ENVIRONMENTAL QUALITY CONTROL OF MINING ACTIVITIES IN THE PROVINCE OF CATAMARCA. ARGENTINE REPUBLIC

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INTRODUCTION

Section 41 of the Constitution of the Argentine Republic states: *"All citizens have the right to a safe and balanced environment... Environmental damage shall primarily involve the obligation to restore as established by law"*. National Law No. 24196 of Mining Development for the Argentine Republic encouraged large mining investments in our country, and Article 7 thereof states *"In order to avoid and remedy any alterations caused by mining activities to the environment, companies shall provide a special allowance for such purpose"*. Section 1 of National Law No. 24585 of Environmental Protection for Mining Activities, states: *"Environment protection and preservation of natural and cultural resources which may be affected by mining activities, shall be ruled by the provisions of this title"*.

On July 8, 1996, the Government of the Province of Catamarca, by virtue of Decree No. 892 with Ministerial Consent, created the Environmental Secretariat of State, whose major mission and purpose is *"to protect the environment, which is within the scope of the State"*.

Within the framework of the creation of this environmental protection agency and, based upon the terms of several national laws and decrees, both the control and monitoring of natural resources were fostered to minimise and, if appropriate, encourage the recovery of environments degraded by the mining activity which, as from the enactment of Law No. 24196, offered wide development prospects in our country.

The enforcing agency of all the rules for the environmental protection of the Province of Catamarca established strict control and monitoring of the natural resources involved in mining activities in order to effectively protect the environment, subject matter of this report.

GEOGRAPHIC LOCATION

The Province of Catamarca (101,660 km^2) is located in the Northwest of Argentina. The Capital City, San Fernando del Valle de Catamarca, is 520 m above sea level and 1,145 km from Buenos Aires. Its large area together with its geographic characteristics (70% mountain) allow this province to have a wide range of microclimates and landscapes. According to the 1991 national census, it had 300,636 inhabitants.

We can divide the province in: east, central and west regions. The latter (where major mining projects are located) includes the departments of Tinogasta, Antofagasta de la Sierra, Belén, Santa María, Pomán and Andalgalá, with climates ranging from arid to desert and cold and a low bio-diversity environmental system.

The west region is connected by two roads, one crossing the area from East to West (National Route No. 60, to Chile), and another one from North to South (National Road No. 40, reaching the provinces of La Rioja and Salta).

Water resources of the area result from surface water intake and underground water in valleys between mountains.

Figure 1 shows the geographic location both of the Province of Catamarca and the West region, where mining projects Farallón Negro, Minera Alumbrera, Minera del Altiplano and Agua Rica are located.

MINING PROJECTS IN CATAMARCA

Bajo de la Alumbrera

Bajo de la Alumbrera deposit is located in the Hualfín district, department of Belén, 2,600 m above sea level. In terms of geology, this deposit is in the Miocene- Pliocene Age Farallón Negro volcanic complex, which is also located in the Sierras Pampeanas region, very close to the south limit of the Puna. It is a porphyry copper-bearing type deposit.

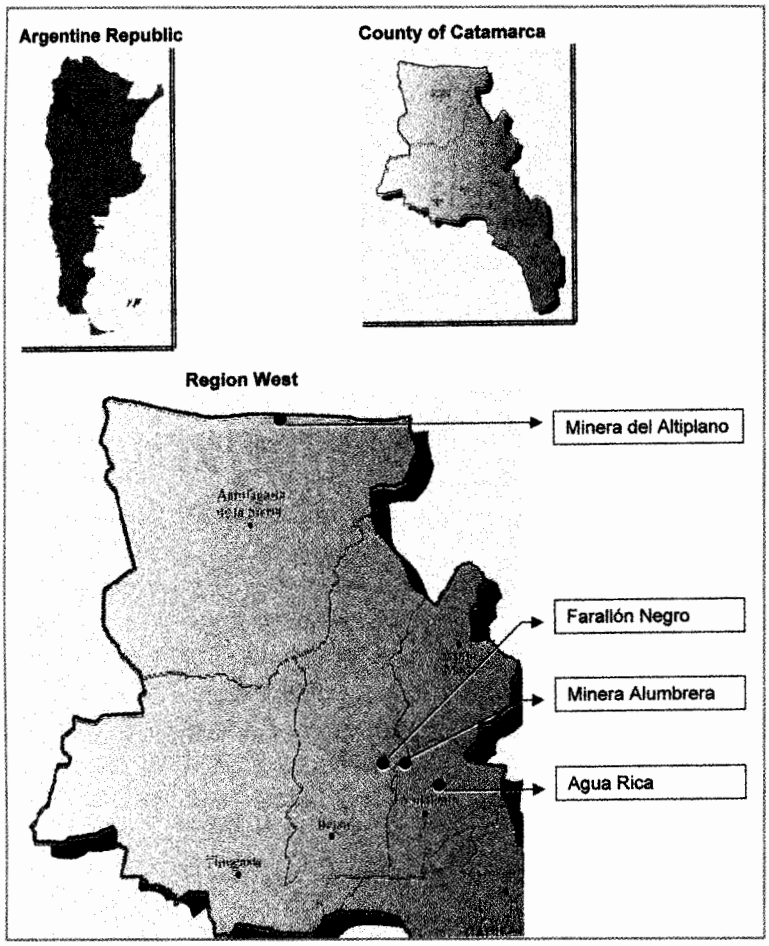


Figure 1. Location of monitoring and inspection sites.

The annual production has been estimated in 730,000 tonnes of concentrate with 190,000 tonnes of fine copper and 710,000 ounces of gold which can be obtained from the concentrate itself and through gravity after treating 80,000 tonnes per day (120,000 tonnes as from year 5) of the ore with an average copper and gold grades of 0,51% and 0,64 gr/ton, respectively.

This is an open pit mine where ore is mined and transported by the heaviest equipment of the market up to the primary crushing process. The concentrate is obtained through a flotation hydrometallurgical process and transported in a 330 km pipeline up to Cruz del Norte, in the province of Tucumán, where the filter plant is located. After drying the concentrate, it is transported to the Port of Rosario where it is shipped to different smelters and refineries abroad.

Production started in October 1997. 75% of capital stock belongs to two Australian companies and the remaining 25%, to a Canadian one. The three companies made up Minera Alumbrera Limited which organised a Joint Venture with Yacimientos Mineros Agua de Dionisio (YMAD), owner of the mining rights to operate the deposit.

The project total investment reached 1.2 billion dollars with a direct investment in the province of Catamarca of 800 million dollars, thus being the most important mining project of the Argentine Republic. Once it starts operations, it will rank 9th among copper mines and 14th among gold ones throughout the world. The life of the project has been primarily estimated in 25 years, however, the company is currently undergoing a deep exploration program to evaluate the availability of resources.

Operation of this mine requires large volumes of water taking into account the process used (flotation), a resource taken from the Campo del Arenal water basin. The waste rock resulting from the pit stripping is deposited in "waste dumps", next to the "tailings dam", where plant tailings are discharged. This waste material is a potential generator of acid drainage because of its mineralogy (sulphides, being the most common, pyrite) and migration of heavy metals deposited over the Río Vis Vis-Amanao water basin, a river flowing to the South to the Salar de Pipanaco basin.

Minera del Altiplano

This project is located in Salar del Hombre Muerto, department of Antofagasta de la Sierra in the north of the province of Catamarca, near the border with the province of Salta, at an average height of 4,000 m above sea level. Salar del Hombre Muerto is a 240 km^2 area from where saturated brine with sodium, lithium, potassium, magnesium, calcium, borate and sulphates is obtained.

Brine is taken from 6 production wells up to 40 m deep. Then, it is pumped to the selective absorption plant where it is concentrated for lithium and most of the other components are eliminated. Treatment occurs in the salt desert, thus obtaining lithium carbonate and the rest is transported to Güemes, province of Salta, where lithium chloride is obtained. Both products

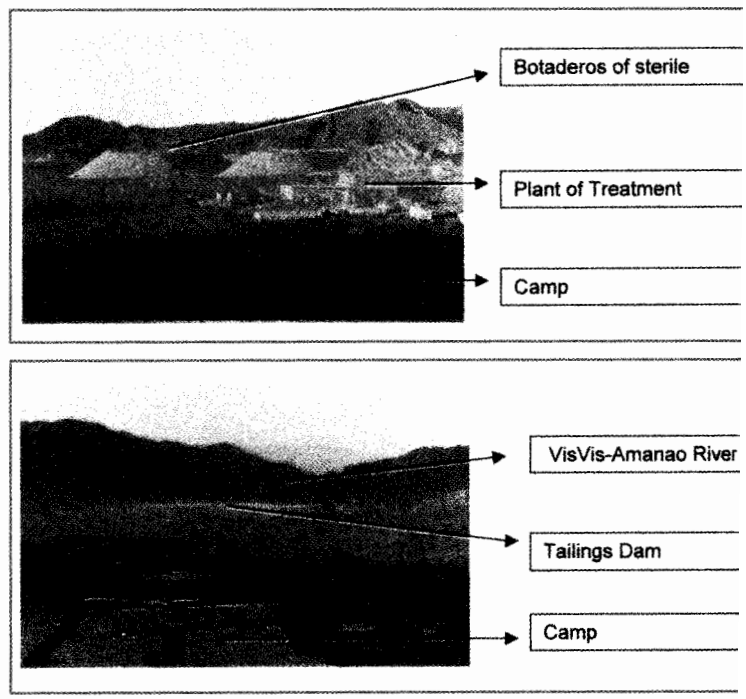
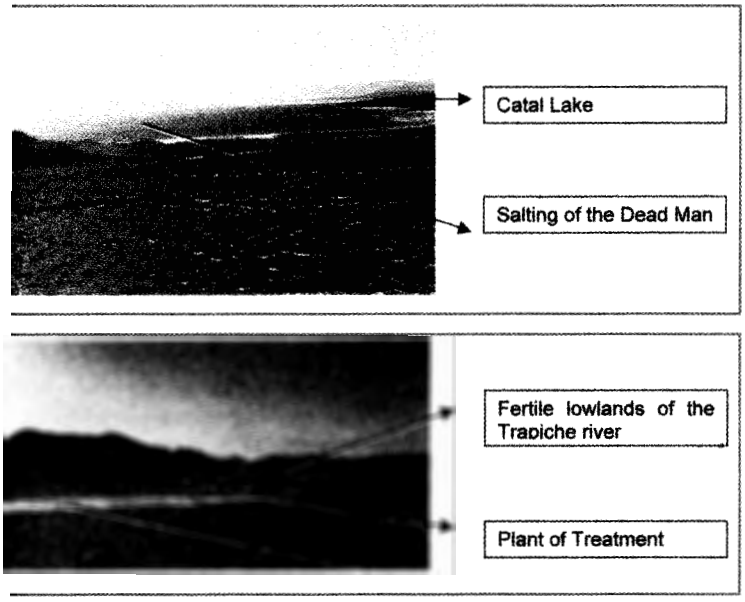


Figure 2 and 3. Minera Alumbrera Treatment Plant and Tailings Dam.

are then exported through the Antofagasta port in the Republic of Chile.

Average lithium concentration is 692 ppm. The selective absorption process was specially designed for this project. Annual production will be 25 million pounds of lithium carbonate and 12 million pounds of lithium chloride.

The so called Fenix project is being developed by FMC Corporation Litium Division which organised in Argentina Minera del Altiplano S.A. company, with a 110 million dollar investment. The company has evaluated the resources for a 75 year life, considering 40 m deep drills. Up to date, drills over 100 m allow to estimate that the life of the deposit could largely exceed such expectation.



Figures 4 and 5. Minera del Altiplano Salar del Hombre Muerto and Treatment Plant.

Farallón Negro

The field is located in the district of Hualfín, department of Belén, at 2,400 m above sea level and approximately 10 km to the Southeast of Bajo de la Alumbrera mine. It belongs to the Farallón Negro volcanic complex. It is a hydrothermal deposit full of fractures with 75 grade dipping veins and 4 m average thickness. Operation is underground with average gold and silver grades of 6 gr/ton and 100 gr/ton, respectively. This deposit is exhausted and currently, a parallel vein, called Alto de la Blenda, with similar characteristics, located 700 m from it is being operated. Gold and silver content amounts to 3,8 gr/ton and 90 gr/ton, respectively.

Metals are obtained through the cyaniding method in a treatment plant with a 500 ton/day capacity, and 350 ton/day being currently treated. Nowadays beaches are being prepared to mine low grade ore through pile leaching.

This mine is being operated by Yacimientos Mineros Agua de Dionisio (YMAD), a state-owned company whose Board is made up of two representatives of the province of Catamarca, two of the National University of Tucumán and a President appointed by the Federal Executive. YMAD is the owner of the Farallón Negro mining district which includes: Farallón Negro, Bajo de la Alumbrera, Alto de la Blenda, Agua Tapada and other important areas.

Agua Rica

Agua Rica deposit is located 30 km to the North of the Andalgalá head of department and about 35 km from Bajo la Alumbrera, on the west side of Nevados de Aconquija, at 3,100 m above sea level. 80% of the 400-hectare concession has slopes over 25 grades and more than 40 % of the area has slopes over 35 grades.

This is porphyry copper-bearing type deposit with an epithermal system overprinted by secondary enrichment, having economically profitable minerals such as copper, gold and molybdenum.

The Joint Venture made up of BHP Minerals, an Australian company, and Northern Orion (holders of 70% and 30% of capital stock, respectively) is performing the final feasibility studies of the Agua Rica Project. For such purpose, 176 holes totalling 67,000 m, have been drilled. Cities Services mining company had drilled, between 1970 and 1972, about 8,000 m, with the field not being operated for over 20 years.

In accordance with the studies performed, reserves are higher than those of Alumbrera. Currently, exploration has been suspended as a consequence of the gold and copper price decline in the world market. If such prices are boosted, during the first years of the next century, civil works to operate the field will start being executed.

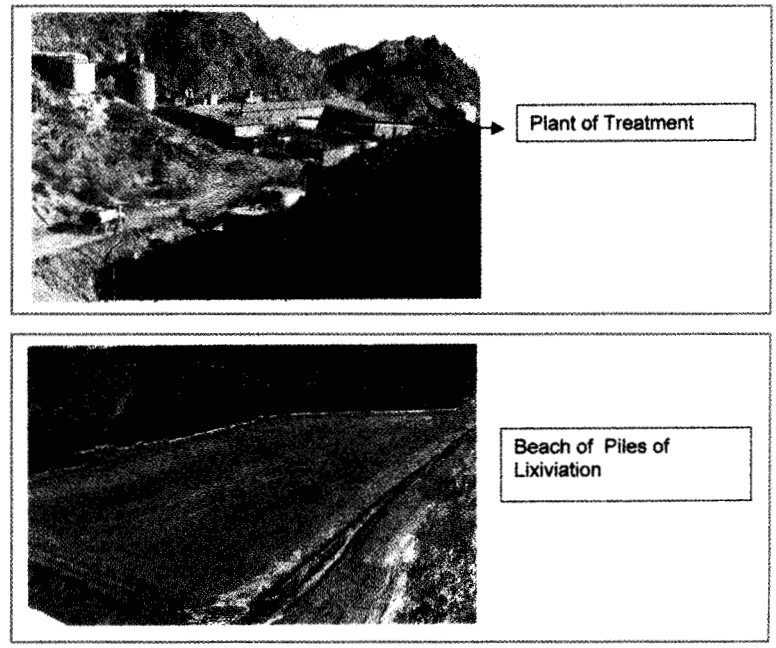


Figure 6 and 7. Farallón Negro Treatment Plant and Leaching Pile Beach.

Figures 8 and 9. General view of Exploration and Environmental Protection Area of BHP Minerals.

ENVIRONMENTAL MONITORING PROGRAMME FOR MINING INDUSTRIES IN CATAMARCA

A work plan including monitoring of the above-mentioned mining areas has been developed by the Instituto de Gestión y Coordinación de la Investigación de los Recursos Naturales (Natural Resources Research and Co-ordination Management Unit) to control and follow up potential environmental changes in the critical areas of each development. For such purpose, a field work plan has been devised with the corresponding lab work plan.

Month / day	1	1	1	1	1	1	1	1	1	
January		MAA	MAA							
February	MAA	MAA	MAA	MAA	SHM	SHM	FN	FN	AR	
March		MAA	MAA							
April		MAA	MAA							
May		MAA	MAA	MAA	MAA					
June		SHM	SHM	FN	FN	MAA	MAA	AR		
July		MAA	MAA							
August		MAA	MAA	MAA	MAA					
September	MAA	MAA								
October		SHM	SHM	FN	FN	MAA	MAA	AR		
November	MAA	MAA	MAA	MAA						
December	MAA	MAA								

MAA Quarterly monitoring of Minera Alumbrera
SHM 4-month monitoring of Salar del Hombre Muerto
FN 4-month monitoring of Farallón Negro
AR 4-month monitoring of Agua Rica
MAA Monthly monitoring of Minera Alumbrera´s Tailings Dam.

MONITORING OF MINERA ALUMBRERA

Water monitoring

Dirección de Hidráulica started environmental monitoring of mining activities (initially including the hydrochemical monitoring of Vis Vis – Amanao River – from Amanao to the minesite) in 1995 with the completion of the technical feasibility study, the approval and commencement of the civil works comprised in the Bajo de la Alumbrera mining facilities. Dirección de Hidráulica became a division of the Environmental Secretariat, when the latter was established. Surface water bodies to be monitored were identified in 1995.

Public water rights over Campo del Arenal for industrial/mining purposes were granted through Decree # 062 to Minera Alumbrera by the Provincial Government in January 1996. Under such decree the company is bound to carry out regular hydrometric and hydrochemical surveys according to a monitoring schedule to be agreed upon with the provincial authorities. Accordingly, in July 1996 the following monitoring programme was agreed:

Ground water monitoring

- Quarterly measurement of the static level of the aquifer in Campo del Arenal, the minesite, the tailings dam and the Vis Vis-Amanao River.
- Field parameters: pH, electric conductivity and temperature (quarterly measurement).
- Sample collection for physical and chemical analyses (semi-annual measurement)
- 26 Monitoring wells

Surface water monitoring

- Quarterly measurement of water flows
- Field parameters: pH, electric conductivity and temperature (quarterly measurement).
- Sample collection for physical and chemical analyses (quarterly measurement)
- Monitoring stations in River Santa María, Los Nacimientos, Las Cuevas and Vis Vis – Amanao (7 stations in aggregate)

Physical and chemical analyses are made by several qualified labs and currently by a government agency (Comisión Nacional de Energía Atómica).

Monitoring results at Campo del Arenal are in line with the company´s MODFLOW predictions.

No major changes requiring a change in the agreed programme have been identified at the minesite.

In order to exercise an effective governmental control, the long-term programme for the tailings dam, Vis Vis-Amanao River area includes a number of stations mainly downstream from the tailings dam (the siting of the pump-back system) and the Vis Vis Amanao River to identify and predict the potential adverse impact on water resources based on mineralisation in the area and the acid-generating nature of the waste dump and tailings dam with the resulting heavy metal migration. Please note that within the project boundaries, water chemical standards vary as shown in the company´s hydro-geochemical models.

Hence – i.e. from the last pumpback well (monitoring station), downstream along Vis Vis Amanao river – to the date hereof, no chemical changes indicating potential water pollution have been identified. Indeed, temporary variations of some regular standards relative to the historical data available could be identified.

Simultaneously to the foregoing monitoring activities, the corresponding Environmental Impact Reports are prepared by the above-mentioned governmental agency in conjunction with the Provincial Mining Secretariat (the enforcement authority in mining issues).

Taking into account the high permeability of the area and the fact that, according to the technical reports provided by the company, both waste dumps and the tailings dam are situated on a complex fault system converging towards the Vis Vis Amanao basin, it is hereby strongly recommended that monitoring be made on a monthly basis and occasionally, every 2 weeks in order to predict anomalies. The company was also required to install additional assessment wells downstream of the company property.

Dangerous waste

Taking into account that the Environmental Secretariat is the enforcement authority of National Act # 24051 (the Dangerous Waste Law) and, pursuant to the provincial law of adherence, waste generation by mineral processing and its related activities is monitored simultaneously to water monitoring. Major anomalies in terms of dangerous waste management have been identified during the early operational months. These anomalies were then corrected and currently all the legal requirements are being met by the company.

General environmental issues

All site visits include the following environmental inspections:

- Vegetation: taking into account the overall ecosystem, the loss of natural habitat at the mine site is negligible - described as "irreversible" in the initial environmental impact report.
- Wildlife: Similarly to the preceding paragraph, the impact is irreversible. On-going discussions with the company of aided revegetation programmes to reinstate the natural habitat. Please note that the phytogeographic area affected by the project (mine, slurry pipeline and powerline) is 0,2%.
- Palaeontological and Archaeological Sites and Cultural Heritage: No major archaeological sites have been identified at the mine site, at the well field or at the water pipeline. As the northern corridor (powerline) goes through major historical and cultural sites, the company together with the Provincial Archaeological Division had to remove several archaeological elements from those sites. The company has now in place a reinstatement programme for the affected area.

MONITORING OF MINERA DEL ALTIPLANO

Water monitoring

The initial visit to Salar del Hombre Muerto was made in March 1998 in order to analyse the strategic locations for environmental monitoring. Thus, five locations were identified:

- Brine feed,
- Fresh water from Trapiche River,
- Fresh water from Trapiche River and additional wells,
- Waste brine,
- Waste water seepage from the camp.

To date, the figures for each sample are within the standards established by Act 24585 (the Environmental Protection Law for Mining Activities), taking into account that it is a brine treatment process.

In order to avoid a strong impact on the local habitat, two areas were identified for the initial study, to wit:

- Fertile lowlands of the Trapiche River: Upstream from the salt lake, the river goes through low lands – which have been removed with the construction of a dam and wells with the corresponding adduction pipeline. The ecological value of vegetation is not high. Historically, however, this area was pasture-land for wildlife.

Currently, specialised staff from this governmental agency, upon our request, are analysing the potential impact on this highly sensitive area considering its geographical location and its high biodiversity relative to the rest. According to the company, the impact is minimum.

- Waste Brine Dump: it is located at the Catal Pond (Salt Lake). Large flocks of water birds (mostly flamingos, bald coots and ducks) are present in this type of lagoon. Although they feed at the lagoon, they do not compete for crustaceae. As these animals live in a salty environment, their osmotic pressure is high as a result of the high concentration of salt. Thus, if salt is removed, water would seep into their cells and tissues with cells collapsing due to the expansion of their cell membrane. Impact might also be strong if the water pH is changed (from slightly alkaline to alkaline) by adding acidic agents which might result in an enzymatic blockage that would in turn affect the cell metabolism thus causing the death of animals and plants.

As stated above, to date no changes affecting the physical and chemical water conditions that may allow us to predict the above-described alterations have been identified.

Dangerous waste

Similarly to the other projects, instructions have been given to the company for the enforcement of the Dangerous Waste Law.

General environmental issues

Whilst no major changes requiring a new company approach have been identified, it was recommended that the ecological flow be included in order to protect the Trapiche River low lands.

MONITORING OF FARALLÓN NEGRO

Water monitoring

Based on our organisational goal of protecting the provincial environment, monitoring of the Aguas de Dionisio river (where Farallón Negro´s tailings dam with cyanide composites is located) started in May 1998. Initially, four monitoring sites were identified. The initial sample results indicate free cyanide and heavy metal (mainly Mn, Fe, Cu) traces below the drinking water standards applicable in Catamarca, Argentina and USEPA.

Notwithstanding the results obtained to date, our goal is to continue meeting the agreed schedule taking into account that such river is a tributary to the Belén River, the 70 km-long source of drinking and irrigation water of a 15,000-people community. This river then feeds the Campo de Belén aquifer, which is an integral part of the Salar de Pipanaco basin - also the mouth of the Amanao River, coming from the Bajo de la Alumbrera mine.

Taking into account that monitoring of this area has not been contemplated in the programme agreed with YMAD authorities (the holder of mining rights over Farallón Negro), the Environmental Secretariat is exclusively responsible for monitoring this area. Our intention is to have such an agreement in place in the near future.

To date, analyses have been made at the water lab of the provincial drinking water utility. The standards identified are within the drinking water standards but are not in line with our requirements. The remaining standards such as heavy metals and free cyanide, are determined using our own equipment – to be described later on.

Several reports on the eventual pollution of the Belén River were made before the provincial environmental agency was established. However, those statements no longer have scientific ground. Our main objective is now to continue with the monitoring programme.

Dangerous waste

As stated above, this company uses cyanide as a process chemical agent. Thus, the current situation should be carefully analysed, as in the past, it was not subject to control by any governmental unit. Thus, objectives were set in subsequent meetings to enforce the Dangerous Waste Law as pile leaching is expected to be implemented in the near future in order to recover low grade gold and silver.

Dry flow monitoring and dangerous waste (including cyanide containers) should be managed downstream from the leaching piles. If the goals are not timely met, the Environmental Secretariat will enforce the applicable environmental provisions.

General environmental issues

Taking into account that the impact of this on-going project in terms of investment is modest, no changes in the regional landscape in terms of vegetation, wildlife, historical and cultural heritage, archaeological sites, etc., have been identified.

In the event minable resources were low, it would have a strong social impact as it employs 200 people who live at the camp which also includes a school, a police station, health facilities, etc.

MONITORING OF AGUA RICA

General environmental issues

It is highly convenient that we be actively involved in the decision-making process for the final location the tailings dam and the joint monitoring stations.

Baseline studies for this mega project have already been completed. Based on its being close to Andalgalá (the second largest town in the province), this project is highly sensitive.

The company has implemented an environmental programme for surface water including 18 sampling stations within the project area. Reports are referred to us for assessment.

Some of these stations are also subject to analysis of water supply for future mineral processing activities.

Subject to the corresponding evaluation and approval, an access trail was cleared in 1997.

EQUIPMENT AND TRAINING

As part of its environmental control activities, we acquired the necessary 4-wheel drive vehicles and portable lab equipment including a UV spectro-photometer, thermal pH and conductivity gauges, a stove, portable glass material, refrigerators, etc. for the field determination of physical and chemical standards (Figure 10).

With the support of the UN, the Training Assistance Programme for Argentine Miners ("PASMA") was implemented in 1997 to train technical staff involved in control mining activities. Thus courses covering the following areas were organised: Environmental Impact Assessment, Tailings Dams, Contingencies, Vegetation and Wildlife, Water Resources, Mathematical Modelling, etc.

We also had the chance to join several nation-wide courses on Dangerous Waste organised by the National Secretariat of Natural Resources and Sustainable Development.

Our intention is to continue providing specialist knowledge in order to optimise our work.

CONCLUSIONS

A control and monitoring programme for natural resources involved in provincial mining projects has been developed by the Environmental Secretariat, through its Natural Resources Research Co-ordination and Management Division. This programme will be a key step in terms of sustainable development that will help improve the quality of life in Catamarca.

Figure 10. Equipment and tasks in field.

One of the objectives of this presentation in an international Congress is to exchange views with international auditors regarding the environmental quality controls being currently made in Catamarca and to learn new techniques from similar projects in order to improve environmental protection.