HISTORY OF THE ENVIRONMENTAL ASPECTS OF THE LAS CRUCES PROJECT (PYRITE BELT, SPAIN)

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ABSTRACT

The Faralaes II exploration licence, which lies along strike to the east of Aznalcollar and covers an area of 69km² of Tertiary sediments (Figure 1), was granted to Riomin Exploraciones, a subsidiary of Rio Tinto, in October 1992. Exploration commenced at the western end of the licence with gravity surveying progressively covering the entire licence area. In late 1993 gravity surveying detected the edge of a large anomaly which was confirmed and closed off in early 1994. As resistivity surveying showed no bedrock relief capable of forming the anomaly and the first drill hole was sited in May 1994.

Due to as yet unknown reasons there is a small hole in the deposit (Figure 2) and the first borehole passed straight through this, missing the gossan and the main sulphide orebody but fortunately intersecting large amounts of (barren) stockwork and clearly indicating the presence of a large mineralised system. To date a total of 277 exploration and delineation holes have been drilled together with another 68 holes for hydrogeological, geotechnical or bulk sampling purposes.

The geological resource is now estimated at approximately 2Mt @ 5g/t Au and 110 g/t Ag in Gossan/leached cap material, 17Mt @ 6% Cu of secondary copper and 25Mt of primary sulphides @ 1% Cu, 1.5% Pb and 3.5% Zn.

During the investigation and evaluation of this deposit numerous environmental controls were undertaken in order to minimise the effect of the fieldwork and numerous environmental studies have been carried out leading up to the production of an EIA report. This document briefly describes the environmental controls and studies carried out in each stage of the project.

MEASURES FOR ENVIRONMENTAL PROTECTION

Several methods to minimise and monitor the environmental effects and risks were implemented progressively at Las Cruces during the various stages of the exploration work.

Initial evaluation phase

During the initial evaluation phase (June 1994 to June 1995) activity on site was fairly low key and was restricted to two drilling rigs with some geophysical surveying (see Figure 3 for the amount drilled each quarter).

Although in environmental terms Riomin had not noted anything of particular interest in the area, after the first borehole proved that the anomaly was due to mineralisation, an environmental check of the area (14km²) was commissioned. Two companies (DBO5 and Ambio) who had experience of the area and were aware of the factors that could be important carried this out. Table 1 indicates the main items covered by the initial survey.

Archaeology
Climate/meteorology
Hydrology
Flora/Fauna
Land use /Soil types

Table 1. Main aspects covered by the initial environmental survey.

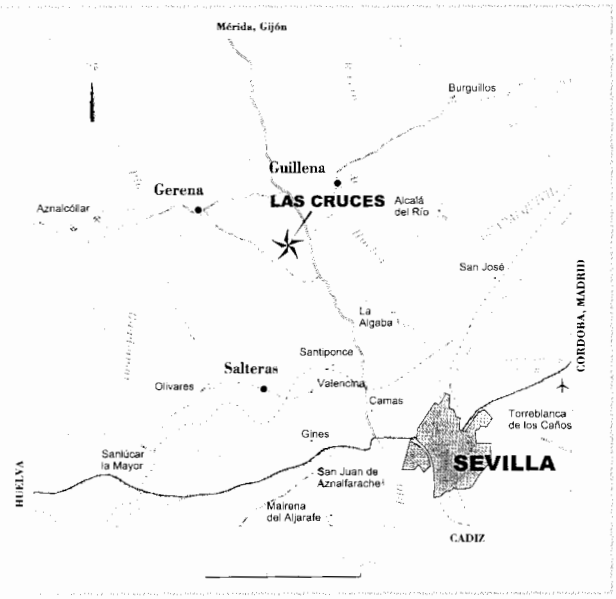


Figure 1. Location map.

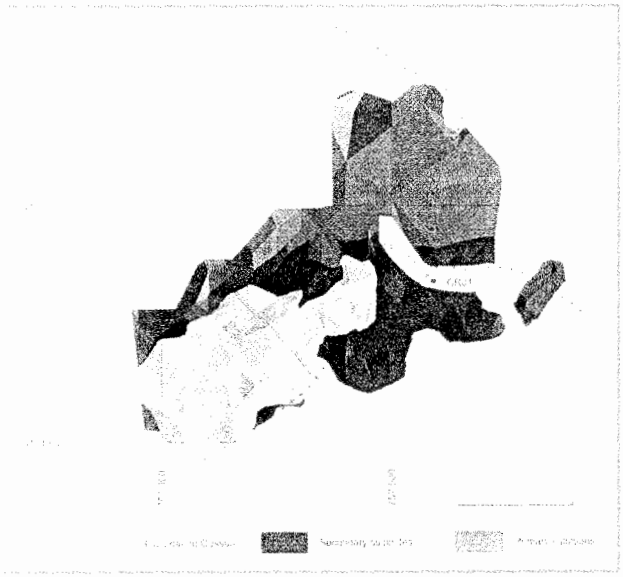
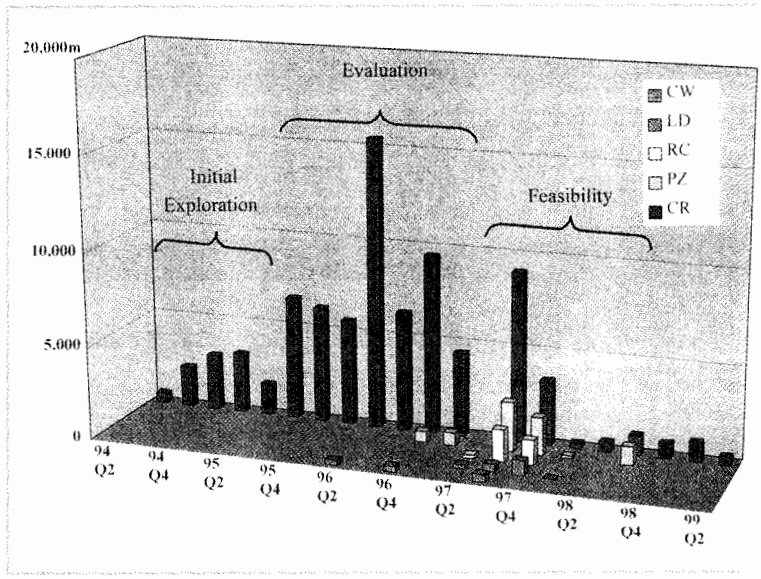


Figure 2. Orebody shape.

Not surprisingly, as the area is intensively farmed and there is a major road (Ruta de la Plata) 1 km away, the survey revealed little in the way of very unusual plant/animal life. However it did reveal the presence of numerous small archaeological sites which had not been noted by Riomin personnel,



(CW – Water Well, LD – Large diameter diamond drilling, RC – Reverse circulation, PZ – Piezometer drill holes. CR – Exploration/Evaluation diamond drill holes).
Figure 3. Quarterly drilling progress.

these consist mainly of fragments of ceramics and building materials which have been broken up and dispersed by years of ploughing. The areas with significant remains were marked in the field and no work that could result in disturbance of the remains was allowed inside these zones and drill sites were specifically moved to avoid them. This was fairly simple as most of the areas with remains are small, generally 20-30 m in diameter or width.

Despite the archaeological survey re-circulation pits excavated for drill holes occasionally encounter remains that have not been detected by the surface survey. As an example, during drilling of a piezometer to the north of the main project area, a small number of bone fragments were discovered in the soil excavated for the re-circulation pit and were identified as human remains. After completion of the borehole the pit was emptied and excavated by an archaeologist. A practically complete human skeleton was discovered, believed to date from the Islamic period, but the site appears to be a single isolated grave rather than a cemetery.

As well as the environmental survey, in the very early stages of the project, a set of 84 soil samples were collected on a 100m x 100m grid. These have been stored in a deep freeze since collection and will be available if necessary in the future to give background levels prior to commencing the project.

Main evaluation phase

Main aspects of the evaluation programme

In July 1995 it was decided to speed up the evaluation work by increasing the number of drilling rigs. Apart from a break in mid 1996 for a technical review of the data, there followed an almost steady increase in the intensity of fieldwork. This reached a peak in mid 1997 when there were 14 drill rigs of

various types operating on the project with most of them working 24 hours a day and 7 days per week. The project work force on site including contractors was in the region of 200 people. Table 2 shows the main tasks that were carried out during this phase of the programme.

This amount of activity obviously had a much large impact than earlier the work and tighter controls on a range of issues were instigated with the drilling and earthmoving contractors.

Task	
Bulk Metallurgical Sample	A total of 115t of mineralisation was obtained by reverse circulation and percussion rigs (11mm Ø).
Large Diameter Drilling	Four large diameter (231mm Ø) were drilled to obtain material for metallurgical and comminution test work.
Hydrogeology programme	A total of 31 piezometers and 8 water wells were completed. Two pumping tests (3 and 4 weeks long) were carried out and one or more shorter tests were made on each well.
Resource Definition	A total of 277 drill holes, over 82km, were drilled, mainly on a 50 x 50m grid.
Geotechnical Programme	7 geotechnical drill holes, 17 trenches and 20 penetrometers were completed.

Table 2. Main field work between July 1995 and December 1997.

Protective measures

With the large number of rigs and the intensive work on site numerous measures were introduced to minimise possible environmental impacts. Some of these were:

- A central storage tank was used for diesel, this was protected by fencing and fitted within a large spill tank with a capacity of 1.5 times that of the diesel tank.
- At drill sites the surface soil layer was removed before drilling and then replaced during rehabilitation.
- Metal drip trays installed under all machinery stationed in the area.
- Special oil-absorbent fabric laid under the drip trays and around the drill rigs.
- Machines were inspected regularly.
- Speed limits imposed to lower dust levels.
- Tracks were sprayed to lower dust levels.
- Metal tanks were used in the circulation pits for sections of the holes with mineralisation to prevent base metals entering the soils and the mud that settled in these tanks was collected and treated by an authorised treatment company (Egmasa).
- All additives used in the drilling had to be approved and be biodegradable.
- After passing through the aquifer the drill holes were cased off and grouted.

Whenever water was needed for drilling, a sample was collected from the source every day and immediately analysed (by DBO5) for pH, Eh, conductivity and ammonia.

The general site and drill rigs were inspected using a check list with at least one rig inspected every day (Figure 4).

Monitoring

Monitoring of the environment is obviously important to allow any unexpected problems to be identified quickly so that corrective action can be taken. The most sensitive aspect in the Las Cruces area is the aquifer water quality. To check the aquifer quality samples are taken every two weeks at one site up flow from the drilling areas and one site down flow and analysed for 22 parameters. In addition to this, analyses are taken whenever pumping tests are carried out and were collected at 3 monthly intervals during the EBS.

These measurements show that the aquifer water quality varies greatly from drinking water near the recharge zone to highly saline south of the project area, where the water is much older. In the area of the site, the aquifer water is not suitable for human consumption without treatment and in the long term might not be useful for irrigation, principally due to chlorine and hydrogen sulphide levels.

Another monitoring method used is aerial photographs. A set of aerial photographs has been taken of the site at roughly 3 monthly intervals since 1995. These cover approximately 75km^2 and allow monitoring of the effects of exploration and the effectiveness of rehabilitation of the sites and access tracks. Photographs are also taken at ground level of all drill sites before, during and after rehabilitation.

Clean up

In May 1999 there was a significant break in the drilling and it seemed unlikely that major drilling campaigns would take place again. The opportunity was therefore taken to carry out detailed restoration work of the central zone where most drilling had taken place. This was necessary as although most foreign material (road metalling, drill pad material, cement/concrete blocks) is removed by machine once it is no longer needed, it is impossible for the machine to remove everything and foreign material eventually accumulates. With over 250 drill holes in the area the accumulated material becomes significant.

During May and June 1999, the project area was inspected on foot and all foreign material above coarse gravel size and all

cement blocks, litter etc. were collected by hand and removed. This has produced a clearly visible improvement in the appearance of the work area and after ploughing the process will be repeated.

ENVIRONMENTAL STUDIES

During the Las Cruces a large number of environmental studies have been carried out. These can be divided into three separate phases:

- Exploration phase
- Evaluation study phase/EBS
- Feasibility phase/EIA

Exploration phase

The studies in this phase, carried out by DBO5 and Ambio, were limited to an initial characterisation of the area to check for environmentally sensitive factors that may not have been noted by Riomin staff. The two main recommendations related to protecting zones with archaeological remains and protecting vegetation along the main streams. A list of the main items covered in this survey is given in Table 1.

Environmental Baseline Study (EBS)

In late 1995 it became clear that a major evaluation programme would be needed and that the deposit was potentially economic. At his point a full environmental baseline study was commissioned to cover an area of 36 km^2 to 100 km^2 depending on the aspect concerned (Figure 5).

The EBS report combines the results of a large number of individual reports. An international company, KPP (Knight Piesold and Partners) managed the study, with the field investigations being carried out by FRASA Ingenieros Consultores, S.L. or subcontractors co-ordinated by FRASA. Table 3 lists all the aspects covered in the EBS.

EBS Section	Area (km^2)	Laboratory
Archaeology/Cultural	36	-
Climate and Meteorology	-	
Surface and Groundwater Geochemistry and Sediments	36	ITGE, CEDEX
Ecology	36	
Land Use Productivity and Evaluation	81	ITGE
Soils and Farm Crops	81	ITGE, CSIC
Noise and Vibration	36	
Dust	36	Tes Bretby
Landscape Appraisal	100	
Socio-economic	-	
Veterinary	36	Cordoba Provincial Health Ministry
Environmental and Planning Legislation	—	

Table 3. EBS Sections.

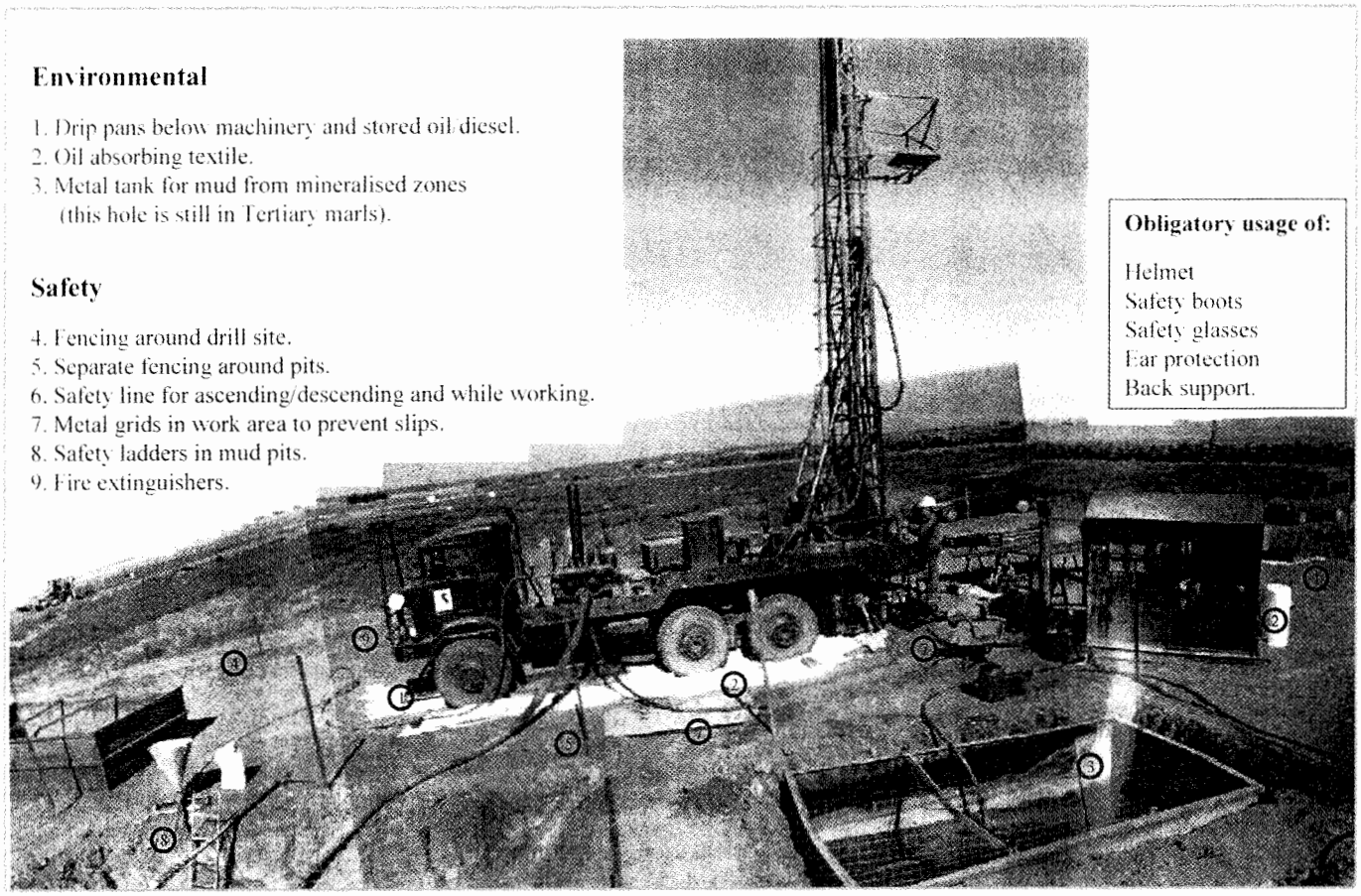


Figure 4. Enviromental and safety features during drilling.

As examples of the studies carried out, Figure 6 shows the distribution of the sampling points for the soil and crop studies and Figure 7 shows the results of an extension to the planned EBS carried out to study the distribution of freshwater turtles in the Garnacha and Molinos streams.

EIA

In September 1998, SRK and WMC, with the participation of FRASA and INIMA, were jointly commissioned to undertake a full environmental impact assessment or EIA and to provide inputs to the Feasibility Study on environmental, hydrological and hydrogeological aspects.

Numerous further studies were made (Table 4) aimed at assessing the environmental impact from the various technical options and thereby allowing environmental aspects to be fully integrated into the decisions made during the feasibility studies. These, and the earlier reports forming the EBS, are integrated into the EIA.

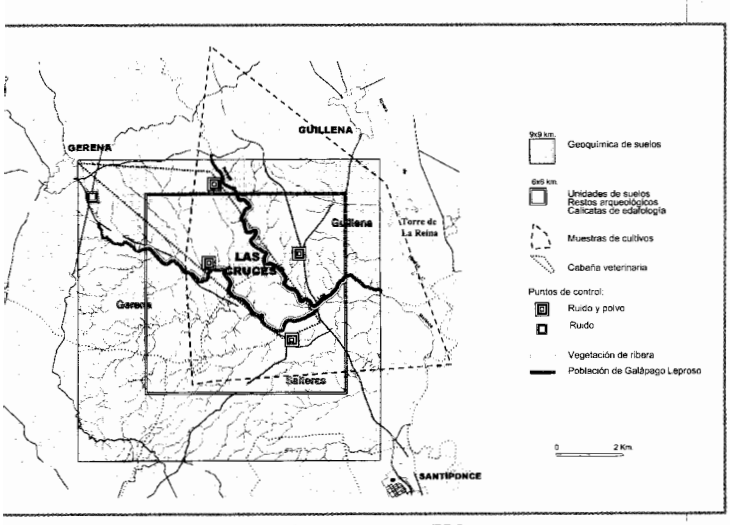


Figure 5. Areas covered by EBS.

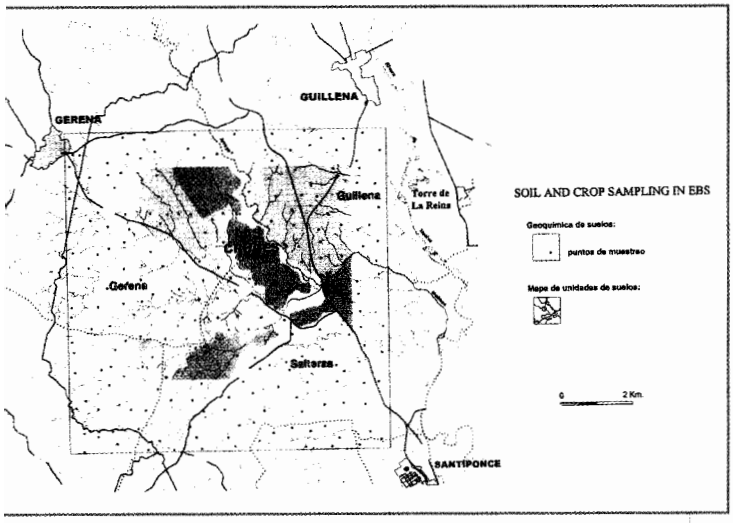


Figure 6. Soil and crop sampling in EBS.

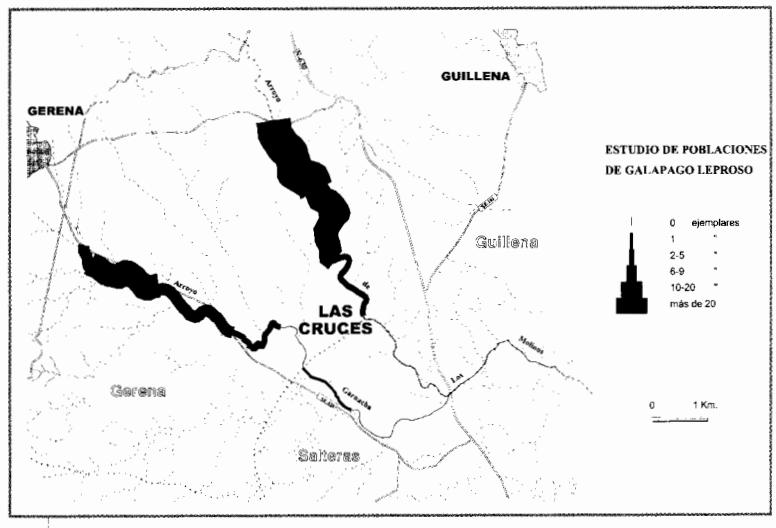


Figure 7. Turtle distribution.

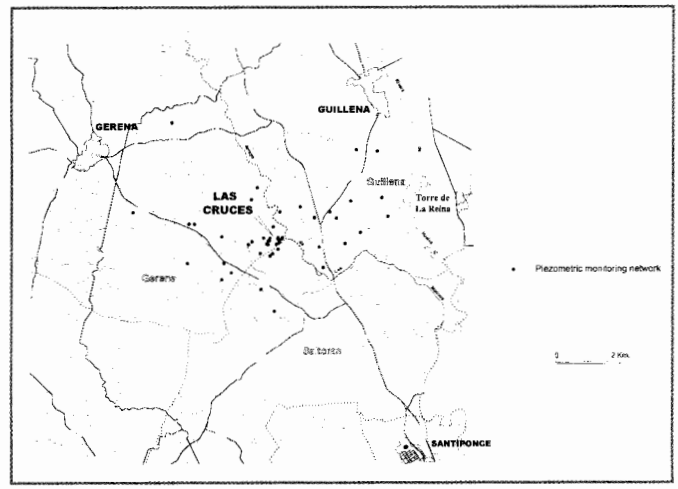


Figure 8. Regional piezometric monitoring network.

Community relations

Communities and other stakeholders also form part of the environment in which the project must operate. One of the prime concepts of the project in this area has been to establish an active two way flow of information with the local communities and social groups in order to understand the opinions and the concerns of these and to give them access to information about the project.

As part of this process one of the studies carried out as part of the EIA was a socio-cultural survey of the local communities around the project. This was undertaken by the Social-anthropological Department of the Sevilla University and covers such aspects as community history, major social groups and interests.

The project is also committed to using as much local labour as possible, however in any project like this it is also better to select people with practical training in mechanical or electrical subjects even if these are not directly applicable to their initial role. With the aid of the local administrations the Consejeria de Trabajo and the Ministry of Education several training schemes have been put in place in the local communities.

SubjectC	Consultant Company	Project Phase
Preliminary Environmental Characterisation	DBO5	Preliminary
Hydrogeological Study of the Faralaes Permit Area	CGS	Evaluation
Study of Stream Diversions	Getinsa	Evaluation
Study of Diversions of Droving Trails	Getinsa	Evaluation
Isotope Study of Part of the Nieblas Posadas Aquifer	CEDEX	Evaluation
EIA for Bulk Sample Shaft	CGS	Evaluation
Steppe Bird Life Distribution	FRASA	Evaluation
Vegetation Structure of Molinos and Garnacha Streams	FRASA	Evaluation
Wheat Sampling.	FRASA	Evaluation
Traffic Study (SE520)	FRASA	Evaluation
Study of the Freshwater Tortoise Populations of the Garnacha and Molinos Streams.	FRASA	Evaluation
Surface and Groundwater Chemistry and Sediments	FRASA	Evaluation
Surface Archaeological Prospection	University of Granada	Evaluation
EBS Report	**Knight Piesold**	**EBS**
Social Economic Impact	University of Sevilla	Feasibility
Social Baseline of Gerena, Guillena and Salteras	University of Sevilla	Feasibility
Power Line EIA	Inima	Feasibility
Environmental Report on Water Supply Options and Pipeline Routes	Inima	Feasibility
Static and Kinetic Testwork of Waste and Wall Rocks	SRK	Feasibility
Static and Kinetic Testwork of Process Wastes	Golders	Feasibility
Study of Public Opinion After Aznalcollar Dam Failure	University of Sevilla	Feasibility
ARD Testwork Report	SRK	Feasibility
Ground and Surface Water Investigations and Mine Water Management	WMC	Feasibility
Preliminary Assessment of Recharge Enhancement Potential	WMC	Feasibility
Estimate of Flood Levels at Plant Site.	WMC	Feasibility
Health and Hygiene Aspects	RT	Feasibility
Assessment of Environmental Noise Impact	SRK	Feasibility
Report on the Tailings Disposal Design	SRK	Feasibility
Constraints and Discharges/Emissions Report	SRK	Feasibility
Air Quality Impact Assessment	NESC	Feasibility
Landscape and Visual Impact Study	CBA	Feasibility
EIA Report	**SRK#**	**EIA**

Other companies (such as FRASA and INIMA) have contributed to this report).
Table 4. Environmental Reports.

These will raise the level of qualifications of members of the local communities and help to ensure the maximum number of local people on the work force.

HYDROLOGY

Water is obviously a particularly important resource in Andalucia and from very early on in the project hydrology and hydrogeology have been important aspects for both environmental and technical reasons.

In 1996 a study was commissioned of the hydrology and hydrogeology from CGS Ogden, a company with extensive experience in the region. This study included drilling and installing various water wells and piezometers and carrying out pumping tests. From this date, monitoring of the piezometric levels in the aquifer has continued (Figure 8) and numerous pumping tests have been carried out, some lasting 3–4 weeks.

It is this data that forms the basis of modelling used to predict the effects of the project on the aquifer. Due to the amount of drilling and studies undertaken, the information avai-

lable and the level of understanding of this part of the aquifer are probably unequalled elsewhere in its extent.

SAFETY

Like many companies Riomin links environment and safety issues, a safety incident can result in damage to the environment and to some extent attitude to safety, particularly of others, links to attitude to the environment.

The initial safety record at Las Cruces was poor and during the evaluation phase drilling for a short time Las Cruces had the highest accident rate of all the operations in the Rio Tinto Copper Division. In early 1997 a major effort was made to reduce this rate. A safety expert with experience of mining/exploration was brought in and training was given to every member of staff on the project including staff from sub-contractors. Detailed and regular inspections of site, offices and all machinery were implemented. To help get things started a bonus scheme was introduced with a monthly bonus to all members of the best drill rig, best in terms of safety and environmental aspects.

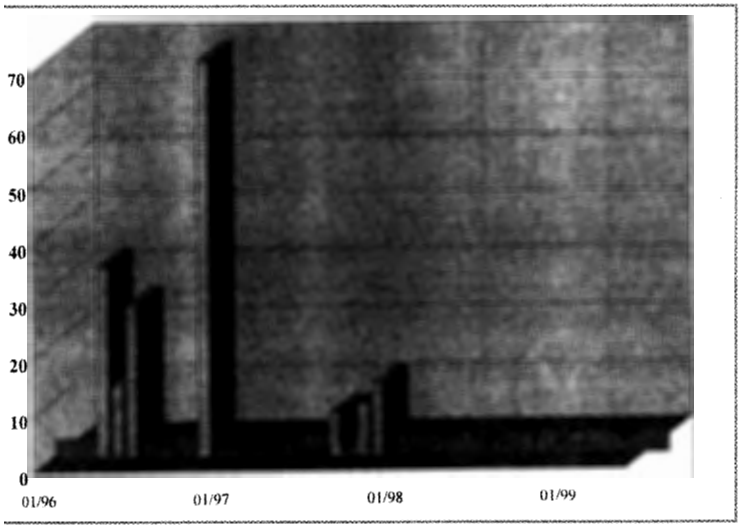


Figure 9. Lost time incident frequency rate (per 200,000 hours).

The response to the stricter safety measures was in general very positive. On an individual level most employees found some of the measures initially irritating but soon accepted them as part of the job. At a contractor level some companies even began to introduce improvements to safety features without being asked, or found simpler or more practical ways of achieving the aims. If incidents had continued at the average rate of 1996, then in the period from January 1997 to mid 1999 we would have suffered 19 lost time incidents, in fact we have had 3.

SUMMARY

Several methods to minimise and monitor the environmental effects and risks have been used at Las Cruces but none of these are particularly unusual, and all have no doubt been applied at other projects. What is perhaps unusual at Las Cruces is that these measures were implemented much earlier than normal, during the exploration phase rather than during construction or production.

Although there was some initial scepticism or even passive resistance to many of the environmental and safety measures introduced the response of contractors and individual workers has been very positive. Some contractors made improvements to work practices or equipment beyond that requested and the net result has been highly satisfactory, drill sites are normally exemplary and the accident rate has been zero for more than 18 months.

There is a certain cost to this but if the necessary practices are put in place right at the start of work then these can be kept reasonably low. Despite having drilled 250 holes in an area of less than 50 hectares the permanent environmental impact is minimal and the area could be returned to farming at any time.