-siliceous and carbonaceous-argillaceous interlayers characterise the cherty-carbonate rocks.

The emplacement of intrusive complexes is attributed to the Middle Carboniferous subduction of the Turkestan paleo-ocean beneath the Kyrgyz-Kazakh microcontinent. The closure of the Turkestan paleo-ocean in the late Carboniferous and early Permian resulted in the generation of collision leucogranites. In the Makmal ore field, leucogranite emplacement was accompanied by doming and fracturing of the roof. These fracture zones served as conduits and hosts for ore mineralization.

2.6.2. Geology of the Makmal Ore Deposit

The geological characteristics of mineral deposits exert significant control on the environmental signatures of mineralised areas and potential environmental signatures that could result from mining if appropriate mining and mine waste management were not followed (Plumlee, 1999). At the Makmal deposit, diorite intrusions, skarns with disseminated gold–copper sulphide mineralization, and later leucocratic granite are combined with magnetite skarns, massive sulphide–polymetallic rare-metal post-skarn greisens, and economic disseminated gold–sulphide mineralisation.

A comprehensive description of the Makmal gold deposit is given by Jenchuraeva et al. (1999). The gold orebodies are confined to metasomatically altered rocks related to a combination of parallel and en-echelon arranged fracture zones of various size and structure. These altered rocks include magnesian and calcareous skarns (metamorphosed carbonate rocks), beresite (a fine-grained granite associated with gold-bearing quartz), greisens (granitic rocks primarily composed of quartz and mica) and quartz-feldspar (plagioclase) rock.

2.7. ORE MINERALISATION

The formation of gold mineralisation corresponds to the granite emplacement and postmagmatic alteration. The disseminated gold-sulphide mineralisation in the garnet skarn at its contact with Middle Carboniferous diorite was formed first. The subsequent emplacement of an Early Permian granitic pluton was accompanied by 4 types of ore mineralisation: 1) Magnetite (syngenetic with skarn); 2) Massive sulphide; 3) Cassiterite mineralisation in greisens; 4) Quartz-gold (sulphide poor).

The high grade and largest gold ore lenses are hosted in post-skarn quartz-feldspar rocks; lenses in beresitised (low-temperature metasomatic rock characterised by quartz, sericite, carbonate (ankerite) and pyrite assemblages resulting from the replacement of both igneous or sedimentary protoliths) and silicified granite are thin and low-grade (Jenchuraeva et al. 1999). In addition to gold, pyrite disseminations are abundant; chalcopyrite, pyrrhotite, sphalerite, galena, molybdenite, bismuth minerals, boulangerite and jamesonite are less frequent. In the beresite zones, the most abundant pyrite is associated with native gold, pyrrhotite, chalcopyrite, molybdenite, marcasite, galena, and sphalerite. In the silicified and quartz-feldspar rocks the same ore minerals are found.

2.8. HYDROGEOLOGY

Carbonate rocks have low storage potential. The fractured granite rocks of the Chaartash intrusion form the largest aquifer. The aquifer properties are almost entirely related to secondary porosity which developed as a result of fracturing and is localized to zones of tectonic disturbances. The groundwater yield of the Chaartash intrusion is 4 l/sec on the basis of observations over the past five years.

The Makmal deposit is a non-aquifer. Steep gradients of the recharge area, low permeability of the ore-bearing rocks and a lack of hydraulic connectivity between the ore deposit strata and the Makmal stream are all factors contributing to the low water storage potential. Water inflow in the vicinity of the orebody does not exceed 10 l/sec.

By chemical composition the groundwaters are of the hydrocarbonate-sulfate, hydrocarbonate-chloride, sodium and sodium-calcium types. Solid residue is 0.23-0.33 g/l. General hardness is up to 2 mg-eq/l with carbonate hardness no more than 1.8 mg-eq/l.

3. History and anthropogenic framework

3.1. MAKMAL MINE

During the Soviet period, Kyrgyzstan was reported to have 170 proven gold deposits. Kyrgyzstan is the third largest gold producer of the CIS countries after Russia and Uzbekistan. The former Soviet Union's largest gold mine was located at Makmal (Figure 5; Figure 6).

Makmal Gold-Mining Enterprise is run by the Kyrgyz Altyn Company that is wholly owned by the Kyrgyz Government. Gold mining of the Makmal deposit started in 1986. The main orebody was worked by open-cast methods until 2001 when the horizon at 2530 m above sea level (and in some places up to 2522.5 m) was reached (Figure 7). Since 2001 underground mining has started below the adit level of 2500 m. Engineering problems concerning slope stability and potential landslides during open cast mining were not uncommon.

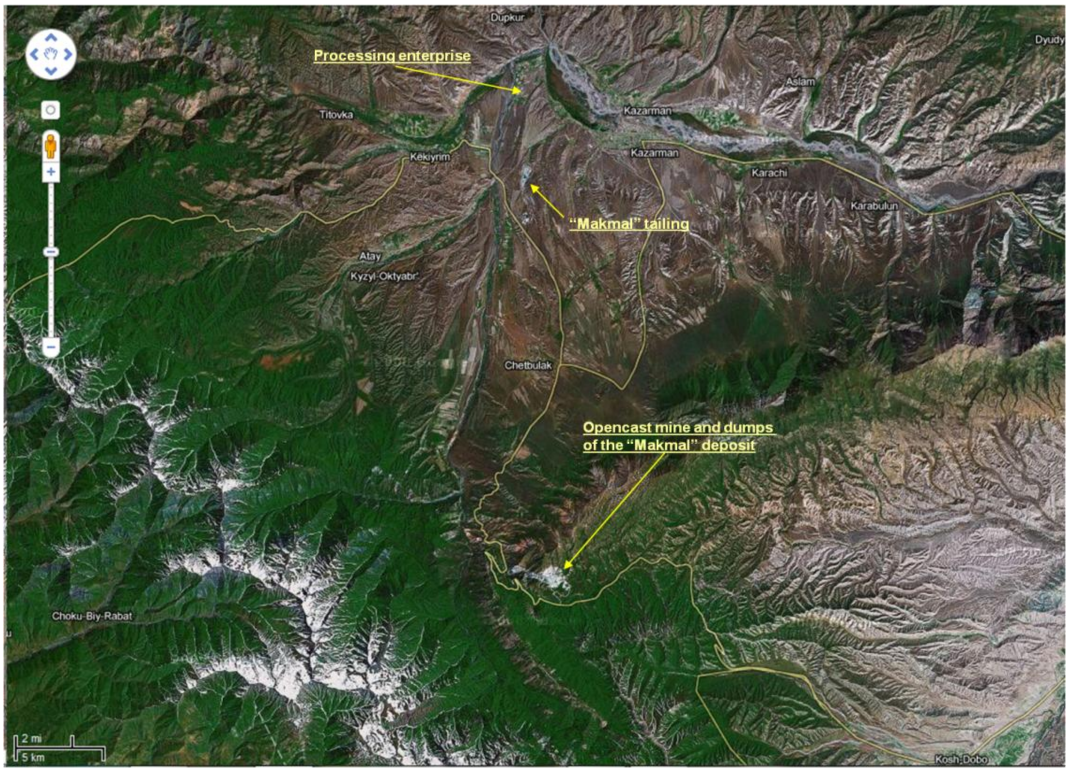

Figure 5- Location of study area

Figure 6 View of Makmal Mine

.

Figure 7 Open cast mining of the Makmal ore deposit

3.2. PROCESSING PLANT

The Makmal gold mine has a gold-extracting plant using cyanide (Figure 8). Refining of gold concentrate is not carried out on site.

Typically the hydrometallurgical gold recovery involves: a leaching step during which the gold is dissolved in an aqueous medium; followed by separation of the gold bearing solution from the residues, or adsorption of the gold onto activated carbon and, finally the gold recovery either by precipitation or elution and electrowinning (BREF, 2004). Gold is not soluble in water, therefore the presence of a complexant such as cyanide (CN), which stabilises the gold species in solution, and an oxidant such as oxygen are required to dissolve gold. The milled ore is conveyed as a slurry to a series of leach tanks in an agitated pulp leaching system. The slurry is agitated in each leach tank to increase the efficiency of the leaching process. The pH of the slurry is raised to pH 10-11 using lime to ensure that hydrogen cyanide gas (HCN) is not generated and that cyanide remains in solution and hence available to form stable gold-cyanide complexes. Highly activated carbon is used to adsorb the dissolved gold. The carbon is then further treated to recover the adsorbed gold.

Alkaline chlorination of CN wastewaters, one of the most widely used methods of treating cyanide wastes, is used at Makmal mine. In this process, cyanogens chloride (CNCl) is formed, which at alkaline pH is hydrolised to the cyanate ion (CNO^-) and lost through evaporation. If free chloride is present, CNO^- can be further oxidised.

The use of cyanide to leach gold has been a much-discussed issue in recent years since the Baia Mare accident in Romania (http://archive.rec.org/ REC/ Publications/ CyanideSpill/ ENGCyanide.pdf). Due to the high toxicity of cyanide, special attention has to be given to tailings management where this process is applied (BREF, 2004).

3.3. TAILINGS IMPOUNDMENT AND MANAGEMENT

The neutralised tailings slurry (0.074 mm class) generated from the gold mineral processing is discharged into the tailings impoundment in the form of pulp (Figure 9). The tailings pond is 12 km south of the Kazarman village (geographical coordinates: 410 20/30// northern latitude - 73059/ eastern longitude, absolute marks above sea level: 1300 m). Within the period of exploitation of Makmal mine over 7 million m^3 of tailings were accumulated. Together with the tailings pulp, the remaining unreacted cyanide flows into the tailings impoundment at a rate of about 2 t per annum.

The current tailings lagoon will reach its full capacity within the next two years (Figure 9 and Figure 10). A new tailings lagoon is planned, upstream of the older one and closer to the processing plant (Figure 11).

Existing and future tailings management facilities are zero discharge types, which is achieved through evaporation and recycling of the water in the plant.

The technical plan for the current tailings lagoon was prepared by the USSR scientific research and design institute “VNIIPROZOLOTO” and has been in operation since

1986. The raised embankment was created by piling sediments to the height required to create sufficient storage capacity, i.e. the tailings pit relates to availability of filling type, which is cross drained by levees. The safety factors used for the dam structure were 1:3 and 1:3.5 for the upstream face and downstream face, respectively. The width of the top of the embankment is 10 m, the length 370 m.

Figure 8 Different views of the processing plant

Due to the reduction of the tailings lagoon capacity in 1999, the research institute "Kazmehanobr" was commissioned to replace the embankment to increase the tailings lagoon capacity. The plan proposed a mixed scheme of extension. The upstream method was used to raise the dam wall on the dry tailings (beach), on the upstream face of the retaining dam, with a total of six levees (height of each levee 3 m, width 6 m).

Since the tailings impoundment was designed to contain cyanide-bearing tailings, a number of measures were put in place to prevent the release of polluted wastewater to the environment. The body of the dam contains a loam membrane and a polyethylene geomembrane provides a screen at the base of the dam to prevent infiltration under the dam.

The impoundment is surrounded by a main diverting dam and diversion channel on the west side for the diversion of surface runoff.

To prevent the contamination of surface water and groundwater from leakage water from the tailings, the seepage water collected by two drainage channels is back-pumped to the existing drainage pumping station. In order to reduce water consumption at the processing stage, there is a system of recycling water supply which returns 2.5 million m^3 of settled and partially neutralised water from the tailings impoundment for use in the technological process.

3.4. MINE TAILINGS CHARACTERISTICS

The tailings contain cyanide together with elevated levels of manganese, lead, zinc, and gold leavings (Appendix 1). In the tailings dam the cyanide slurry decomposes naturally. Cyanide partially precipitates in the form of insoluble salts while some is lost through evaporation.

3.5. OTHER WASTE

Other industrial wastes at the site are wood wastes, incompletely burned lime, ash from the boiler room, metal casks and shavings. Annually, over 200 t of industrial waste and approximately 70 t of ash from the boiler plant are transported to the industrial waste ground. Over 80 t per year of solid domestic waste is transported out to the village disposal tip.

3.6. REMEDIATION AND RESTORATION TECHNIQUES

At Makmal reclamation of the open pit has not been performed because of the on-going underground mining which is linked directly to the mine.

Presently a plan for the 1st stage reclamation of the mine has been developed for an area of 26.4 ha encompassing the area allocated for ore storage and roads, which is unused at present. The plan is under examination by the Ministry of Natural Resources of the Kyrgyz Republic.

Figure 9- Different views of the mine tailings lagoon

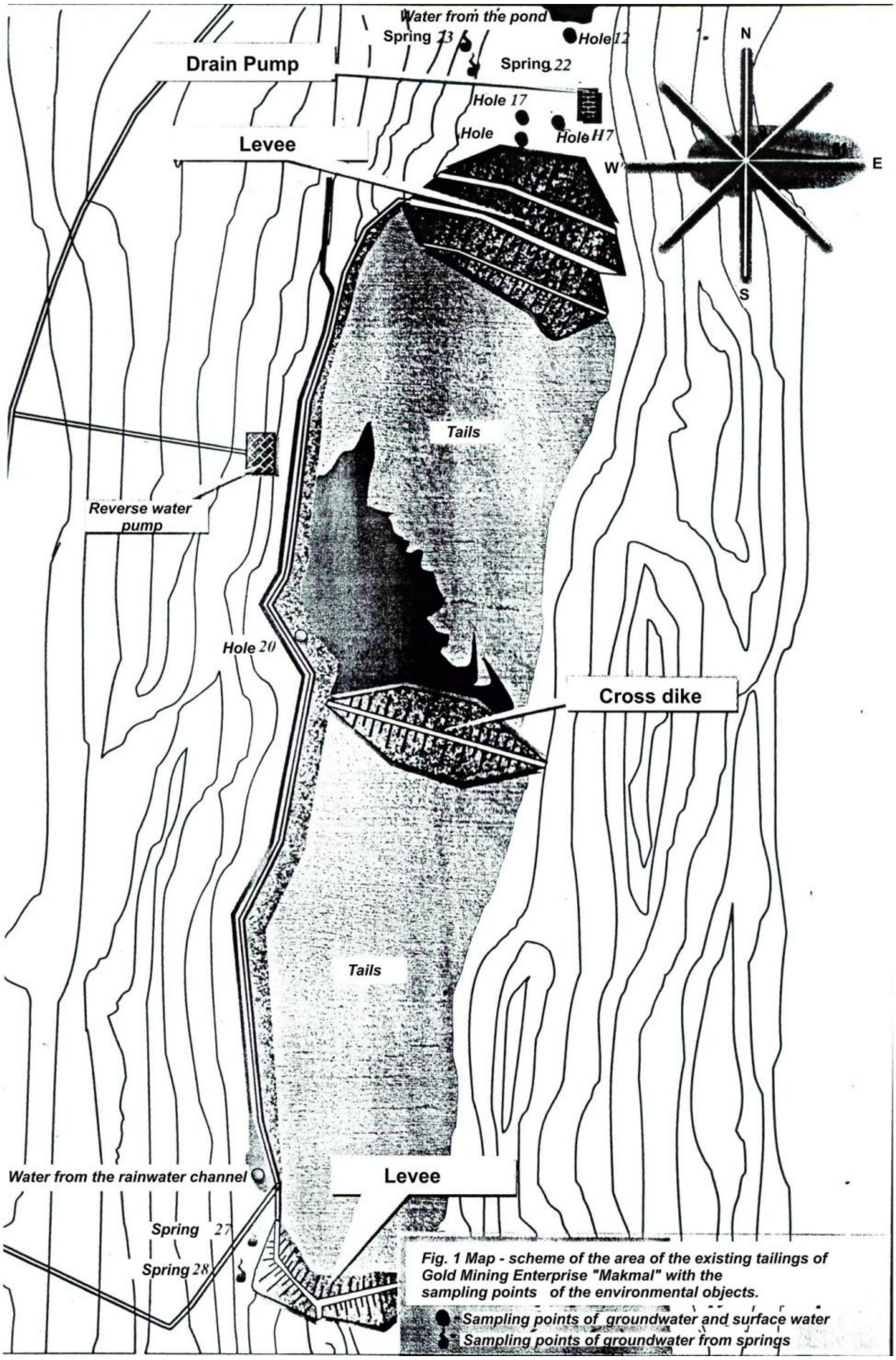

Figure 10- Tailings lagoon map

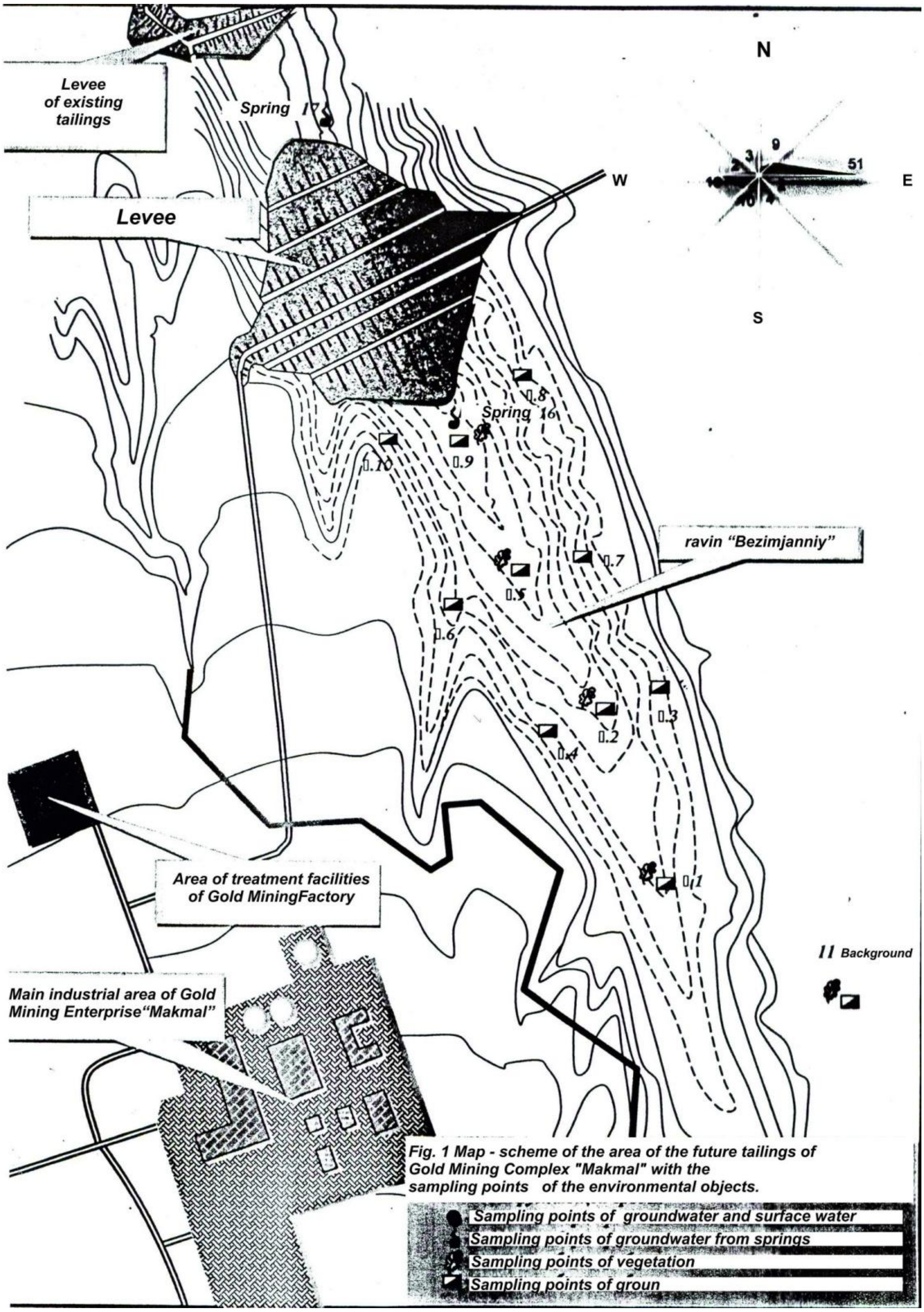

Figure 11- Future tailings lagoon plan

4. Conceptual site model

4.1. INTRODUCTION

This section presents the available information regarding known apparent environmental impacts; collates information about the site environmental setting that would influence the transport of contaminants from the source to the receptors through identified potential exposure pathways; and links them using a CSM.
Examining the CSM results in the identification of data needed for a full environmental assessment of mining in Sokolov and provides the rational for EO selection.

4.2. ENVIRONMENTAL ISSUES

4.2.1. Cyanide Hazard

Toxicity

Workers in industries that use or produce cyanide compounds are at risk of exposure to a hazardous substance. Equally, any loss of cyanide to the environment is a major concern because it is toxic to a wide variety of organisms. If cyanide is ingested in sufficiently high doses, it can be poisonous, even fatal, to humans and animals. Poisoning may take place via skin contact, via inhalation or via ingestion.

Cyanide may have a chronic effect on the environment in three different ways (Clarke and Linkson, 1987*)*. The first is to produce a direct and ongoing minor acute poisoning, producing chronic symptoms including anomalies in the nervous systems of many higher organisms. The second is by the formation of its compound thiocyanate, interfering with specific common metabolic pathways. Thirdly, because cyanide and thiocyanate are capable of complexing metals dissolved in waters, organisms using these waters could either be subjected to toxic doses or deficiencies. The surpluses could arise from metals being retained in solution in assimilable complexes (e.g. Cu), while deficiencies in naturally occurring trace elements could result from the retention of these in non-assimilable complexes (e.g. Fe).

However, cyanide does not give rise to chronic health or environmental problems when present in low concentrations. Cyanide does not bio-accumulate or build up in humans or animals based on repeated exposure. This is because cyanide decomposes through natural physical, chemical and biological processes into other less toxic chemicals when exposed to sunlight, air and other oxidants.

Chemistry

Understanding of the behaviour of cyanide and the metal complexes of cyanide is facilitated by the use of the thermodynamic stability fields of the stable species cyanide (CN^-), cyanite (CNO^-) and hydrogen cyanide gas (HCN) in terms of redox potential (Eh and pH). At low redox, HCN and CN^- predominate with the latter being the dominant species at pH greater than 9.2. At high redox potential, CNO^- becomes the only stable phase. However, in practice, the formation of CNO^- is kinetically inhibited in aerated solutions. The presence of sulphur which commonly occurs in mine waste systems will react with CN^- forming thiocyanate ions (SCN^-). Thiocyanate anions can degrade to form ammonium (NH_4) (Stott et al., 1999), which can be detrimental to fish and a threat to the sustainability of aquatic ecosystems promoting eutrophication in receiving water bodies during nitrification.

Cyanide behaviour after spillage

Geochemical processes, such as volatilisation, bacterial degradation, precipitation as insoluble cyanide solids, and photolytic degradation, influence how rapidly cyanide is degraded once in the environment. In general, degradation is most rapid in systems open to the atmosphere, either in surface waters or in the vadose zone above the water table. Climate and geology play an important role by controlling the volumes and composition of the water with which the processing water interacts. Ice cover can inhibit cyanide volatilisation. The persistence of the cyanide will depend on the relative flow volumes of the released solutions versus those of the receiving waters. Dilution is often the first mechanism of attenuation. Dilution of alkaline cyanide rich solutions by acidic or near neutral surface waters will eventually lead to breakdown of weak cyanide complexes and cyanide volatilisation (acid waters favour the break-down of the metal–cyanide complexes to form hydrogen cyanide HCN, which then volatilises). If waters are more alkaline, cyanide spillages are more likely to persist for appreciable distances downstream (Smith and Mudder, 1999).

International Cyanide Management Code

Cyanide is a toxic and hazardous substance, however proper management of cyanide ensures the protection of both human health and the environment. The International Cyanide Management Code (http://www.cyanidecode.org/) was developed by the minerals industry, government, NGOs and academia under the guidance of the United Nations Environment Program (UNEP) and the then International Council on Metals and the Environment (ICME), now the International Council on Mining and Metals (ICMM). The code assists gold mining companies to employ stringent risk management systems to protect human health and to reduce the environmental impacts from the use of cyanide.

4.2.2. Tailings facility management

The presence of a tailings management facility containing hazardous material, such as in Makmal mine tailings lagoon, must be secure against physical damage from outflow or natural hazards, and must not pollute the surrounding area, neighbouring water courses, the groundwater, or the atmosphere (BREF, 2004).

4.2.3. Available environmental impact assessment reports

According to the agreement with JSC KyrgyzAltyn, the Chui Ecological Laboratory carries out bi-annual monitoring of environmental impact indicators related to the activities of Makmalgold Enterprise. The results are submitted to KyrgyzAltyn in the form of reports. The following paragraphs summarise available data, which refer mostly to a single sampling event (2009), extracted from the above reports and reported in Appendix 1.

Wastewater discharges

Water samples were taken for chemical analysis at the outlet of the treatment facilities at the Makmal mine, the treatment facilities at the gold extracting plant and the treatment facilities in the Kazarman village. The analytical results prove that requirements concerning established standards for maximum permissible wastewater discharges were mainly met. The only exceptions relate to an excess of suspended matter at the mine, excess of ammonium-nitrogen (NH_4) at the gold extracting plant and ammonium-nitrogen, sulphate and pH at the treatment facilities in the village (Appendix 1).

The chemical analysis of the water from a tailings pond pulp sample indicates concentrations of copper 3.51 mg/l, zinc 1.43 mg/l, CN 15.45 mg/l, sulphate 500 mg/l, while ammonium was not determined. The copper and zinc concentrations in the tailings pond are more dilute; similarly, the CN is less than 0.035 mg/l.

Emissions to air

According to the 2010 six month-report to KyrgyzAltyn, a survey was undertaken of emission sources of harmful chemical substances to air with reference to established standards for maximum permissible pollutant discharges in air. The results received prove the observance of established standards for maximum permissible pollutant discharges. The inventory covered 81 sources of air pollutants. Out of 81, 38 sources were checked by instrument measurements including 26 ventilating devices and 12 technological sites without vents.

Emissions to water and soil

A survey of water and soil was made in the zone of impact by tailings and industrial waste ground. In soils of the tail water there was no evidence of enhanced levels of mine-derived elements.

Chemical analysis of water samples taken in 2009 is provided in Appendix 1. Monitoring points include a number of springs upstream of the existing tailings dam (springs 16-17) and close to the upstream embankment (springs 27 and 28), downstream from the tailings dam (springs 22 and 23), and a number of boreholes (unknown depth) on the western side of the tailings dam (hole 20) and downstream from the tailings dam (holes 7, 12, 17). Water from the pond at the dam footing and the Naryn and Kugarat rivers was also monitored.

All waters have an alkaline pH and moderate to high contents of sulphate and chloride. The level of fluoride in most spring and borehole water exceeds the threshold set in the Limit of Permissible Concentration for Household and Community water use (LPC H&C). Ammonium LPC H&C is exceeded in springs and boreholes at the toe of the tailings dam. Relatively high values of lead, above the LPC H&C threshold, are found in springs and boreholes both upstream and downstream of the tailings dam. Cyanide concentrations are also above the LPC H&C threshold (0.1 mg/l) at springs and boreholes at the toe of the tailings dam. The Kugarat River exceeds the quality standards for irrigation water with regards to ammonium. Both the Naryn and Kugarat rivers exceed the limit of permissible concentrations for fishing for copper and zinc.

It is important to note that the available analytical data are limited to a single monitoring event (unknown sampling season) apart from for a few exceptions. Due to the importance of climatic factors, including temperature, in influencing cyanide degradation and the water flow regime, seasonal variability of water quality of seepage and groundwater is expected. This cannot be evaluated on the basis of present data.

4.3. CONCEPTUAL MODEL OF THE ENVIRONMENTAL SYSTEM AT MAKMAL MINE

Sources, pathways and receptors and the existing or potential linkages between sources and receptors are described in the following paragraphs.

4.3.1. Contaminant Sources

Contaminant sources associated with the Makmal mine can be placed into the following categories:

Processing plant

As noted in preceding paragraphs, the main hazard is associated with the use of cyanide in the gold ore processing and its storage. The use of other chemicals may represent further hazard sources.

Tailings dam

The material from which the gold has been extracted in the processing plant is referred to as tailings. The tailings slurry is discharged into the tailings dam.

The tailings slurry or pulp generated from the gold mineral processing has been reported to have 15 mg/l CN (CAIAG source: date of analysis 2006). The tailings also contain 0.7 mg/kg gold, 0.04 mg/kg lead, 0.07 mg/kg zinc, and 0.017 mg/kg arsenic (CAIAG source). Cyanide is therefore the main hazardous substance significantly enriched in the tailings.

The natural decomposition of cyanide discharged into the tailings dam is the main mechanism for cyanide degradation. However, this mechanism may be critical in cold climates where natural volatilisation of cyanide from holding ponds is relatively slow (Smith and Mudder, 1999).

The tailings composition (Appendix 1) indicates that the material is relatively low in lead, zinc and arsenic compared to other examples of gold mine tailings from literature (BREF, 2004). Their concentrations may not represent a significant hazard. However, a complete chemical characterisation of the tailings including other hazardous elements is not available.

Other material characteristics of the tailings, such as particle size distribution, solid to liquid ratio, Acid Mine Drainage (AMD) potential, mineralogy and trace element content, could be used to determine the leaching characteristics of the material in the Makmal mine tailings lagoon. These characteristics have an important influence on the operational management and, ultimately, suitable decommissioning methods for the tailings (BREF, 2004).

There was no direct information available at the time of preparing this report regarding the sulphide content of the mine tailings and its AMD potential. However, the quartz-gold (sulphide-poor) type of ore mineralisation (Jenchuraeva et al., 1999) of the Makmal ore deposit suggests a low sulphide mineral content that, combined with the acid-buffering capacity of widespread carbonate alteration assemblages, would prevent significant AMD associated with the tailings. The existence of locally higher concentrations of sulphide minerals, which can lead to significant metal-rich acid mine drainage, cannot be precluded.

Open pit

The use and type of explosive is unknown. Explosives used in mining operations, because contain significant amounts of ammonium nitrate, may represent a primary source of nitrates entering the water system.

The ore and enclosing rocks are reported to be a potential cause of silicosis for exposed human receptors during mining operation, as contain 80% free silica (Tapsiev et al., 2011).

4.3.2. Physical hazards sources

Open pit and underground mines

The available information indicates that the opencast mining of the Makmal deposit was completed in 2001, when underground mining commenced. It has been reported that landslides, rockslides and slope instability issues have occurred at the edges of the opencast mine. Underground extraction in the thick Southern orebody under the existent open pit bottom has produced collapses over the stopes (Tapsiev et al., 2011). These authors describe the experience of backfilling mined-out spaces through gaps in the open pit bottom by using non-commercial waste rock in the north and south ore lentils of the Southern ore body of the Makmal deposit.

Mine waste dumps

Very little information is available at the moment to evaluate if and how waste rock dumps represent a hazard.

4.3.3. Pathways

The primary release mechanisms at a mine waste facility are related to the movement of water through the contaminant sources. Typically this is the result of infiltration of snowmelt and precipitation; infiltration of surface water; groundwater discharge to surface water; groundwater table fluctuations; erosion, and sediment transport. Wind erosion can also be a significant release mechanism in certain scenarios where dry tailings are exposed, due to their fine particle size. The CSM for the mine tailings is summarised in Figure 12 and Figure 13 and categorises the primary release mechanisms into: i) surface runoff, ii) infiltration / percolation and iii) erosion.

The following paragraphs give details of the site specific release mechanisms. The release scenarios portrayed can occur during normal operations, abnormal operations and accidents, as in the case of dam failure.

Migration of cyanide and toxic elements from the tailings dam due to seepage

The mine waste facility was designed as a zero discharge unit. A number of control measures are in place to prevent surface water runoff and infiltration/percolation outside the tailings lagoon: i) water in the tailings lagoon is re-circulated during the operation of the mine, ii) mine seepage water is collected by two drainage channels and back-pumped to the existing drainage pumping station and iii) surface water infiltration from storm events and snow melt is substantially reduced by a diversion system around the dam. It is also reported that a clay-geomembrane lining system is in place for the embankment; however, it should be noted that no information is available as to whether the upstream face of the downstream embankment is lined.

The purpose of these control measures is to reduce the potential impact of mine wastewaters to the receiving water bodies. However, according to the available analysis of borehole waters and springs outside the mine tailings facility, significant concentrations of cyanide, sulphate, lead, zinc and ammonium have been found downstream of the dam. This suggests that, despite the protection measures, migration of wastewater seepage to groundwater occurs in the tailings lagoon area of Makmal mine.

The efficiency of the drainage system in the prevention of contaminant migration to receiving surface water cannot be evaluated due to lack of surface water monitoring points and a drainage network map that would allow assessment of the proximity of the mine tailings to watercourses and preferential flow patterns. Acquiring this information is a requirement to improve our understanding of the migration pathways.

The information gathered at this stage indicates that the bedrock at the mine is characterised by low permeability bedrock, with faults and shear zones representing more permeable zones. It is plausible to hypothesise that these zones may control ground water flow and represent preferred hydraulic migration pathways for recharge to the base of the tailings and/or contaminant migration away from the tailings. The distribution of these zones of higher permeability in relation to the tailings lagoon is unknown. The extent and seasonality of the interaction between the tailings lagoon and groundwater is also unknown. Further investigation would be necessary to evaluate the significance of these features.

Cyanide emission to air as HCN

It is reasonable to expect that gaseous emissions of HCN are generally low because of the alkaline water type that characterises the environment at Makmal, in which CN ions rather than HCN are stable. However, if pH decreases towards neutral to acid pH, most of cyanide would be in the form of HCN and volatilisation could be an important migration pathway for cyanide.

Dispersal of toxic dust from tailings

The collated information is incomplete at this stage and more evidence needs to be collected.

Nitrate problems in water quality from use of explosives

The collated information is incomplete at this stage and more evidence needs to be collected.

Tailings dam failure

Tailings impoundment dams can fail due to a number of natural hazards as well as natural hazards in combination with anthropogenic factors (Djenchuraev, 1999). One of the most common reasons for dam failure is pond overtopping due to improper water discharge. In the mountain environment this problem may also be caused by sudden floods or mudflows. Mining waste sites can also be destroyed by landslides, which are very frequent in some mountainous areas. Earthquakes can be another reason for a dam failure, especially for tailings impoundments located in areas of high seismic activity and in close proximity to geological faults.

An evaluation of the geotechnical stability of the tailings embankment was not available at the time of the preparation of the CSM.

4.3.4. Exposure media

Exposure media (also secondary sources) are: i) surface/water sediments, ii) groundwater, iii) soil and iv) dust.

The Kugarat River fails the quality standards for irrigation water with regards to ammonium. Both the Naryn and Kugarat Rivers exceed the limit of permissible concentrations for fishing for copper and zinc. Ammonium might be related to the cyanide degradation, however high concentrations of ammonium in water are often associated with the use of explosives in the mining industry. This potential additional source of ammonium cannot be precluded at this stage.

It should be noted that the available data refer to one chemical analysis per river. More monitoring points and new data are needed to verify the chemical status of these rivers and whether it is changing with time.

4.3.5. Exposure pathways

Exposure pathways are the routes by which receptors may be exposed to contaminants from mining related sources. In general, exposure pathways within Makmal Mine include: i) inhalation; airborne dust and volatile compounds, ii) ingestion; surface water, groundwater, soil/sediment, and food, iii) dermal absorption; direct contact with soil, surface water and groundwater.

4.3.6. Receptors

Endpoint receptors liable to be adversely affected by the release of contaminants are: i) ecological receptors (terrestrial and aquatic), ii) people, and iii) properties (damage to property and loss of amenity).

Very little information in terms of receptor type and distribution is available to evaluate if receptors are present and likely to be affected by leakage of cyanide or dispersion of mine tailings from the mine.

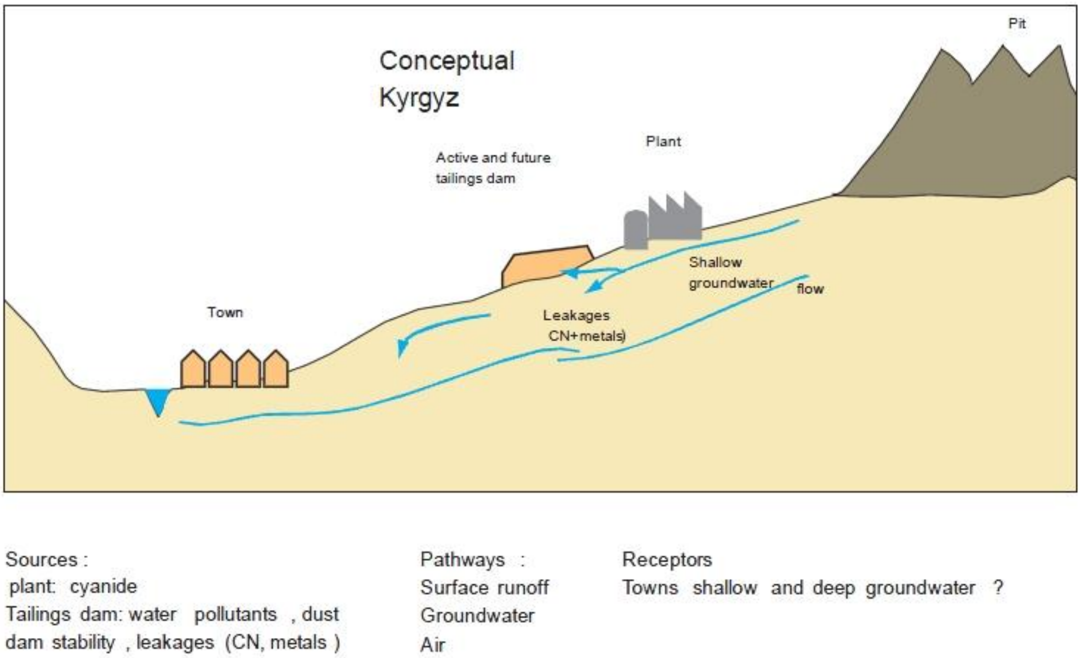

Figure 12: schematic diagram illustrating potentail source, pathways and receptors at Makmal Mine

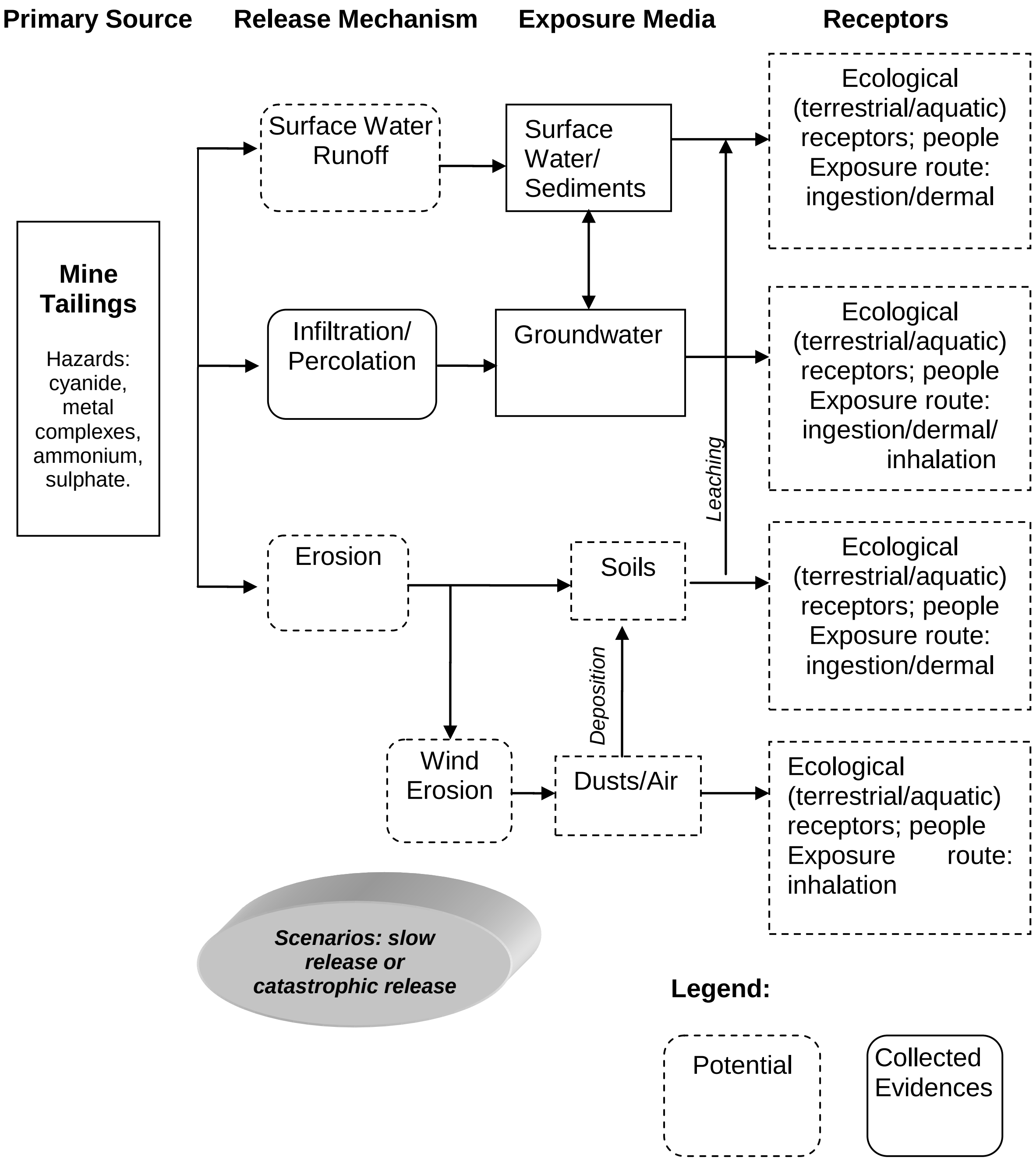

Figure 13- Conceptual model for the mine tailings lagoon at Makmal Mine

4.3.7. Data gaps and potential for remote sensing assessment

Table 1 highlights the missing information and potential for remote sensing assessment. The potential for remote sensing assessment excludes in-situ data, and those remote sensing data listed are suggested appropriate sensors and do not constitute an exhaustive list of all available sensors.

Data Gap	Description	Significance	Potential for EO
Source			
Mine tailings characterisation from the tailings lagoon	Full suite element chemical analysis of mine tailings	Full characterisation of the tailings is not complete. Evidence of potentially harmful elements other than CN is necessary.	YES – Hyperspectral airborne data, ASTER or Hyperion
Influence of seasons on CN contents in the tailings lagoon	Assessing the CN cycle in the tailings through the year	The effects of different hydrologic and meteorological conditions have not been evaluated. Available data might not represent the seasonality of the tailings lagoon wastewater quality.	Direct and temporal data required
Sulphide occurrence	Occurrence of sulphide rich veins or waste	The sulphides are a potential source of ARD and of release of hazardous elements.	YES – Hyperspectral airborne data, ASTER or Hyperion
Open pit	Information on potential chemical and physical hazards of open pit and relationship with underground mine	Potential slope instability issues, exposure of sulphidic veins and potential release of contaminants (nitrates from use of explosives).	YES – elevation models such as SRTM, LiDAR or ASTER for slope instability and YES – Hyperspectral airborne data, ASTER for the detection of sulphidic veins
Mine waste dumps	Potential chemical and physical hazards of mine waste dumps	Potential slope instability issues, exposure of sulphidic veins and potential release of contaminants.	YES – elevation models such as SRTM, LiDAR or ASTER for slope instability and YES – Hyperspectral airborne data, ASTER or Hyperion for the detection of sulphidic veins

Table 1 - Data gap analysis and potential for EO assessment

Data Gap	Description	Significance	Potential for EO
Pathways			
Surface drainage network	Map of surface drainage system	Limited information (in digital form) is available on streams at the site, their proximity to the source, runoff direction, hydraulic continuity with groundwater. Consideration should be given to the most likely surface route of any discharge from the source.	YES – elevation models such as SRTM, LiDAR or ASTER
Subsurface geology/hydrogeology	Geologic cross sections of the area occupied by the tailings. Ground water table and proximity to surface in the tailings lagoon area	The geology at the site is only broadly defined. The presence of permeable rock units or faults that intercept the lagoon may have a significant impact on contaminant migration.	YES – Hyperspectral airborne data, ASTER or Hyperion for the classification of geology and structures at surface if there is little or no vegetation cover. Geophysics could be used to give sub surface measurements.
Subsurface seepage from the tailings lagoon	Contaminant migration through the engineered structure	Subsurface seepage might contaminate GW/SW or soils; evidences of change in soil moisture might be present.	YES – Hyperspectral airborne data, ASTER or Hyperion for the classification of materials at surface. Geophysics could be used to give sub surface measurements.
Release of contaminant due to the tailings embankment failure	Geotechnical stability of the tailings embankment (Slope instability – Physical integrity)	Geotechnical instability of the tailings embankment has a great potential to cause pollutant dispersion and harm to humans.	YES – SRTM, LiDAR or ASTER can provide slope models and if the embankment materials are known, the risk of failure can be estimated.
Wind Erosion	Air-suspended particulate matter		YES – Hyperspectral airborne data, ASTER or Hyperion but in situ data will provide better accuracy.
Exposure media and Receptors			
Sediments	Sediment chemistry	Lack of data downstream of the mine tailings and baseline data makes it difficult to evaluate if sediments are a significant exposure medium for receptors.	YES – Hyperspectral airborne data, ASTER or Hyperion could provide a coarse baseline dataset but in situ data is required.
Receptors	Distribution and characterisation of ecological receptor, people and properties	The distribution and sensitivity of environmental receptors liable to be adversely affected by release of contaminants from the mine is poorly defined.	YES – Hyperspectral airborne data, ASTER or Hyperion

Table -1 (continued) Data gap analysis and potential for EO assessment

5. References

BOGDETSKY, V., STAVINSKIY, V., SHUKUROV, E.. SUYUNBAEV, M. (2002) Mining Industry and Sustainable Development in Kyrgyzstan. IIED MMSD Report, 95 pp.

CURTIS, G. E. (1996) Kyrgyzstan. A country study. Federal Research Division. Library of Congress. Washington.

BREF (2004) Reference Document on Best Available Techniques for Management of Tailings and Waste-Rock in Mining Activities. European Commission. DG. JRC. Institute for Prospective Technological Studies. Sustainability in Industry. Energy and Transport. European IPPC Bureau. Seville.

BUYERS, LYDIA (Editor). 2003. Central Asia in focus: political and economic issues. Nova Science Pub Inc. 250pp

CLARKE, M. C. and LINKSON, P. B. (1987) The toxicity and degradation of cyanide in mine tailings pg 87-94. In Mining and environment- a professional approach. The Australian Institute of Mining and Metallurgy. Victoria. Australia.

DJENCHURAEV, N. D. (1999) Current environmental issues associated with mining wastes in Kyrgyzstan. Central European University.

http://www.cyanidecode.org/

JENCHURAEVA, R. J., PAK., N. T., SOROKIN, T. A., USMANOV, I. A. (1999) The Makmal Gold Deposit. Kyrgyzstan Geology of Ore Deposits. Vol. 41

PLUMLEE, G.S. (1999) The environmental geology of mineral deposits. In:The Environmental geochemistry of mineral deposits. Part A: Processes. Techniques. and Health Issues. Chapter 3. Eds: Plumlee GS and Logsdon MJ. Reviews in Economic Geology.

SMITH, A.C.S. and MUDDER, T. I. (1999) The environmental geochemistry of cyanide. In:The Environmental geochemistry of mineral deposits. Part A: Processes, Techniques. and Health Issues. Chapter 11. Eds: Plumlee GS and Logsdon MJ. Reviews in Economic Geology.

STOTT, M. B., ZAPPIA, L R., FRANZMANN, P. D., MILLER, P. C., WATLING, H. R., HOUCHIN, M. R., AMILS, R. and BALLESTER, A. (1999) Bacterial degradation of thiocyanate in saline process water. 809-818 in Process Metallurgy: 9 (Elsevier.) ISBN 1572-4409.

TAPSIEV, A., FREIDIN, A., FILIPPOV, P., NEVEROV, A., NEVEROV, S., ARTEMENKO, Y., USKOV, V., AND UFATOVA, Z. (2011) Extraction of gold-bearing ore from under the open pit bottom at the Makmal deposit by room-and-pillar mining with backfill made of production waste. Journal of Mining Science 47, 324-329.

Appendix 1

№ of sample	Sampling point	Content mg/l														
		pH	HCO3	SO4	Cl	NO2	NO3	F	P	Ca	Mg	Na+K	Fe^{+3}	Fe^{+2}	NH4	Cr
10347	Spring t.16	7.80	671.30	111.10	47.20	0.048	<0.01	**4.80**	<0.01	116.20	60.80	98.00	<0.01	<0.01	**4.40**	n/d
10348	Spring t. 17	8.25	244.10	184.40	20.20	0.028	5.75	**2.68**	<0.01	80.16	43.80	19.30	<0.01	<0.01	0.54	n/d
10358	Spring t. 27	8.25	231.90	138.26	28.40	<0.01	5.20	**2.48**	<0.01	64.13	29.18	47.50	n/d	n/d	<0.01	<0.01
10359	Spring t. 28	8.20	231.90	144.00	28.40	<0.01	4.20	**2.36**	<0.01	64.13	31.62	45.00	n/d	n/d	<0.01	<0.01
10357	Pond L and PS	8.20	195.30	141.56	28.40	0.028	1.88	**2.48**	<0.01	48.10	31.62	47.50	n/d	n/d	1.20	<0.01
10349	Hole №20	8.20	280.70	274.10	33.70	0.04	19.60	**1.88**	<0.01	96.20	51.10	55.00	<0.01	<0.01	0.86	n/d
10350	Hole №N7	8.15	36.60	768.70	202.40	0.072	<0.01	2.12	<0.01	128.30	43.80	292.80	<0.01	<0.01	**24.00**	n/d
5695	Hole № N7(2006)	8.04	n/d	**877.32**	n/d	<0.01	<0.01	**3.00**	n/d	182.36	49.86	n/d	<0.01	<0.01	n/d	n/d
10351	Hole №17	9.10	30.51	88.10	303.50	0.044	0.66	0.84	<0.01	16.00	12.16	225.80	<0.01	<0.01	**4.64**	n/d
5693	Hole №17(2006)	8.53	n/d	26.94	n/d	0.06	<0.01	0.40	n/d	4.00	1.22	n/d	<0.01	<0.01	n/d	n/d
10352	Spring №2	8.10	183.10	**604.90**	74.20	0.232	10.20	**2.32**	<0.01	188.40	43.80	112.80	<0.01	<0.01	**10.60**	n/d
5692	Spring №2(2006)	8.20	n/d	455.11	n/d	0.31	3.96	**2.00**	n/d	180.36	41.74	n/d	<0.01	<0.01	n/d	n/d
10353	Spring №3	8.25	244.10	253.50	33.70	0.024	**15.20**	**2.20**	<0.01	88.20	41.30	60.00	<0.01	<0.01	0.60	n/d
10354	Hole №12	7.30	79.30	392.60	78.10	0.88	**16.20**	**1.60**	<0.01	60.12	48.64	116.80	0.20	n/d	**3.12**	<0.01
5687	Hole №12(2006)	8.54	n/d	397.51	n/d	0.94	0.64	**2.00**	n/d	80.20	36.70	n/d	<0.01	<0.01	n/d	n/d
10355	Pond at dam footing	7.80	317.30	387.60	67.50	0.144	**12.50**	**2.80**	<0.01	164.30	51.10	55.20	n/d	n/d	**7.20**	<0.01
5688	Pond at dam footing (2006)	8.30	n/d	480.62	n/d	0.520	1.16	**2.80**	n/d	108.42	31.10	n/d	<0.01	<0.01	n/d	n/d
10356	Spring t. 25	8.15	231.90	344.80	49.70	0.02	**12.50**	**2.32**	<0.01	108.20	48.64	75.00	n/d	n/d	0.60	<0.01
57(H	Settling pond of tailings (2006 r.)	8.20	n/d	385.20	n/d	**1.28**	2.30	0.68	n/d	168.10	121.6	n/d	<0.01	<0.01	n/d	n/d
5707	Pulp (2006)	8.06	n/d	499.60	n/d	**1.60**	0.90	0.44	n/d	168.10	7.30	n/d	<0.01	<0.01	n/d	n/d
10360	Naryn river	8.20	189.20	102.00	35.50	<0.01	1.94	0.60	<0.01	60.12	24.32	30.00	n/d	n/d	<0.01	<0.01
10361	Kugarat river	8.35	231.90	41.20	10.70	<0.01	1.88	<0.01	<0.01	50.10	20.64	19.00	n/d	n/d	0.30	<0.01
LPC H&C (Limit of Permissible Concentration for Household and Community water use)		6.5-8.5	-	500.0	350.0	1.0	10.0	1.5	0.0001*	-	-	200+50*	0.30*	0.30*	2.00	-
LPC F (FOR FISHING)		6.5-3.5	-	100.0	300.0	0.08	40.0	0.75*	-	180.0*	50.0*	120+50*	0.10*	0.10*	0.50	-
Norms of irrigation water quality		6.5-8.4	300.0	500.0	250.0	0.5	45.0	1.5	10.0	300.00	150.0	150+30	2.0	2.0	0.1	

Table A 1- Chemical analysis of water samples taken in 2009 in the area of “Makmalgold” *from 2010, Ltd. "Kyrgyzaltyn". A new tailings GEE «Makmalgold ». EIA (Environmental Impact Assessment).*

№ of sample	Sampling point	Content mg/l														
		Al	As	Sb	V	Mo	Ti	Mn	Cu	Zn	Pb	Ni	Co	Cd	CN gen	Solid residue
10347	Spring t.16	<0.01	<0.001	<0.01	<0.01	<0.01	<0.01	**0.16**	0.007	0.043	**0.031**	0.020	0.019	**0.003**	0.03	868
10348	Spring t. 17	<0.01	<0.001	<0.01	<0.01	<0.01	<0.01	0.017	0.004	0.023	0.025	0.008	0.010	0.001	<0.01	484
10358	Spring t. 27	<0.01	<0.001	<0.01	<0.01	<0.01	<0.01	0.006	<0.005	0.025	0.009	0.005	0.011	0.001	<0.01	470
10359	Spring t. 28	<0.01	<0.001	<0.01	<0.01	<0.01	<0.01	0.003	<0.005	0.040	0.010	0.002	0.012	**<0.005**	<0.01	466
10357	Pond L and PS	<0.01	<0.001	<0.01	<0.01	<0.01	<0.01	0.009	0.002	0.055	0.010	0.010	0.015	0.001	<0.01	442
10349	Hole №20	<0.01	<0.001	<0.01	<0.01	<0.01	<0.01	0.010	0.007	0.298	0.015	0.015	0.015	**<0.005**	<0.01	699
10350	Hole №N7	<0.01	<0.001	<0.01	<0.01	<0.01	<0.01	0.095	0.012	0.260	**0.035**	0.030	0.028	**<0.003**	0.31	**1524**
5695	Hole № N7(2006)	<0.01	<0.001	<0.01	<0.01	<0.01	<0.01	0.01	0.300	0.055	0.028	0.010	0.008	**<0.005**	<0.035	**1748**
10351	Hole №17	<0.01	<0.001	<0.01	<0.01	<0.01	<0.01	0.015	0.012	0.107	0.020	0.010	0.011	0.001	0.06	700
5693	Hole №17(2006)	<0.01	<0.001	<0.01	<0.01	<0.01	<0.01	<0.01	0.008	0.007	<0.01	0.006	0.005	**<0.005**	<0.035	392
10352	Spring №2	<0.01	<0.001	<0.01	<0.01	<0.01	<0.01	**1.88**	0.006	0.232	**0.035**	0.010	0.030	0.002	1.16	**1144**
5692	Spring №2(2006)	<0.01	<0.001	<0.01	<0.01	<0.01	<0.01	<0.01	0.017	0.030	0.020	0.009	0.008	**<0.005**	<0.035	**1406**
10353	Spring №3	<0.01	<0.001	<0.01	<0.01	<0.01	<0.01	0.015	<0.005	0.057	0.013	0.007	0.015	0.001	0.04	578
10354	Hole №12	<0.01	<0.001	<0.01	<0.01	<0.01	<0.01	**0.135**	0.004	0.243	0.010	0.005	0.015	0.001	<0.01	816
5687	Hole №12(2006)	<0.01	<0.001	<0.01	<0.01	<0.01	<0.01	<0.01	0.015	0.067	0.018	0.012	0.007	**<0.005**	<0.035	746
10355	Pond at dam footing	<0.01	<0.001	<0.01	<0.01	<0.01	<0.01	0.009	0.001	0.005	0.012	0.005	0.021	**<0.005**	<0.01	**1102**
5688	Pond at dam footing (2006)	<0.01	<0.001	<0.01	<0.01	<0.01	<0.010	<0.01	0.014	0.067	0.018	0.012	0.007	**<0.005**	<0.035	**1320**
10356	Spring t. 25	<0.01	<0.001	<0.01	<0.01	<0.01	<0.01	0.08	0.021	0.005	0.020	0.010	0.020	**0.003**	<0.01	878
5704	Settling pond of tailing (2006 г.)	<0.01	<0.001	<0.01	<0.01	<0.01	<0.01	<0.01	0.104	0.136	0.023	0.021	0.009	**<0.005**	<0.035	**1078**
5707	Pulp (2006)	<0.01	<0.001	<0.01	<0.01	<0.01	<0.01	<0.01	**3.51**	**1.43**	0.015	0.019	0.026	**<0.005**	**15.45**	**1184**
10360	Naryn river	<0.01	<0.001	<0.01	<0.01	<0.01	<0.01	0.005	***0.013***	***0.015***	0.005	0.005	0.015	0.001	<0.01	374
10361	Kugarat river	<0.01	0.001	<0.01	<0.01	<0.01	<0.01	0.010	***0.005***	***0.017***	0.005	0.008	0.005	0.002	<0.01	266
LPC H&C		0.50*	0.05*	0.05	0.10	0.25	0.10	0.10	1.0	1.0	0.03	0.10	0.10	0.001	0.10	1000
LPC F		-	0.05*	-	0.001	0.0004	-	0.01	0.001	0.01	0.10	0.01	0.01	0.005	0.05	470
Norms of irrigation water quality		0.50	0.05	0.05	-	0.50	-	-	1.0	1.0	0.03	0.20	0.20	-	-	1000
Note: 1. Rates exceeding LPC H&C are in bold type; 2. Rates exceeding LPC F are in bold and italic type; 3. Rates active for the Republic of Kazakhstan are marked as *.																

Table A 1- (continued) Chemical analysis of water samples taken in 2009 in the area of "Makmalgold" from 2010 г.. Ltd. "Kyrgyzaltyn". A new tailings GEE «Makmalgold ». EIA (Environmental Impact Assessment)

№ samples	№ prospecting hole	Depth m	Elements name mg/kg																							
			Sr	Co	Zn	Y	Cu	Sn	Mo	Ba	Ni	Mn	V	Ti	Pb	Cr	Ag	Zr	Li	Be	Bi	Ga	W	P	As	Sb
The territory of a prospective tailing of «Makmal Gold» Mining Enterprise																										
10286	2	0-10	**300**	10 3.10	50	30	40 1.10	4	2	400	40 2.90	500	60.00	**2000**	30 7.10	50	1.5	**100**	**40**	1.5	1	8	**3**	500	29.9	15
10287		10-25	100	15 1.10	80	30	60 0.30	4	2	300	50 1.50	600	80	**3000**	150 1.50	50	100	**100**	30	1.5	10	10	3	600	27.7	**60**
10288		25-40	**200**	15 1.90	60	30	50 1.30	4	2	300	50 1.90	500	80	**2000**	30 2.50	50	1.50	**100**	**40**	1.50	1	10	3	600	32.8	15
10289	5	0-10	**300**	15 1.50	60	30	50 1.00	4	2	300	40 2.30	500	80	**3000**	20 4.20	60	1.00	**100**	**40**	1.5	1	10	3	600	18.1	15
10290		10-40	**200**	10 3	50	30	50 1.20	4	3	300	40 3.60	500	80	**2000**	60 5.30	50	100	**100**	30	1.5	3	8	3	600	27.7	30
10291		>40	**200**	15 3	60	30	60 1.00	4	2	300	50 3.10	500	80	**3000**	30 5.80	60	1.00	**100**	**40**	1.5	1	10	3	600	25.3	15
10292	9	0-10	100	10 nd	60	20	50 nd	5	2	300	50 nd	600	80	**3000**	20 nd	60	1.00	**100**	**40**	1.5	1	15	3	600	nd	15
10293		10-25	100	10 nd	60	20	50 nd	4	2	300	50 nd	600	80	**3000**	30 nd	60	25	**100**	30	1.5	1	10	3	600	nd	15
10294		25-40	100	10 nd	50	30	50 nd	4	3	300	50 nd	600	80	**3000**	30 nd	80	2.50	**100**	**40**	1.5	1	10	3	800	nd	15
Elements average concentrations in the soils of a prospective tailing territory of «Makmal Gold» Mining Enterprise																										
Average concentrations of hor. 0-10			**233**	11.7 2.30	56	26	46.67 1.50	4	2.00	333	43.33 2.60	533	73	**2667**	23.33 5.65	56	1.17	100	**40**	1.50	1.00	11	3	566	24	15
Average concentrations of hor. 10-25			133	11.7 2.05	63	26	53.33 0.75	4	2.33	300	46.67 2.55	566	80	2667	80 3.40	53	75	100	30	1.50	4.67	9.33	3	600	27.7	35
Average concentrations of hor. 25-40			**167**	13.3 2.45	57	30	53.33 1.15	4	2.33	300	50.00 2.50	533	80	2667	30 4.15	63	1.67	100	**40**	1.50	1.00	10	3	667	29.1	15
Average of all hor.			**178**	12 2.3	58.9	27	51.11 0.98	4.1	2.22	311	46.67 2.55	544	77.8	**2667**	44.44 4.40	57.8	25.9	**100**	**37**	1.50	2.22	10	3	611	26.9	22
SPZ territory of a prospective tailing of «Makmal Gold» Mining Enterprise																										
10286	1	0-10	100	25 0.10	80	30	60 0.20	4	2	300	50 0.30	600	80	**3000**	80 2.5	50	80	**150**	**40**	1.5	2	15	3	600	36.7	15

Table A 2- Chemical analysis of soils from the Makmal Gold Mining Enterprise area (2009).

№ samples	№ prospecting hole	Depth m	Elements name, mg/kg																						
			Sr	**Co**	**Zn**	**Y**	**Cu**	**Sn**	**Mo**	**Ba**	**Ni**	**Mn**	**V**	***Ti***	**Pb**	**Cr**	**Ag**	**Zr**	**Li**	**Be**	**Bi**	**Ga**	**W**	**P**	**As**	**Sb**
10287	1	10-25	100	25 1.1	60	30	50 0.50	4	2	300	50 1.10	500	80	**3000**	30 0.20	60	1	**100**	**40**	1.5	1	10	3	600	30.9	15
10288		25-40	100	15 2.30	60.00	30	60 1.00	4	2	300	40. 1.90	500	80	**3000**	150 1.50	50	100	**100**	20	1.50	8	8	3	600	32.6	**50**
10289	3	0-10	100	20 0.60	150	30	80 0.50	4.00	2	300	50 0.40	600	80	**3000**	150 0.10	50	100	**100**	30	1.50	10	15	3	600	29.6	**60**
10290		10-40	**300**	15 3.80	60	20	40 1.40	4	1.5	400	40 3.60	500	80	**2000**	20 5.80	60	1.50	**100**	40	1.50	1.00	8	3	500	24.5	15
10291		>40	**400**	10. 0 3.90	50	20	40 1.6	4	1.5	300	40.00 3.90	500	80	**2000**	20 10	60	2	**100**	30	1.5	1	8	3	500	23.9	15
10292	4	0-10	100	20 0.8	150	30	100 0.00	4	2	300	40 1.00	600	80	**3000**	400 0.20	50	100	**100**	**40**	1.50	25	15	3	600	28.1	**150**
10293		10-25	100	15 1.2	80	30	50 0.40	4	2	300	40 1.9	500	80	**3000**	20 0.9	50	1.50	**100**	**40**	1.5	1	10	3	600	20.4	15
10294		25-40	100	20 1.7	80	30	50 0.8	4	2	300	40 2.8	500	80	**3000**	40 2.60	60	50	**100**	**50**	1.50	1.00	10	3	600	29.8	15
10286	6	0-10	100	20 nd	150	20	60 nd	4	2	300	50 nd	600	80	**3000**	60 nd	60	60	**100**	**40**	1.50	3.00	15	3	600	nd	15
10287		10-25	100	10 nd	80	20	50 nd	4	1.5	300	40 nd	600	80.00	**3000**	20 nd	60	2.50	**100**	30	1.50	1.00	10	3	600	nd	15
10288		25-40	**200**	10 nd	50	20	50 nd	4	1.5	300	40 nd	600	80	**3000**	40 nd	60	40	**100**	**40**	1.50	2.00	10	3	600	nd	15
10289	.	0-10	**200**	10 nd	40	20	40 nd	4	1.5	300	40 nd	500	80	**3000**	15 nd	60	1.5	**150**	30	1.50	1.0	10	3	600	nd	15
10290	7	10-40	**300**	10 nd	40	20	50 nd	4	1.00	300	40 nd	600	80	**3000**	30 nd	80	50	**100**	30	1	2	10	3	600	nd	15
10291		>40	**200**	10 nd	40	20	50 nd	3	1.50	400	50 nd	600	80	**3000**	15 nd	60	1.50	**100**	**40**	1.50	1.0	10	3	600	nd	15
10292	8	0-10	100	15 0.10	150	30	60 0.40	4	2	300	50 0.70	600	80	**3000**	40 0.10	50	40	**100**	**40**	1.50	3.0	15	3	600	30.2	20
10293		10-25	**200**	10 2.20	50	20	50 1.0	4	1.5	300	40 3.10	600	80	**3000**	15 3.30	60	2.5	**100**	**40**	1.50	1.00	10	3	600	29.8	15

Table A 2 (continued) Chemical analysis of soils from the Makmal Gold Mining Enterprise area (2009).

№	samples	Depth, m	Elements name, mg/kg																						
			Sr	**Co**	**Zn**	**Y**	**Cu**	**Sn**	**Mo**	**Ba**	**Ni**	**Mn**	**V**	**Ti**	**Pb**	**Cr**	**Ag**	**Zr**	**Li**	**Be**	**Bi**	**Ga**	**W**	**P**	**As**	**Sb**
10294		2540	**200**	8.00 2.50	50	20	50 1.40	4	1.5	300	40 3.30	500	80	**3000**	40 5.20	60	40	**100**	30	1.5	2.00	10	3	600	24. 7	15
10286		0-10	100	10	60	20	50	4	1.5	300	50	600	80	**3000**	30	60	15	**100**	30	1.5	1.00	15	30.	600	nd	15
10287		10-25	100	15	60	30	50	5	2	300	50	600	80	**3000**	20	80	2.50	**100**	**40**	1.5	1.00	15	4	800	nd	15
10288		25-40	100	15.	80	20	50	5.00	2.00	300	50	600	80	**3000**	40	80	40.00	**100**	50	1.5	1.00	15	3	800	nd	15
Elements average concentrations in the SPZ soils of a prospective tailing of «Makmal Gold» Mining Enterprise																									
Average concentrations of hor. 0-10			114.3	17.14 0.40	111.43	25.71	64.29 0.28	4.00	1.86	300	47.14 0.60	585.7	80	**3000**	110.7 0.73	54.29	56.64	**114**	**36**	1.5	6.43	14.29	7	600	31	**41.4**
Average concentrations of hor. 10-25			**171.5**	13.57 2.08	61.43	24.29	50 0.83	4.14	1.64	314	42.86 2.43	557.1	80	**2857**	22.14 2.55	64.29	8.79	**100**	**37**	1.5	1.14	10.43	3.14	614	26	15
Average concentrations of hor. 25-40			**186**	12.57 2.60	58.57	24.29	50 1.20	4.00	1.71	314	42.86 2.98	542.9	80	**2857**	49.29 4.83	61.43	39.07	**100**	**37**	1.5	2.29	10.14	3	614	27	20
Average of all hor.			**157**	14.43 1.69	77.14	24.76	54.76 0.77	4.05	1.74	310	44.29 2.00	561.9	80	**2905**	60.71 2.70	60	34.83	**105**	**37**	1.5	3.39	11.62	4.38	610	28	25.48
Background of «Makmal Gold» Mining Enterprise																									
10292	11 Back groun d	0-10	100	15 0.50	60	30.00	50 0.40	4.00	2.00	300	501.2 0	600	80	**3000**	30 0.50	60	1.5	**100**	**40**	1.5	1.00	15.00	3	600	29	15
10293		10-25	100	15 0.50	80	30.00	50 0.40	5.00	2.00	300	50.00 1.80	600	80	**3000**	50 0.20	80	40	**100**	**50**	1.5	3.00	15.00	4	600	29	15
10294		25-40	100	15 2.30	60	20.00	40 1.20	4.00	2.00	300	50.00 3.10	600	80	**3000**	30 5.30	60	1.0	**100**	**40**	1.5	1.00	15.00	4	600	32	15
Elements average concentrations in the soils of a background of «Makmal Gold» Mining Enterprise																									
Average concentrations of hor. 0-10			100	15 0.50	60	30.00	50 0.40	4.00	2.00	300	50.00 1.20	600	80	**3000**	30 0.50	60	1.5	**100**	**40**	1.5	1.00	15.00	3	600	29	15
Average concentrations of hor. 10-25			100	15.00 0.50	80.00	30	50 0.40	5.00	2.00	300	50.00 1.80	600	80	**3000**	50 0.20	80	40	**100**	**50**	1.5	3.00	15	4.00	600	29	15.0
Average concentrations of hor. 25-40			100	15.00 2.30	60.00	20	40 1.20	4.00	2.00	300	50.00 3.10	600	80	**3000**	30.0 0	60	1.00	**100**	**40**	1.5	1.00	15	4.00	600	32	15.0
Average of all hor.			100	15.00 1.10	66.67	26.67	46.67 0.67	4.33	2.00	300	50.00 2.03	600	80	**3000**	36.67 2.00	66.67	14.17	**100**	**43.33**	1.5		15	3.67	600	30	15.0

Table A 2 (continued) Chemical analysis of soils from the Makmal Gold Mining Enterprise area (2009).