EVALUATION OF WATER QUALITY IN CAJAMARCA, PERU

Annual Monitoring Report 2004-2005

Prepared for:

Compliance Advisor/Ombudsman (CAO)
2121 Pennsylvania Ave., NW
Washington, DC 20433, USA

and:
La Mesa de Diálogo y Consenso CAO-Cajamarca
Jr. Los Cerezos 127, Urbanizacion El Ingenio
Cajamarca, Perú

Project Team:
David Atkins, Project Manager
Carlo Calderon
Eduardo Montoya
Elizabeth Morales

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Annual Monitoring Report, 2004-2005

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Evaluation of the Quality of Water in Cajamarca, Peru

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1. Introduction

This report describes the objectives, methods, results, and conclusions of a participatory monitoring program to evaluate water quality in the vicinity of the Yanacocha Mining District. The Yanacocha Mining District is located in the Andes Mountains of northern Peru, approximately 15 km north of the city of Cajamarca. The mine is located on the Continental Divide at an elevation of approximately 4,000 m, and spans four basins, the Porcon, Rejo, Honda (Llaucano) and Chonta basin.

The mine is operated by Minera Yanacocha S.R.L. (hereafter referred to as Minera Yanacocha). Minera Yanacocha is a joint venture of Newmont Peru Limited (51%), Compañía de Minas Buenaventura (44%), and the International Finance Corporation, the private sector lending arm of the World Bank, or IFC (5%).

The monitoring program is being conducted on behalf of the Mesa de Diálogo y Consenso CAO-Cajamarca (the Mesa). The Mesa is a voluntary group of stakeholders with an interest in the economic, social, and environmental consequences of the operation of Minera Yanacocha S.R.L. (MYSRL). The Mesa includes participants from rural and urban communities, public and private institutions, and MYSRL, and was convened in September 2001 by the Compliance Advisor Ombudsman (CAO), the independent accountability mechanism of the private sector institutions of the World Bank, in response to two complaints filed on behalf of citizens in the Cajamarca area alleging adverse impacts caused by mining activities.

The purpose of the Mesa is to use dialogue, conflict resolution, and consensus building approaches to promote communication, enhance understanding, and promote actions that prevent and resolve problems between the community and the mine stemming from the mining operation and the relationship between the mine and the community. The Mesa process involves the voluntary participation of key stakeholders who come together to define and agree on a scope of issues that are important to them. Participants engage each other to voice their concerns, listen to and understand others' perspectives, and search for consensus on a course of action that will resolve the problem. It was in this spirit that the participatory monitoring program was developed.

The Mesa collectively agreed during its October 2001 meeting that concerns associated with potential impacts to water quality and quantity are the highest priority issues for both rural and urban communities and institutions. To address these concerns, the Mesa decided to commission an independent study to assess potential water quality and quantity changes related to mining activities. Stratus Consulting of Boulder, Colorado, USA, together with Mesa participants, completed the independent study in October 2003.

The independent study recommended that the Mesa continue to evaluate water quality and quantity in Cajamarca with the participation of individuals and institutions. To meet this objective, the Mesa convened a workshop in April 2004 in Cajamarca to determine the scope of the proposed participatory program. Workshop participants developed the following broad objective for the work:

- To ensure in an ongoing and participatory manner that the quality and quantity of surface and ground water in the basins adjacent to Minera Yanacocha provide adequate conditions for different uses (human consumption, livestock and irrigation) in such a way that each institution involved assumes responsibility.

To achieve this broad objective, workshop participants defined a broad objective for the monitoring work:

- Formulate a plan of participatory and continuous monitoring of the quantity and quality of surface and ground water in the basins adjacent to Minera Yanacocha, seeking the credibility and confidence of the community.

And specific expectations for the results of the monitoring program:

- To increase confidence in and ensure credibility of environmental information being generated on an ongoing basis in Cajamarca.
- To continue the collaborative, participatory and transparent nature of the Mesa water study.
- To stimulate the participation of the community in the vigilant stewardship of water resources.

Several specific goals were developed to achieve these expectations:

- Obtain information on the quality and quantity of surface and ground water in the basins adjacent to the mining operation, taking into account the different uses (human consumption, livestock and irrigation), and make this information available permanently to the public in a participatory and transparent way.
- Generate credibility and confidence in the monitoring results.
- Report to the public on the quantity and quality of water.
- Implement a geographical database of monitoring results at the start of the monitoring.

Mesa participants are also concerned about impacts to aquatic life, and these impacts are being addressed by a separate study conducted by consultants to Minera Yanacocha with participation and oversight by the Mesa and its technical advisors.

1.1 Investigation Overview

Since the completion of the Mesa independent water study in October 2003, a number of other participatory programs have been implemented to monitor water quality and quantity on a monthly basis, including:

- SEDACAJ, the municipal water supply company for the City of Cajamarca monitors streams in the Porcon Basin
- COMOCA Sur monitors irrigation canals, mainly in the Porcon Basin
- COMOCA Este monitors irrigation canals, mainly in the Chonta Basin
- The Community of Granja Porcon monitors canals and surface water in the Rejo Basin
- The Centros Poblados Yanacancha monitor surface water and canals in the upper Honda Basin
- The Centros Poblados Llaucan monitor surface water in the lower Honda (Llaucan) basin.

In addition, Minera Yanacocha conducts its own monitoring of locations within and near the boundary of the mine on a quarterly basis. In total, these institutions monitor water quality and flow at over 100 locations in the four basins surrounding the mine (Porcon, Chonta, Honda, and Rejo).

Minera Yanacocha has played a central role in developing, implementing and funding all of the participatory programs. Each of these programs emphasizes participation and dissemination of results, and shares some similarities with the original Mesa water study.

Workshop participants recognized the value of the data collected by these institutions during their workshop in April 2004, and decided to formulate a monitoring program that complements rather than competes with the existing programs. They realized that the Mesa could provide an independent source of funding, validity, and interpretation of monitoring results.

The Mesa technical team and veedores representing institutions in the Mesa accompany the staff from the participating institutions while sampling. The Mesa takes field measurements at each location and collects double samples at a subset of locations (approximately 10% of the total number of locations). Sampling results are put into a database maintained by the Mesa technical team.

The Mesa technical team compares Mesa sample results to institution sample results to evaluate data validity and quality. The Mesa technical team then assesses water quality for different uses and the potential effects of the mine by measuring the concentrations of metals and other components in the water and comparing them to baseline water characteristics and to Peruvian water quality standards and international guidelines that have been developed to protect human health and the environment.

The Mesa technical team and a Technical Commission consisting of representatives of institutions that participate in the Mesa review the data and interpretation on a quarterly basis and these results are given to the community.

1.2 Project Organization

The Coordinator and the Technical Commission of the Mesa provide project oversight. The technical team is composed of four members:

- Project Manager: David Atkins, Independent Consultant, Boulder, Colorado, USA
- Technical Assessor: Elizabeth Morales, Independent Consultant, Lima, Peru
- Technical Coordinator: Carlo Calderon, Mesa staff, Cajamarca Peru
- Technical Assistant: Eduardo Montoya, Mesa staff, Cajamarca Peru.

The technical team also works with members of the Mesa. Veedores from the institutions participating in the Mesa work with the technical team and accompany the technical coordinator and project assistant during sampling trips.

1.3 Report Organization

Chapter 2 presents an overview of the study area, Chapter 3 describes the data quality assessment that was used to verify data collected by the participating institutions, Chapter 4 presents the water quality assessment results, and Chapter 5 presents conclusions and recommendations.

Technical supporting documents for the report are contained in the annexes. The annexes are designed to be used by interested readers who desire more information about the technical details of the study. The annexes include a table that describes the sample locations (Annex A), water quality data tables (Annex B) and statistical summaries (Annex C), water quality parameter graphs (Annex D), the sampling and analysis plan (Annex E), the 2003 Mesa water study summary and recommendations (Annex F), and sample site maps and photos (Annex G).

2. Study Overview

The Yanacocha Mining District is located in the Department of Cajamarca, an area of the northern Peruvian Andes, at a latitude 7° south of the equator. Minera Yanacocha operates the largest open pit, heap leach gold operation in the world within the mining district. The district is located on the Continental Divide, separating streams that drain eastward into the Amazon Basin and then to the Atlantic Ocean (in the Porcón, Llaucano and Honda basins) from those that drain westward to the Pacific Ocean (in the Rejo Basin).

The study area terrain is rugged and characterized by steep mountain slopes and gorges. The mining facilities are located between 3,500 and 4,200 m above mean sea level (a.m.s.l.). The city of Cajamarca is located in a valley to the south of the mining district at an elevation of 2,750 m a.m.s.l.

2.1 Geographic Overview

The participatory monitoring program was developed to evaluate current surface water quantity and quality conditions in the streams, canals, and other waters downstream of the Yanacocha Mining District. The geographic scope of the investigation includes streams and canals in the four basins potentially influenced by mine activities and facilities:

- The **Porcón Basin** drains the southern side of the Yanacocha Mining District, and includes two major sub-watersheds, the Río Grande and the Río Porcón. The two rivers converge north of Cajamarca to form the Río Mashcón. The portion of the basin in the study goes from the mine boundary to the city of Cajamarca, a distance of approximately 12 km.

- The **Rejo Basin** drains the western side of the mining district, and is the only basin that flows to the Pacific Ocean. Tributaries to the Río Rejo that flow from the mine property include the Río Shoclla, Quebrada Yanacocha/Shilamayo, Quebrada de la Pajuela, and Quebrada Pampa de Cerro Negro. The Río Tinte becomes the Río Rejo just upstream of the community of Granja Porcón when it joins Quebrada Chacacoma. The portion of the basin in the study goes from the mine boundary to the community of Granja Porcón, a distance of approximately 10 km

- The **Honda (Llaucano) Basin** drains the northern portion of the mining district. Perennial tributaries of the Rio Llaucano that flow from the mine district include the Río Colorado and Quebrada Pampa Larga. The two tributaries converge to form Quebrada Honda, which flows north toward Bambamarca and becomes the Río Llaucano. The portion of the basin in the study goes from the mine boundary to a point near the community of Yanacancha Baja, a distance of approximately 20 km

- The **Chonta Basin** drains the eastern side of the mining district. The Río Chonta is formed by the convergence of the Quinua Río, Río Azufre, and Río Grande of the Chonta at a location known as Tres Tingos. Río Chonta flows through the community of Baños del Inca to join the Río Mashcón and form the Río Cajamarca. The portion of the basin in the study from the mine property boundary to a point upstream of the community of Baños del Inca, a distance of approximately 15 km.

2.2 Community Water Use

Both rural and urban communities are concerned about water quantity and quality issues associated with the mine. Land use in the area surrounding the Yanacocha Mining District is primarily agricultural. Approximately 30,000 people live in rural farming communities within the area around the mining district. Numerous irrigation canals convey water for agricultural and domestic use over steep terrain from streams to fields, and some of these canals originate on mine property and flow along contours around and off the mine property.

The study area includes a large number of canals. Water in the canals is used for irrigation, washing, and livestock watering, and could be used as a drinking water source by some, although this use is not well documented. Crops grown in the Cajamarca area include potatoes, beans, and grains. In addition, many pastures are irrigated and cultivated for grazing. Crops are irrigated only in the dry season, whereas pastures require some irrigation year round. The canals contour along hillsides, and are constructed to maintain a low gradient.

Many rural communities in the study area have potable water supplies that have been constructed by Minera Yanacocha or other organizations. Springs generally serve as the source for rural potable water supplies.

The Municipality of Cajamarca has two water treatment plants that supply water to approximately 150,000 residents: Santa Apolonia and El Milagro. Water treated at Santa Apolonia supplies 30% of the water for the Municipality of Cajamarca and originates in the Río Ronquillo. This river basin is outside the area of influence of the mine. Water treated at El Milagro supplies the remaining 70% of the water for the Municipality of Cajamarca and originates in the Porcón Basin. Two intake structures supply water to El Milagro, one on the Río Porcón and one on the Río Grande. The Río Grande intake is currently the only one of Cajamarca's drinking water intakes with mining facilities at its headwaters. Most rural and urban communities do not rely on groundwater wells for potable water or for irrigation.

2.3 Mine Water Use

The Yanacocha mine comprises six open pit mines: Carachugo, Maqui Maqui, San José, Cerro Yanacocha, La Quinua and Cerro Negro. Mining operations in the Yanacocha Mining District began in 1993 with the construction of the Carachugo facilities. Since then, the mine has continued to expand. Construction of the Maqui Maqui facilities began in July 1994 and mining started in October 1994. The third mine, San José Sur, began operation in 1996, and the fourth mine, Cerro Yanacocha, began project operations in December 1997. Production began at the fifth mine, La Quinua, in September 2001 and at the sixth mine, Cerro Negro, in 2004.

The Yanacocha mine has three general types of mine features and associated facilities that could potentially decrease the quantity and degrade the quality of water in streams and canals downstream of the mining district: open pits, heap leach pads and associated ponds, and waste rock dumps. To mitigate the effects of these facilities, Minera Yanacocha collects, treats, and discharges excess water from leach pads and acid water from mine pits and seeps at excess water treatment plants (EWTPs) and acid water treatment plants (AWTPs), respectively.

In addition, the mine captures runoff from access roads, bare ground around facilities, and other areas and sends the water to serpentines, which settle suspended sediment before discharging the water. The mine has also constructed two dams to retain surface water from the site and allow sediment to settle before being released: the 35-m high Rio Rejo dam and the 46-m high Rio Grande dam.

The Carachugo, Yanacocha, Maqui-Maqui, and Quinua heap leach pads all have excess water that needs to be collected and treated. The Carachugo and Yanacocha EWTPs remove cyanide and metals from excess process water from the heap leach pads, particularly in the rainy season, and discharge to Quebrada Pampa Larga in the Honda Basin. Thus, water originating in the Chonta and Rejo basins may be discharged to the Honda Basin, resulting in a cross-basin transfer of water.

The Yanacocha Mining District contains several open pits that extend below the groundwater table. These pits must be dewatered to be mined. The mine's two acid water treatment plants (the Quinua and Yanacocha Norte AWTPs) treat acidic groundwater from pit dewatering as well as water seeping from waste rock by raising the pH and precipitating metals. Treated water from AWTPs is discharged to Quebrada Pampa Larga in the Honda Basin and Quebrada Callejón in the upper Río Grande in the Porcón Basin.
A brief description of mine facilities in each basin follows:

1. **Porcón Basin**: Mining facilities in the Porcón Basin include portions of the Yanacocha, Carachugo, San José, and Quinua complexes. All of the existing mine facilities in the Porcón Basin are in the Río Grande sub-basin. The Quebrada Encajón sub-basin contains the Carachugo operations, including the Carachugo Open Pit and the Carachugo North Waste Rock Dump; the Yanacocha operations, including portions of the Yanacocha South Open Pit; and the San José operations, including a portion of the San José Open Pit and a portion of the San José Waste Rock Dump. The Quinua facilities, including the Quinua Open Pit and the oxide portion of the Quinua Waste Rock Dump, are in the Quebrada Callejón sub-basin. The Quinua AWTP discharges water to Quebrada Callejón. The Cerro quilish exploration area is located in the headwaters of the Porcon Basin.

2. **Rejo Basin**: Mining operations in the Rejo Basin include the Cerro Negro, Quinua, and Yanacocha operations, and maintenance facilities. The Cerro Negro operations include the open pit. The Quinua operations in the Rejo Basin include a portion of the Quinua Waste Dump and the Quinua Leach Pad and associated process ponds. The Yanacocha operations in the Rejo Basin include the Yanacocha North Pit, the Yanacocha Leach Pad and associated process ponds, and the Yanacocha Waste Rock Dump. The Yanacocha Waste Rock Dump generates acid seepage that is routed via underdrains, pipes, and a collection pond to a serpentine for treatment.

3. **Honda (Llaucano Basin)**: Mining facilities located in the Honda Basin include the Carachugo Leach Pad (currently the largest leach pad in the world) and the associated Merrill Crowe facility for extracting gold and silver; the Maqui Maqui pits and Waste Rock Dumps; the Yanacocha Norte AWTP; and the Carachugo and Yanacocha EWTPs. Flow from these treatment plants is discharged to Quebrada Pampa Larga, and is monitored at DCP. Quebrada Pampa Larga is the only stream that receives discharge of EWTP water in the mining district. The Maqui Maqui facilities in the Honda Basin include most of the Maqui Maqui Waste Rock Dump, the Maqui Maqui North Open Pit, and part of the Maqui Maqui South Open Pit. The Maqui Maqui pits are wet, meaning that groundwater seeps into the open pits. During mining, the pits were dewatered by pumping the groundwater out. The acidic groundwater was routed to the Yanacocha Norte AWTP for treatment before discharge to Quebrada Pampa Larga. Mining at Maqui Maqui is now complete, and the waste rock dump will be reclaimed. Pit dewatering operations have ceased, groundwater in the pits is no longer collected, and lakes are forming in the pit.

4. **Chonta Basin**: Mining facilities located in the Chonta Basin include part of the Maqui Maqui South Open Pit, a portion of the Maqui Maqui Waste Rock Dump, and the Maqui Maqui Leach Pad. Mining at Maqui Maqui is now complete. Other facilities in the Chonta Basin include a small part of the Carachugo Leach Pad, the Chaquicocha Open Pit, and an associated waste rock dump, and the Carachugo South Waste Rock Dump, the San José East and South Waste Rock Dumps, and part of the San José Open Pit.

2.4 Participatory Monitoring Program Design

The Mesa technical team and veedores accompany participating institution staff on sampling trips. The Mesa team collects field measurements (temperature, pH, specific conductivity, and dissolved oxygen) and measures flow at all locations. The Mesa technical team also collects double samples for laboratory analysis at approximately 10 percent of the total number of locations sampled for verification and quality control.

2.5 Sample Locations and Laboratory Analyses

Since the completion of the original independent water study, other participatory monitoring programs have been implemented in Cajamarca, and the Mesa works with these institutions. The participating institutions include the irrigation canal users programs (COMOCA Sur and Este), the municipal water treatment plant program (SEDACAJ), the Centros Poblados Granja Porcon, Yanacancha and Llaucan, and MYSRL. Together these institutions monitor a total of 112 locations, including:

- 18 streams and 14 canals at a total of 51 locations in the Porcon Basin
- 7 streams and 3 canals at a total of 12 locations in the Rejo Basin
- 6 streams and 3 canals at a total of 16 locations in the Honda Basin
- 5 streams and 11 canals at a total of 18 locations in the Chonta basin
- 5 locations in the SEDACAJ network
- 4 groundwater wells and 2 discharge points at the mine site.

A brief description of each program follows:

1. **SEDACAJ** monitors 31 surface water locations monthly:

- 18 streams at 26 total locations in the Porcon Basin
  - o Samples are analyzed at the Catholic University Laboratory in Lima (ICP-PUCP) for total metals, WAD-cyanide, oil and grease. Total and fecal coliform bacteria are analyzed at NKAP in Cajamarca.
- 5 locations in the collection system and storage reservoirs of the treated water collection and distribution system.
  - o Samples are analyzed at the SEDACAJ laboratory for total metals

2. **COMOCA Sur** monitors 28 surface water locations monthly:

- 14 irrigation canals at 23 total locations in the Porcon Basin
- 2 irrigation canals and 1 stream in the Rejo Basin
- 1 irrigation canal and 1 stream in the Honda Basin
  - o Samples are analyzed at ICP-PUCP laboratory in Lima for WAD cyanide, nitrates, sulfate, hardness, and total and dissolved metals. Total and fecal coliform bacteria are analyzed at NKAP in Cajamarca.

3. **COMOCA Este** monitors 12 surface water locations monthly:

- 10 canals at12 total locations in the Chonta Basin
  - o Samples are analyzed at SGS laboratory in Lima for WAD cyanide, nitrates, sulfate, hardness, and total metals. Total and fecal coliform bacteria are analyzed at NKAP in Cajamarca.

4. **CENTRO POBLADOS YANACANCHA GRANDE and BAJA** monitor 8 locations monthly:

- 2 canals, 4 streams and 1 spring at 8 total locations
  - o Samples are analyzed at Envirolab for acidity and alkalinity, carbonate and bicarbonate, chloride, total and free cyanide, hardness, fluoride, TDS, sulfates at some times and WAD cyanide nitrates, sulfates, TSS and total metals at all times. Total and fecal coliform bacteria are analyzed at NKAP in Cajamarca.

5. **CENTRO POBLADO LLAUCÁN** monitors 3 locations monthly:

- 3 streams
    - Samples are analyzed at Envirolab for acidity and alkalinity, carbonate and bicarbonate, chloride, total and free cyanide, hardness, fluoride, TDS, sulfates at some times and WAD cyanide nitrates, sulfates, TSS and total metals at all times. Total and fecal coliform bacteria are analyzed at NKAP in Cajamarca.

6. **COOPERATIVA GRANJA PORCÓN** monitors 6 locations monthly

- 3 streams and 1 canal at 6 total locations
    - Samples are analyzed at Envirolab for acidity and alkalinity, carbonate and bicarbonate, chloride, total and free cyanide, hardness, fluoride, TDS, sulfates at some times and WAD cyanide nitrates, sulfates, TSS and total metals at all times. Total and fecal coliform bacteria are analyzed at NKAP in Cajamarca.

7. **MINERA YANACOCHA**

- 15 streams, 2 discharge points, 4 groundwater wells and 1 spring at a total of 24 locations
    - Samples are analyzed at ALS Laboratory in Lima for grease, acidity and alkalinity, hardness, ammonia and nitrates, chloride, fluoride and sulfate, TDS, TSS, total, WAD and free cyanide, and total and dissolved metals.

The influence of mine activities on sample locations is variable, and not all streams and canals included in the monitoring program have water that could be influenced by the mine. Streams and canals with direct mine influence receive mine discharge or are directly downstream of mine facilities, including sediment control structures. Indirect influence on streams and canals could be from construction, road building or exploration or may be further downstream from mine facilities than streams with direct influence. Consequently, this study classifies mine influence at sampling locations as ‘direct’, ‘indirect’ and ‘none’. We have designated some locations in the Porcon as ‘indirect’ influence because they are within the mine boundary. The mine currently has no operations in the Porcon basin.

3. Data Quality Assessment

3.1 General Considerations

One of the primary purposes of the participatory monitoring program is to evaluate the quality of data collected by participating institutions in Cajamarca. This data quality review increases confidence in the water quality data collected by the participating institutions. We do this in two ways:

- First we collect duplicate samples at a subset of the total number of locations that the participating institutions monitor and send them for analysis to a laboratory we selected.
- Next we determine the quality of the data by evaluating quality control samples. We evaluate blank and duplicate samples collected by the institutions. We also evaluate blank, standard reference, and duplicate samples that we collect and send to our own laboratory.

The data quality assessment ensures that results used for the annual monitoring report are of high enough quality to draw conclusions.

To achieve the objectives of the study, we developed and implemented quality assurance and quality control procedures (QA/QC) to guarantee that the quality of the data collected is acceptable. Quality assurance measurements allow us to assess the quality of the data produced in the study, and to determine the efficacy of quality control procedures.

Monitoring was conducted according to the agreements made during the workshop. Fo9r the participating institutions, data collection was supervised by the participating institution supervisors, who controlled field sampling activities to confirm that they were performed according to sampling protocols. Analytical laboratories were selected using criteria from each party. After collection, the samples were sealed and sent to the laboratories under strict chain-of-custody procedures. The laboratories analyzed the samples according to the lab's work plan, and the laboratory evaluated, corrected (if needed), and validated the analytical results.

The Mesa technical team conducted a quality assurance assessment for monitoring and analysis of samples during assessment, and also collected duplicate, blanks and standard reference samples.

Finally, we evaluated data quality including the performance of the analytical laboratories and whether the data could be used for the assessment.

3.2 Methods

The participating institutions (SEDACAJ, Minera Yanacocha, COMOCA Este and Sur, the Centros Poblados Llaucano and Yanacancha and the community of Granja Porcón) used the following analytical laboratories: ALS-Environmental, Instituto de Corrosión y

Protección de la PUCP, Envirolab, SGS Enviromental and NKAP for microbiological samples. The Mesa technical team used the Instituto de Corrosión y Protección de la PUCP lab and the ALS-Environmental lab.

Parameters we chose for analysis include components that are commonly found in mines, as well as those appearing naturally in surface water but which may be altered as a result of mining activities.

We included the following parameters in the analysis: general water quality parameters, including (temperature, dissolved oxygen, specific conductivity, suspended solids and total solids and pH); significant anions (alkalinity, chloride, sulfate and fluoride); important cations (sodium, calcium, magnesium and potassium); trace metals and metalloids (aluminum, antimony, arsenic, barium, beryl, boron, cadmium, chrome, cobalt, copper, iron, lead, manganese, mercury, nickel, selenium, silver, thallium and zinc); nitrate + nitrite and ammonia); and weak acid dissociable (WAD) cyanide.

Table 3.1. Water Quality Analyses

Analyte	Analytic Lab / Method Number SGS	ALS	Envirolab	ICP-PUCP
Total Metals				
Aluminum	EPA 200.7	EPA 200.8	EPA 200.7	EPA 200.7
Arsenic	EPA 200.7	EPA 200.8	ICP-GH	SM3114B
Cadmium	EPA 200.7	EPA 200.8	EPA 200.7	EPA 200.7
Calcium	EPA 200.7	EPA 200.7	EPA 200.7	EPA 200.7
Copper	EPA 200.7	EPA 200.8	EPA 200.7	EPA 200.7
Chrome	EPA 200.7	EPA 200.8	EPA 200.7	EPA 200.7
Iron	EPA 200.7	EPA 200.7	EPA 200.7	EPA 200.7
Magnesium	EPA 200.7	EPA 200.7	--	EPA 200.7
Manganese	EPA 200.7	EPA 200.8	EPA 200.7	EPA 200.7
Nickel	EPA 200.7	EPA 200.8	EPA 200.7	EPA 200.7
Silver	EPA 200.7	EPA 200.8	EPA 200.7	EPA 200.7
Lead	EPA 200.7	EPA 200.8	EPA 200.7	EPA 200.7
Potassium	EPA 200.7	EPA 200.7	EPA 1631E	EPA 200.7
Sodium	EPA 200.7	EPA 200.7	ICP-GH	EPA 200.7
Thallium	EPA 200.7	EPA 200.8	EPA 200.7	EPA 200.7
Zinc	EPA 200.7	EPA 200.8	EPA 200.7	EPA 200.7
Mercury	EPA 7470 A	AA Cold Steam	EPA 1631E	EPA 245.1
Selenium	SM 3114-C	EPA 200.8	ICP-GH	C/98
TSS	SM 2540-D	Gravimetry	SM 2540-D	SM 2540-C/98
Dissolved Metals				
Aluminum	EPA 200.7	EPA 200.8	EPA 200.7	EPA 200.7
Arsenic	EPA 200.7	EPA 200.8	ICP-GH	SM3114B
Cadmium	EPA 200.7	EPA 200.8	EPA 200.7	EPA 200.7
Calcium	EPA 200.7	EPA 200.7	EPA 200.7	EPA 200.7
Copper	EPA 200.7	EPA 200.8	EPA 200.7	EPA 200.7
Chrome	EPA 200.7	EPA 200.8	EPA 200.7	EPA 200.7
Iron	EPA 200.7	EPA 200.7	EPA 200.7	EPA 200.7
Magnesium	EPA 200.7	EPA 200.7	EPA 200.7	EPA 200.7
Manganese	EPA 200.7	EPA 200.8	EPA 200.7	EPA 200.7
Nickel	EPA 200.7	EPA 200.8	EPA 200.7	EPA 200.7
Silver	EPA 200.7	EPA 200.8	EPA 200.7	EPA 200.7
Lead	EPA 200.7	EPA 200.8	EPA 200.7	EPA 200.7
Potassium	EPA 200.7	EPA 200.7	EPA 200.7	EPA 200.7
Sodium	EPA 200.7	EPA 200.7	EPA 200.7	EPA 200.7
Thallium	EPA 200.7	EPA 200.8	EPA 200.7	EPA 200.7
Zinc	EPA 200.7	EPA 200.8	EPA 200.7	EPA 200.7
Mercury	EPA 7470 A	AA Cold Steam	EPA 1631E	EPA 245.1
Selenium	SM 3114-C	EPA 200.8	ICP-GH	C/98
Carbonates	AOAC 920.194:2000	Titillation	SM 2320-B	SM 2320 B/98
Ammonia	SM 4500-NH3-D	Potentiometric	SM 4500-NH3-F	Hach 8038/92
Chloride	SM 4500-Cl-B	Titillation	---	SM 4500-Cl-C/98
Fluor	SM 4500-F-C	Potentiometric	EPA 340.2	EPA 300.0/93
Nitrates	SM 4500	Colorimetry	EPA 352.1	Hach 8171/92
Sulfate	SM 4500-SO4-E	Turbidimetry	EPA 375.4	---
TDS	SM 2540-C	Gravimetry	EPA 160.1	SM 2540-C/98
Cyanide WAD	SM 4500-CN-I-F	DesT Colorimetry	SM 4500-CN-I	---
Total Coliforms	SM 9221 A.B.C	NKAP Analysis Lab		
Fecal Coliforms	SM 9221 A.B.C.E1			

SM: APHA:.AWWA.WEF

3.3 Laboratory Procedures

The labs used were accredited under the Standard 17025 of Peru (Competence Standard for Test Laboratories) and accredited by the Canadian Council of Standards and

Regulations; the internal procedures, methods and quality control of each laboratory were subjected to a performance assessment.

The laboratory also has protocols for the analytical methods used for each analysis, including detection limits for each chemical analyzed.

Internal quality control criteria for laboratories included the use of:

- Method targets and continuous calibration targets, to assess if the samples were contaminated during preparation and analysis.
- Duplicate lab samples to check analysis accuracy.
- Control samples for laboratory and continuous calibration checks to guarantee analysis accuracy.

For each sample, the lab set specific acceptability limits for the results, as well as corrective actions which must be applied if the sample results do not comply with the acceptability limits.

Each analytic lab performed chain-of-custody procedures for the samples. To assure the integrity of samples transportation, the date and time of reception for the samples was recorded, as well as the temperature within the cooler. The receipt of each sample bottle was verified in the chain-of-custody forms. The samples were stored in a safe area in the analytical laboratory, according to the documented procedures for each laboratory.

The laboratory qualified the samples in cases where the concentration was below the method detection limit (MDL).

- “U” Data below MDL indicate “not detected”.
- “B” Calculated value.
- “H” Surpassed the limit time for analysis.
- “BH” Calculated value when the times for analysis has passed.

3.4 Analytical Data Validation

La validación de datos se dio en un nivel que corresponde a la evaluación de capacidad de utilización y se basa en el grado general de integridad, precisión y representación de datos (es decir, si los números y tipos de análisis de muestras especificados en el programa se realizaron efectivamente).

3.5 Quality Assurance Samples (QA/QC)

3.5.1 Institution Data

Participating institutions collect two types of QA samples: blank and duplicate.

Duplicate samples are collected in the field by each institution, and are analyzed for the whole analytical profile (total and dissolved metals, cyanide, anions, alkalinity, nitrate, TDS, and total and fecal coliforms). Results of institution duplicate analyses are presented in Annex C: Table C.1.1. Duplicate samples collected by institutions.

Blank samples are clean water from the laboratory prepared and analyzed by each institution using the same procedures as those for samples used to assess water quality. Results of institution blank samples are presented in Annex C: Table C.1.2. Blank samples collected by institutions.

3.5.2 Mesa Samples

The Mesa technical team collected three types of QA samples: blanks, duplicates and standard reference samples.

3.5.2.1 Blank Samples

The Mesa technical team collected 5 blank samples for each type of analysis (metals, cyanide, anions, alkalinity, nitrate and TDS/TSS). Ultrapure water from the laboratory was used to prepare all the blank samples. Sample results are presented in AnnexC: Table C.1.3 Blank and Duplicate Samples collected by the Mesa.

In the blank samples prepared by the Mesa, some elements were detected in three samples: aluminum 2 of 3, calcium 1 of 3, iron 3 of 3, potassium 1 of 3, sodium 2 of 3 zinc 2 of 3, ammonia 1 of 3 and nitrite+nitrate 2 of 3. Nevertheless, a thorough assessment of the data shows that in most cases the median of the values detected for these analytes are just a bit under the method detection limit, indicating that laboratory contamination level is very low. For example, the median detected concentration of total calcium in blank samples is 0.015 mg/L, compared to the 0.02 mg/L method detection limit. So, even when there were some substances detected in blank samples, their levels are generally near the detection level and do not affect the results of the analysis.

3.5.2.2 Duplicate Samples

The Mesa technical team also collected duplicate samples with the institutions to assess the validity and quality of the institution data and the repeatability of field collection procedures. Between July 2004 and August 2005, the Mesa technical team collected 120 duplicate samples. The results are presented in Annex C: Table C.1.4. Comparison Table between Institution samples and Mesa samples.

The analyte concentrations in each duplicate pair were compared to each other, and the difference was expressed as a relative percent difference (RPD). RPD is calculated as the difference between the two values divided by the value of the institution sample. Acceptance criteria used for field duplicates are 35% RPD for metals by ICP or ICP MS for values five times larger than the required detection limit, and 50% RPD for distillation cyanide (U.S. EPA, 1994). Mercury and conventional substances do not have RPD values set, so we use the 35% RPD criterion.

In general, the median RPD for most substances is below 35%. This shows that analytical results of the two samples are generally the same. However, in some of these substances there are individual pairs of duplicated samples with RPD values higher than 35% For example, although the median RPD for Arsenic in 4 duplicate pairs from the Chonta Basin is 34%, one pair of duplicated samples has a 100% RPD. Nevertheless, in this example the duplicate pair with the high RPD has measured values of 0.005 and 0.01 mg/L of Arsenic, with the first number slightly over the 0.004 mg/L detection limit of the method. RPDs for other substances are also sometimes high for the duplicate pairs when absolute concentrations of a substance are low and analytical accuracy becomes more difficult. Many analytical results for the duplicate pairs are 'non-detect' so we could not calculate an RPD. Results are summarized in Annex C: Table C.1.5 RPD Information for Field Samples Duplicates

Based on our evaluation of RPDs, we conclude that for all analyses, field duplicate results show that samples collection, preservation, storage, handling and analytical lab procedures produce repeatable and accurate results.

3.5.2.3 Standard Reference Samples

As part of the QA/QC program, the Mesa technical team also collected standard reference samples; these samples were prepared by Environmental Resource Associates (ERA), and are samples with a known concentration of chemical substances, which are sent blind to the lab, preventing the lab from knowing that it is analyzing a control sample, as well as the actual concentrations in the samples. Results are presented in Annex C: Table C.1.6 Standard Reference Water Samples.

3.6 Conclusions

The participating institutions and the Mesa technical team implemented quality assurance and quality control (QA/QC) to assess whether the quality of the data collected is acceptable.

The Mesa technical team collected field samples according to the Sampling Plan. Analytical laboratories were selected based on criteria designed to ensure that the labs were free of interest or influence on the results of the monitoring and had the technical skills and internal procedures to produce valid and accurate data.

For all Mesa/institution duplicate samples:

- The water the institution sampled was the same as the water the Mesa technical team sampled.
- Different sample collection methods yielded similar results.
- The samples were not altered during handling and shipping to the laboratory.

- The samples were not altered at the laboratories.
- Laboratory results were comparable.

Relative percent difference values were generally within an acceptable range for each duplicate pair of samples. Based on this assessment, we know that the data collected by the Mesa and the institutions is valid. Therefore, we know that we can rely on all data collected by the institutions for our water quality assessment (over 1,000 total samples).
Relative percent differences for all duplicate samples were within an acceptable range. All blank samples had very low or non-detected concentrations of the analytes the laboratory measured. The relative percent differences between standard reference sample concentrations and the known concentrations were also within an acceptable range. Therefore, we conclude from the quality control sample results that all of the data collected by the Mesa technical team and the institutions can be used for the water quality assessment. The data generated by the study is valid and reflects the environmental conditions variability at the time this assessment took place (June 2004-August 2005).

4. Water Quality Assessment

The water quality assessment is designed to address the following specific goals of the participatory program as described in Chapter 1:

- Report to the public on the quality of water in the basins adjacent to the operations of Minera Yanacocha.
- Implement a geographical database of monitoring results.

The assessment takes into account the different uses of the water, including human consumption, livestock consumption and irrigation. The Mesa technical team uses the data collected by the participating institutions to assess water quality for different uses and the potential effects of the mine.

We evaluate whether the water is usable for drinking, and agriculture in two ways. First, we compare concentrations of important constituents in each water sample to Peruvian water quality standards established by the General Water Law. Then we compare measured concentrations to international guidelines that have been developed to protect human health and the environment. The international guidelines we use were established by: the World Health Organization (WHO); the U.S. Environmental Protection Agency (EPA); the State of Nevada Division of Environmental Protection, United States; Environment Canada; and the Food and Agriculture Organization of the United Nations (FAO).

4.1 Baseline Water Quality

Baseline water quality is the water quality that would have existed in streams in the absence of the mine. The natural quality of water is affected by the chemical composition and chemical and physical weathering of bedrock and soils. In areas where rocks are highly altered and naturally mineralized, such as in the Yanacocha Mining District, chemical weathering can produce water with naturally elevated concentrations of metals and naturally low pH. Natural water quality also can be altered by human land uses that are not related to the mine, including road building and construction, streambed mining for gravel and cobble, and agricultural practices such as grazing and tilling. These human land uses can accelerate natural rates of chemical and physical weathering, and can have adverse affects on water quality. Mining-related processes that can influence surface water quality include physical disturbances and removal of vegetation that increase erosion of soils and sediment loading to streams. Chemical changes in water quality related to mining can result from discharges of treated and untreated process and waste water, and runoff and seepage from mine facilities. Mining activities can produce water with elevated concentrations of metals and low pH.

To characterize baseline conditions, in 2002 and 2003 Stratus Consulting collected water quality samples from 20 streams draining mineralized areas (ore bodies and associated altered rock) that have not yet been mined, and from streams that drain unmineralized areas that are subjected to the types of land uses that existed in the area of the mine before the mine began operations. Thirteen locations were located on streams that drain mineralized rock, and 7 locations on streams that do not drain mineralized rock, or that drain areas with a small percentage of mineralized rock. Results from baseline sampling were used to define the range of natural variability in water quality that would be expected in waters draining the mine site if the mine did not exist.

Some natural waters have lower concentrations of metals or sediment and neutral pH values, and some natural waters have higher concentrations of metals or sediments and lower pH values. Similarly, non-mining human activities can cause increases in various analytes or changes in pH.

Baseline water quality was characterized as follows:

- Most of the unmineralized baseline stream locations were calcium-bicarbonate or calcium-bicarbonate/sulfate type waters with neutral pH values, indicating that they are draining terrain with some neutralizing ability. In contrast, the majority of the mineralized baseline locations were calcium-sulfate type waters with low pH values, indicating that their drainages contain mineralized rocks with little neutralizing ability. Even though mineralized streams had low pH values, they generally did not contain elevated concentrations of most metals.
- None of the unmineralized baseline samples exceeded any of the water quality standards. With the exception of non-mining-related fecal coliform and some locations with naturally low pH, baseline conditions at both mineralized and non-mineralized locations were fully supportive of agricultural and domestic drinking uses.

In the assessment conducted by the Mesa in 2002-2003, water quality data at locations downstream from the mine were compared to baseline conditions to determine if the mine had changed water quality. The baseline water quality samples were analyzed at a laboratory that was able to achieve extremely low detection limits (in some cases below 1 ug/L for trace metals). Metals are naturally low in concentration in the region, so the baseline water quality data set had many detected values at very low concentrations.

The data collected for the participatory programs were analyzed at laboratories that were generally not able to achieve these low detection limits, and the data set for this study had many non-detect values at detection limits above measured values from the baseline data set. Consequently, it was not possible to compare the participatory program data to the baseline data and have meaningful results. Therefore, all data collected for this study were compared to the water quality limits described in the next sections.

4.2 Water Quality Assessment Methods

We used the following steps for the water quality assessment:

1. First we compiled all data from participating institutions into a database. The technical coordinator and assistant entered data as they were received from the

participating institutions, and used this database for meetings with the technical commission and to prepare the quarterly communiqués. All analyses were entered into the database.

2. We focused on a subset of the total anaytes entered into the database. The subset was chosen because these analytes have been a concern in previous investigations in Cajamarca and they can be related to mining as well as other natural and human activities. Analytes include: fecal coliform bacteria, total dissolved solids, nitrate, cyanide, aluminum, arsenic, cadmium, copper, chromium, manganese, mercury, lead and selenium. Standards and guidelines are presented in Sections 4.2.1 and 4.2.2.

3. Most institutions collect only total (unfiltered) metals, so although the dissolved metals are in the database and are presented in the data tables in this report, we did not include them in the data analysis.

4. The technical manager prepared a statistical summary of the data for each analyte. The summary included the minimum, median, maximum values, as well as the 25th, 50th, 75th and 90th percentiles for each analyte concentration. Values that were presented on the laboratory data sheets as 'non-detect' were entered at one-half the detection limit. To illustrate the meaning of these percentiles, the 90th percentile concentration for an analyte means that 90% of the measured concentrations were lower, and approximately 10% were higher than this value. We prepared these statistical summaries for all the data aggregated for each basin and for each location.

5. We compared the data to standards from the General Water Law of Peru as described in Section 4.2.1. We prepared tables that show how many of the measured analyte concentrations exceed General Water Law standards for each basin and for each location.

6. We then compared the data to international water quality guidelines as described in Section 4.2.2. We prepared tables that show how many of the measured analyte concentrations exceed these guidelines.

7. We then compared the 90th percentile from the statistical analysis described in item 2 above to the standards and guidelines. The 90th percentile provides a good comparison because the guidelines we used are very protective and conservative. Therefore, it is acceptable if analyte concentrations occasionally exceed these standards and guidelines. If the 90th percentile concentration of an analyte does not exceed a guideline, then the standard or guideline is surpassed less than 10% of the time.

The following sections describe the standards and guidelines we used for the water quality assessment.

4.2.1 General Water Law of Peru Standards

Streams and canals in the project area are divided into different classes according to the General Water Law (Supreme Decrees No. 007-83-SA and No. 003-2003-SA) administered by Ministry of Health (DIGESA). These classifications are according to the predominant use of the water. Two classes are applied to the waters in this study:

1. **Class II**: Raw water used for domestic purposes that is made potable by treating with coagulation, sedimentation, filtration and chlorination, as approved by the Department of Health. Streams in the study area that supply the City of Cajamarca water treatment facilities are designated as Class II, and include:

    a. Rio Grande
    b. Quebrada Encajon
    c. Rio Quilish
    d. Rio Porcon
    e. Rio Ronquillo.

2. **Class III**: Raw water used for vegetable irrigation and animal (livestock) consumption. The following streams in the study are designated as Class III:

    a. Rio Llaucano
    b. Rio Mashcon
    c. Rio Rejo
    d. Rio Chonta.

Based on these designations, we use the following General Water Law of Peru standards for this study:

- **Class II**: Streams in the Porcon Basin, including the sub-basins Porcon and Grande and all tributaries.
- **Class III**: Streams in the Rejo, Chonta and Honda (Llaucano) basins and all tributaries; Canals in the Porcon, Rejo, Honda and Chonta basins.

The mine is operated such that discharges do not lead to these water quality standards being exceeded.

Standards for analytes of concern are presented below.

		Peru General Water Law Class (17752)	
parameter	**units**	**II**	**III**
Fecal coliform	mpn/100 mL	4000	1000
Cyanide	ug/L	200	na
Arsenic	ug/L	100	200
Cadmium	ug/L	10	50
Chromium	ug/L	50	1000
Copper	ug/L	1000	500
Lead	ug/L	50	100
Mercury	ug/L	2	10
Selenium	ug/L	10	50

na: not applicable

Mine operations are also conducted to comply with the Maximum Permissible Limits established by the Ministry of Energy and Mines (MEM) in the Supreme Decree No. 011-96-MEM, and the guidelines established by the International Finance Corporation of the World Bank for discharge from open-pit mining operations. Discharge compliance points are monitored by Minera Yanacocha to assess compliance.

4.2.2 International Water Quality Guidelines for Different Uses

We also compared water quality data to international guidelines for human consumption, livestock consumption, and irrigation. The international guidelines we use were established by: the World Health Organization (WHO); the U.S. Environmental Protection Agency (EPA); the State of Nevada Division of Environmental Protection, United States; Environment Canada; and the Food and Agriculture Organization of the United Nations (FAO).

4.2.2.1 Livestock Guidelines

We evaluated data in comparison to guidelines for livestock developed by the State of Nevada and Environment Canada.
These guidelines are summarized below:

parameter	units	State of Nevada	Environment Canada
Fecal coliform	mpn/100mL	1000	na
Total dissolved solids	mg/L	3000	3000
Nitrate	mg/L	na	100
WAD cyanide	ug/L	na	na
Aluminum	ug/L	na	5000
Arsenic	ug/L	200	25
Cadmium	ug/L	50	80
Copper	ug/L	500	500
Chromium	ug/L	1000	50
Manganese	ug/L	na	na
Mercury	ug/L	10	3
Lead	ug/L	100	100
Selenium	ug/L	50	50

na: not applicable

4.2.2.2 Irrigation Guidelines

We evaluated data in comparison to guidelines for irrigation developed by the State of Nevada, Environment Canada and the Food and Agriculture Organization (FAO). These guidelines are summarized below:

parameter	**units**	**FAO**	**State of Nevada**	**Environment Canada**
Fecal coliform	mpn/100mL	na	na	100
Total dissolved solids	mg/L	450	na	500
Nitrate	mg/L	na	na	na
WAD cyanide	ug/L	na	na	na
Aluminum	ug/L	5000	na	5000
Arsenic	ug/L	100	100	100
Cadmium	ug/L	10	10	5
Copper	ug/L	200	200	200
Chromium	ug/L	100	100	8 (Cr VI)
Manganese	ug/L	200	200	200
Mercury	ug/L	na	na	na
Lead	ug/L	5000	5000	200
Selenium	ug/L	20	20	20

na: not applicable

4.2.2.3 Human Consumption Guidelines

We evaluated data in comparison to guidelines for drinking water developed by the General Water Law of Peru (Class I for domestic water use with only simple disinfection), the World Health Organization, the State of Nevada, and the United States Environmental Protection Agency (EPA) These guidelines are summarized below:

parameter	**units**	**Peru LGA Class I**	**World Health Organization**	**State of Nevada**	**United States EPA**
Fecal coliform	mpn/100mL	0	0	0	0
Total dissolved solids	mg/L	na	na	na	na
Nitrate	mg/L	na	50	10	10
WAD cyanide	ug/L	80 (tot.)	70	200 (free)	200 (free)
Aluminum	ug/L	na	na	na	na
Arsenic	ug/L	100	10	50	10
Cadmium	ug/L	10	3	5	5
Copper	ug/L	1000	na	na	1300
Chromium	ug/L	50	na	100	100
Manganese	ug/L	na	na	na	na
Mercury	ug/L	2	1	2	2
Lead	ug/L	50	10	na	15
Selenium	ug/L	10	10	50	50

na: not applicable

Drinking water quality guidelines are designed to be protective of water that is consumed by a person every day for a lifetime. We considered the following aspects of the guidelines when we conducted the evaluation:

- Concentrations in excess of the guidelines do not necessarily mean that adverse effects will occur. For example, in describing their drinking water standards, the World Health Organization states that "short-term deviations above the guideline values do not necessarily mean that the water is unsuitable for consumption" (World Health Organization, 1996).
- Regulatory agencies use the guidelines to monitor public water supplies for potential long-term problems with drinking water quality, and consider water supplies at risk when the standards are consistently exceeded in routine monitoring.
- The guidelines are calculated based on an assumption that an individual would drink the water every day for 70 years.

Thus, an excedence of these guidelines does not indicate that the water poses an imminent and serious danger to people, or is unsafe to drink. Nevertheless, the evaluation of drinking water guideline excedences does indicate whether the quality of drinking water may be compromised, and which analytes could be causing problems.

4.3 Water Quality Assessment Results

We evaluate water quality by grouping sampling locations by basin and for different uses. We then compare the statistical summary of the groupings to water quality standards and guidelines. For each basin, we compared:

- The statistical summary for all water quality data from each basin to Peru Water Law Standards and International Guidelines for human consumption, livestock and irrigation to give a view of overall water quality in each basin.
- Water quality in specific stream and water treatment network locations to Peru Water Law Standards and International Guidelines for drinking water (Porcon Basin only).
- Water quality in specific canal locations to Peru Water Law Standards and International Guidelines for livestock and irrigation.
- Water quality at specific locations from the previous Mesa study that were identified as influenced by mining activities ("critical points") to Peru Water Law Standards and International Guidelines for livestock and irrigation.
- Water quality in mine-site groundwater wells and discharge compliance points to Peru Water Law Standards and International Guidelines for livestock and irrigation.

The statistical analysis of water quality data and comparison to standards helps us determine the overall water quality and the suitability of the water for different uses. Tables in the following sections contain the following types of information:

- The 90th percentile value for each analyte of importance for each basin. We use the 90th percentile for these comparisons because an occasional exceedance of a standard is generally acceptable. The 90th percentile value means that 9 out of 10 samples will have a concentration below this value.
- Whether the 90th percentile value exceeds a water quality standard or guideline for each sampling location. Where there are multiple guidelines for a certain use, we compare to the lowest (most conservative) value.
- The number of times that the standard or guideline was exceeded for each sampling location (frequency of exceedence).

4.3.1 Porcon Basin

A total of approximately 675 samples were collected in the Porcon Basin between July 2004 and August 2005. The following table shows the 90th percentile concentration for each analyte of concern and whether this value exceeds Peru Water Law standards and International Guidelines.

Table 4.3.1: Porcon Basin Statistical Summary

			Exceeds Peru Water Law Standards?			**Exceeds International Guidelines?**		
						Consumption		
Analyte	*Units*	*90th %*	*Class I*	*Class II*	*Class III*	*Human*	*Livestock*	*Irrigation*
Fecal coliform	mpn/100mL	5000	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
Cyanide WAD	ug/L	2.5	No	No	No	No	No	No
TDS	mg/L	202	-	-	-	-	No	No
Nitrate	mg/L	0.3	No	No	No	No	No	No
Arsenic	ug/L	5	No	No	No	No	No	No
Cadmium	ug/L	0.5	No	No	No	No	No	No
Copper	ug/L	104	No	No	No	No	No	No
Chromium	ug/L	1	No	No	No	No	No	No
Manganese	ug/L	344	-	-	-	-	-	**Yes**
Mercury	ug/L	0.2	No	No	No	No	No	No
Lead	ug/L	5	No	No	No	No	No	No
Selenium	ug/L	5	No	No	No	No	No	No

With the exception of fecal coliform bacteria, water quality in the Porcon Basin meets Peru Water Law Class II and Class III standards. Results indicate that the most pervasive water quality issue in the basin is coliform bacteria. The previous Mesa study determined that bacteria do not result from mine operations because concentrations of bacteria were lowest near the mine boundary and increased downstream as agricultural and human activities increased. Manganese concentrations in the Porcon Basin also exceed international guidelines for irrigation.

4.3.1.1 Porcon Basin Human Consumption Water Quality

The following table presents a comparison of the 90th percentile water quality parameter concentrations for streams to Peru Water Law Class II standards (streams in the Porcon Basin are designated Class II by DIGESA because they provide the source of raw water for the City of Cajamarca). We also compare the 90th percentile concentration to International Guidelines for *treated* drinking water.

Table 4.3.1.1.a: Porcon Basin Drinking Water

	Peru Water Law			*International guidelines*		
	Class II			**Human consumption**		
Stream	**90th% exceeds**	**analytes**	**freq**	**90th% exceeds**	**analytes**	**freq**
No mine influence						
Qda Quishuar Corral	No	-	-	No	-	-
Qda Santa Rosa	No	-	-	No	-	-
Qda Tual	No	-	-	No	-	-
Rio Chilincaga	No	-	-	No	-	-
Rio Hornamayo	No	-	-	No	-	-
Rio Porcon	No	-	-	No	-	-
Rio Purhuay (Quengorio)	No	-	-	No	-	-
Rio Quilis	No	-	-	No	-	-
Rio Ronquillo	No	-	-	No	-	-
Indirect mine influence						
Qda Corral Blanco	No	-	-	No	-	-
Qda China Linda	No	-	-	No	-	-
Qda Hunigan	No	-	-	No	-	-
Qda Quilish	No	-	-	No	-	-
Qda Quilish La Paccha	No	-	-	No	-	-
Qda Vizcachayoc	No	-	-	No	-	-
Direct mine influence						
Qda Encajon	No	-	-	Yes	Cd	4/16
Qda Callejon	No	-	-	Yes	Pb	1/12
Upper Rio Grande	No	-	-	No	-	-
Lower Rio Grande	No	-	-	Yes	Pb	2/13
Camera de Mezcla Rapida	No	-	-	No	-	-

Water quality in the Porcon Basin meets Peru Water Law Class II standards. Monitoring locations in the upper Rio Grande occasionally exceeded International Guidelines for cadmium and lead in treated drinking water. (This comparison is only for reference. Water in these locations is not treated.) These contaminants are removed in the El Milagro treatment plant and water quality in the City of Cajamarca meets International Guidelines as shown in the next table.

Next, we evaluated the 90th percentile concentration from samples taken in the SEDACAJ treated water network.

Table 4.3.11b: City of Cajamarca Drinking Water Network

	Peru Water Law			*International guidelines*		
	SUNASS			**Human consumption**		
Monitoring point	**90th% exceeds**	**analytes**	**freq**	**90th% exceeds**	**analytes**	**freq**
Salida El Milagro	No	-	-	No	-	-
Salida Santa Apolonia	No	-	-	No	-	-
Reservorio de Abastaciemento	No	-	-	No	-	-
Redes	No	-	-	No	-	-

All samples collected met both Peru Water Law standards as well as International Guidelines for treated drinking water quality.

4.3.1.2 Porcon Basin Canal Water Quality

The following table presents a comparison of the 90th percentile water quality parameter concentrations for canals to Peru Water Law Class III standards (canals are designated Class III by DIGESA). We also compare the 90th percentile concentration to International Guidelines for livestock and irrigation use.

Table 4.3.1.2 Porcon Basin Canals

	Peru Water Law			*International guidelines*					
	Class III			**Livestock**			**Irrigation**		
canal	**90th% exceeds**	**analytes**	**freq**	**90th% exceeds**	**analytes**	**freq**	**90th% exceeds**	**analytes**	**freq**
No mine influence									
Carhuaquero Yacuchilla	No	-	-	No	-	-	No	-	-
Indirect mine influence									
Arcuyoc Potrero	No	-	-	No	-	-	No	-	-
Atunmayo	No	-	-	No	-	-	Yes	Mn	2/9
Capa Rosa	No	-	-	No	-	-	No	-	-
Cince de las Vizcachas	No	-	-	No	-	-	No	-	-
Colpa	No	-	-	No	-	-	No	-	-
Hermanos Cueva	No	-	-	No	-	-	No	-	-
Hermanos Cueva Derecha	No	-	-	No	-	-	No	-	-
Hermanos Cueva Izquierda	No	-	-	No	-	-	No	-	-
Quilish	No	-	-	No	-	-	No	-	-
Salvador Coremayo	No	-	-	No	-	-	Yes	Mn	1/9
Direct mine influence									
Tual	No	-	-	No	-	-	Yes	Cu, Mn	3/10
Encajon Collatan	Yes	Pb	2/14	Yes	As, Pb	2/14	Yes	Cu	8/14
Llagamarca	No	-	-	No	-	-	Yes	Cu, Mn	5/14
Quishuar	No	-	-	Yes	As	2/14	Yes	Cu, Mn	5/14

Only lead in Canal Encajon Collatan exceeded Peru Water Law Class III standards (occasionally for lead). As with the general water quality assessment for the basin (Table 4.3.1), manganese exceeds international guidelines in several canals with both limited mine influence (Atunmayo and Salvador Coremayo) and where the mine discharges water directly (Tual, Encajon Collatan, Llagamarca, and Quishuar). In addition, canals with direct mine discharge exceeded international irrigation guidelines for copper. Arsenic and lead occasionally exceeded international guidelines for livestock in two canals with direct mine discharge.

4.3.1.3 Porcon Basin Critical Point Water Quality

"Critical Points" in the Porcon basin include streams near the mine boundary that have mine facilities upstream (Qda Encajon) and/or direct discharge of treated water (Qda Callejon and the upper Rio Grande).

Table 4.3.1.3 Porcon Basin Critical Points

		Peru Water Law			*International guidelines*					
		Class II			**Livestock**			**Irrigation**		
Stream		**90th% exceeds**	**analytes**	**freq**	**90th% exceeds**	**analytes**	**freq**	**90th% exceeds**	**analytes**	**freq**
	Qda Encajon	No	-	-	No	-	-	Yes	TDS, Mn	14/16
	Qda Callejon	No	-	-	No	-	-	Yes	Mn	7/12
	Upper Rio Grande	No	-	-	No	-	-	Yes	Mn	5/14

These locations met Peru Water Law Class II standards and frequently exceeded international guidelines for manganese in irrigation water.

4.3.2 Rejo Basin

A total of approximately 120 samples were collected in the Rejo Basin between July 2004 and August 2005. The following table shows the 90th percentile concentration for each analyte of concern and whether this value exceeds Peru Water Law standards and International Guidelines.

Table 4.3.2 Rejo Basin Statistical Summary - All Locations

			Exceeds Peru Water Law?			**Exceeds International Guidelines?**		
						Consumption		
Analyte	*Units*	*90th %*	*Class I*	*Class II*	*Class III*	*Human*	*Livestock*	*Irrigation*
Fecal coliform	mpn/100mL	280	**Yes**	No	No	**Yes**	No	**Yes**
Cyanide WAD	ug/L	5	No	No	No	No	No	No
TDS	mg/L	476	-	-	-	-	No	No
Nitrate	mg/L	0.3	No	No	No	No	No	No
Arsenic	ug/L	11.4	No	No	No	No	No	No
Cadmium	ug/L	2.5	No	No	No	No	No	No
Copper	ug/L	34.5	No	No	No	No	No	No
Chromium	ug/L	5	No	No	No	No	No	No
Manganese	ug/L	295	-	-	-	-	-	**Yes**
Mercury	ug/L	0.3	No	No	No	No	No	No
Lead	ug/L	13	No	No	No	**Yes**	No	No
Selenium	ug/L	1	No	No	No	No	No	No

Water quality in the Rejo Basin meets Peru Water Law Class III standards. Results indicate that the most pervasive water quality issue in the basin is coliform bacteria. The previous Mesa study determined that bacteria do not result from mine operations because concentrations of bacteria were lowest near the mine boundary and increased downstream as agricultural and human activities increased. Manganese concentrations in the Rejo Basin slightly exceeded international guidelines for irrigation water and lead slightly exceeded international guidelines for *treated* drinking water (the water we sampled in this basin is not treated and we made this comparison only for reference).

4.3.2.1 Rejo Basin Canal Water Quality

The following table presents a comparison of the 90th percentile water quality parameter concentrations for canals to Peru Water Law Class III standards (canals are designated Class III by DIGESA). We also compare the 90th percentile concentration to International Guidelines for livestock and irrigation use.

Table 4.3.2.1 Rejo Basin Canals

	Peru Water Law			*International guidelines*					
	Class III			**Livestock**			**Irrigation**		
canal	**90th% exceeds**	**analytes**	**freq**	**90th% exceeds**	**analytes**	**freq**	**90th% exceeds**	**analytes**	**freq**
Direct mine influence									
Tual	No	-	-	No	-	-	Yes	Mn	1/6
Capa Rosa	No	-	-	No	-	-	No	-	-
Chorro Blanco	No	-	-	No	-	-	No	-	-

Water quality in the canals meets Peru Water Law Class III standards as well as international guidelines for livestock water. Only manganese in 1 out of 6 samples in Canal Tual exceeded the international guidelines for irrigation.

4.3.2.2 Rejo Basin Critical Point Water Quality

"Critical Points" in the Rejo basin include streams near the mine boundary that have mine facilities upstream (including the new sediment control dam).

Table 4.3.2.2 Rejo Basin Critical Points

	Peru Water Law			*International guidelines*					
	Class III			**Livestock**			**Irrigation**		
Stream	**90th% exceeds**	**analytes**	**freq**	**90th% exceeds**	**analytes**	**freq**	**90th% exceeds**	**analytes**	**freq**
Qda Shoclla	No	-	-	No	-	-	Yes	Mn	3/11
Rio Tinte	No	-	-	No	-	-	No	-	-
Rio Rejo	No	-	-	No	-	-	No	-	-

Water quality at the critical points meets Peru Water Law Class III standards as well as international guidelines for livestock water. Only manganese in 3 out of 11 samples in Qda Shoclla exceeded the international guidelines for irrigation.

4.3.3 Honda Basin

A total of approximately 110 samples were collected in the Honda Basin between July 2004 and August 2005. The following table shows the 90th percentile concentration for each analyte of concern and whether this value exceeds Peru Water Law standards and International Guidelines.

Table 4.3.3 Honda Basin Statistical Summary

			Exceeds Peru Water Law?			Exceeds International Guidelines?		
						Consumption		
Analyte	*Units*	*90th %*	*Class I*	*Class II*	*Class III*	*Human*	*Livestock*	*Irrigation*
Fecal coliform	mpn/100mL	500	**Yes**	No	No	**Yes**	No	**Yes**
Cyanide WAD	ug/L	20	No	No	No	No	No	No
TDS	mg/L	1043	-	-	-	-	No	**Yes**
Nitrate	mg/L	21	No	No	No	**Yes**	No	No
Arsenic	ug/L	7	No	No	No	No	No	No
Cadmium	ug/L	2.5	No	No	No	No	No	No
Copper	ug/L	100	No	No	No	No	No	No
Chromium	ug/L	5	No	No	No	No	No	No
Manganese	ug/L	133	-	-	-	-	-	No
Mercury	ug/L	0.6	No	No	No	No	No	No
Lead	ug/L	37	No	No	No	**Yes**	No	No
Selenium	ug/L	11	**Yes**	**Yes**	No	**Yes**	No	No

Water quality in the Honda Basin meets Peru Water Law Class III standards. The 90th percentile concentration exceeded international standards for lead and selenium for drinking water and total dissolved solids (TDS) for irrigation water.

4.3.3.1 Honda Basin Canal Water Quality

The following table presents a comparison of the 90th percentile water quality parameter concentrations for canals to Peru Water Law Class III standards (canals are designated Class III by DIGESA). We also compare the 90th percentile concentration to International Guidelines for livestock and irrigation use.

Table 4.3.3.1 Honda Basin Canals

	Peru Water Law			*International guidelines*					
	Class III			**Livestock**			**Irrigation**		
canal	**90th% exceeds**	**analytes**	**freq**	**90th% exceeds**	**analytes**	**freq**	**90th% exceeds**	**analytes**	**freq**
<u>*Direct mine influence*</u>									
Tual	No	-	-	No	-	-	Yes	TDS, Cu, Se	4/14
<u>*Indirect mine influence*</u>									
Campanario	Yes	Pb	1/6	Yes	As, Pb	1/6	Yes	As, Mn	1/6
Piedra Gacha	No	-	-	No	-	-	No	-	-

Water quality in Canal Tual and Piedra Gacha meets Peru Water Law Class III standards as well as international guidelines for livestock water. International standards for irrigation water were exceeded in Canal Tual for TDS, copper and selenium. Water quality standards and guidelines were exceeded in Canal Campanario on 1 out of 6 times.

4.3.3.2 Honda Basin Critical Point Water Quality

"Critical Points" in the Honda Basin include the treated water discharge location in Qda Pampa Larga and the upper part of Qda Honda.

Table 4.3.3.2 Honda Basin Critical Points

		Peru Water Law			*International guidelines*					
		Class III			**Livestock**			**Irrigation**		
Stream		**90^{tho}% exceeds**	**analytes**	**freq**	**90^{tho}% exceeds**	**analytes**	**freq**	**90^{tho}% exceeds**	**analytes**	**freq**
	Qda Pampa Larga	Yes	Pb	2/5	Yes	As	1/5	Yes	TDS, Pb, Mn, Se	2/6
	Qda Honda	No	-	-	No	-	-	No	-	-

Water quality in Qda Pampa Larga exceeded Peru Class III standards for lead. In addition, international irrigation guidelines were exceeded for total dissolved solids, lead, manganese, and selenium on 2 of 6 occasions. Qda Honda water quality met all standards and guidelines.

4.3.4 Chonta Basin

A total of approximately 110 samples collected in the Honda Basin between July 2004 and August 2005. The following table shows the 90th percentile concentration for each analyte of concern and whether this value exceeds Peru Water Law standards and International Guidelines.

Table 4.3.4 Chonta Basin Statistical Summary

			Exceeds Peru Water Law?			**Exceeds International Guidelines?**		
						Consumption		
Analyte	*units*	*90th %*	*Class I*	*Class II*	*Class III*	*Human*	*Livestock*	*Irrigation*
Fecal coliform	mpn/100mL	300	**Yes**	No	No	**Yes**	No	**Yes**
cyanide	ug/L	5	No	No	No	No	No	No
TDS	mg/L	355	-	-	-	-	No	No
Nitrate	mg/L	1	No	No	No	No	No	No
Arsenic	ug/L	5	No	No	No	No	No	No
Cadmium	ug/L	2.5	No	No	No	No	No	No
Copper	ug/L	37	No	No	No	No	No	No
Chromium	ug/L	5	No	No	No	No	No	No
Manganese	ug/L	524	-	-	-	-	-	**Yes**
Mercury	ug/L	0.5	No	No	No	No	No	No
Lead	ug/L	22	No	No	No	**Yes**	No	No
Selenium	ug/L	2.5	No	No	No	No	No	No

Water quality in the Chonta Basin meets Peru Water Law Class III standards. Manganese concentrations in the Chonta Basin exceeded international guidelines for irrigation water and lead and arsenic slightly exceeded international guidelines for *treated* drinking water (the water we sampled in this basin is not treated and we made this comparison only for reference).

4.3.4.1 Chonta Basin Canal Water Quality

The following table presents a comparison of the 90th percentile water quality parameter concentrations for canals to Peru Water Law Class III standards (canals are designated

Class III by DIGESA). We also compare the 90^{th} percentile concentration to International Guidelines for livestock and irrigation use.

Table 4.3.4.1 Chonta Basin Canals

	Peru Water Law			*International guidelines*					
	Class III			**Livestock**			**Irrigation**		
canal	**90^{th}% exceeds**	**analytes**	**freq**	**90^{th}% exceeds**	**analytes**	**freq**	**90^{th}% exceeds**	**analytes**	**freq**
No mine influence									
Cocan	No	-	-	No	-	-	No	-	
Quihuila Quecher Pabellon	No	-	-	No	-	-	No	-	-
Unigan Tornuyoc	No	-	-	No	-	-	No	-	-
Indirect mine influence									
Azufre Ventanilla	No	-	-	No	-	-	No	-	-
Azufre Ahidero	No	-	-	No	-	-	No	-	-
Tres Tingos	No	-	-	No	-	-	Mn	Mn	4/10
Direct mine influence									
La Shacsha	No	-	-	No	-	-	Yes	Al, Mn	12/13
Azufre Atonconga	No	-	-	No	-	-	Yes	Al, Mn	1/9
Shacsha Unigan	No	-	-	No	-	-	Yes	Mn	1/4
Tomacucho	No	-	-	No	-	-	Yes	Mn	1/4

Water quality in all canals in the Chonta Basin meets Peru Water Law Class III standards and international guidelines for livestock. Irrigation water in Canal La Sacsha exceeded international guidelines for aluminum and manganese the majority of the time.

4.3.4.2 Chonta Basin Critical Point Water Quality

Critical points in the Chonta Basin include streams directly downstream of mine operations.

Table 4.3.4.2 Chonta Basin Critical Points

	Peru Water Law			*International guidelines*					
	Class III			**Livestock**			**Irrigation**		
Stream	**90^{th}% exceeds**	**analytes**	**freq**	**90^{th}% exceeds**	**analytes**	**freq**	**90^{th}% exceeds**	**analytes**	**freq**
Qda Arnacocha	No	-	-	No	-	-	Yes	Mn	1/5
Qda Chaquicocha	Yes	Pb	1/3	Yes	Al, As, Pb	2/3	Yes	Al	2/3
Qda Ocucha Machay	No	-	-	No	-	-	No	-	-
Qda San Jose	Yes	Cu	1/5	Yes	Al, Cu	4/5	Yes	TDS, Al, Cu, Mn	4/5

Water quality in Quebrada Arnacocha and Qda Ocucha Machay met Peru Water Law Class III standards as well as international livestock guidelines. Qda Chaquicocha and Qda San Jose occasionally exceeded Peru Water Law standards for lead and copper, respectively. These two streams also exceeded international guidelines for livestock and irrigation the majority of the time.

4.3.5 Mine Monitoring Points

Minera Yanacocha collects data from three groundwater monitoring wells (Pozo Maqui Maqui, Pozo Cerro Yanacocha, and Pozo La Quinua) on a quarterly basis. Minera Yanacocha also monitors two treated water discharge points (Punto Descarga La Quinua in the Porcon Basin and Punto Descarga Pampa Larga in the Honda Basin).

Table 4.3.5 Mine Monitoring Points

	Peru Water Law			*International guidelines*					
	Class III			**Livestock**			**Irrigation**		
	90th% exceeds	**analytes**	**freq**	**90th% exceeds**	**analytes**	**freq**	**90th% exceeds**	**analytes**	**freq**
Groundwater wells									
Pozo Maqui Maqui	No	-	-	No	-	-	Yes	Mn	2/5
Pozo Cerro Yanacocha	No	-	-	No	-	-	Yes	Mn, TDS	3/5
Pozo La Quinua	No	-	-	No	-	-	Yes	Mn	1/5
Discharge Points									
La Quinua	No	-	-	No	-	-	Yes	Mn, TDS	4/5
Pampa Larga	Yes	Cu	1/5	Yes	Cu	1/5	Yes	Se, Cu, TDS	2/5

5. Summary, Conclusions and Recommendations

Since July 2004 the Mesa de Diálogo y Consenso CAO-Cajamarca (the Mesa) has been conducting a participatory monitoring program to evaluate water quality in the vicinity of the Yanacocha Mining District near Cajamarca, Peru. The monitoring program is a response to the recommendations of an independent water assessment conducted on behalf of the Mesa and completed in 2003.

The basic study design was prepared in April 2004 during a workshop composed of Mesa participants and professionals from institutions in Cajamarca. The workshop defined the following specific objectives:

- Obtain information on the quality and quantity of surface and ground water in the basins adjacent to the mining operation, taking into account the different uses (human consumption, livestock and irrigation).
- Implement a geographical database of monitoring results.
- Make this information available permanently to the public in a participatory and transparent way.
- Generate confidence in monitoring results and enhance credibility of data interpretation.
- Report to the public on the quality of water in Cajamarca.

To achieve these objectives, the Mesa technical team works with other institutions that monitor water quality and quantity in Cajamarca, including SEDACAJ (the municipal water supply company for the City), COMOCA Sur and Este (the canals users associations), Minera Yanacocha, the community of Granja Porcon and the Centros Poblados Yanacancha and Llaucan. Together, these institutions monitor water quality and flow monthly at over 100 locations in the four basins surrounding the mine (Porcon, Chonta, Honda, and Rejo). The Mesa complements and strengthens these monitoring efforts by providing an independent source of funding, validation, and interpretation of monitoring results.

This annual monitoring report presents the results and interpretation of water quality data collected monthly between July 2004 and August 2005. Water quality data were collected and evaluated at over 100 locations, including:

- 18 streams and 14 canals at a total of 51 locations in the Porcon Basin
- 7 streams and 3 canals at a total of 12 locations in the Rejo Basin
- 6 streams and 3 canals at a total of 16 locations in the Honda Basin
- 5 streams and 11 canals at a total of 18 locations in the Chonta basin
- 5 locations in the SEDACAJ treated drinking water network
- 4 groundwater wells and 2 discharge points at the mine site.

The Mesa technical team and veedores representing institutions in the Mesa accompany the staff from the participating institutions while sampling. The Mesa takes field measurements at each location and collects double samples at a subset of locations (approximately 10% of the total number of samples collected). The Mesa technical team compares Mesa sample results to institution sample results to evaluate data validity and quality.

The technical team then evaluates whether the water is usable for drinking, and agriculture in two ways. First, we compare concentrations of important constituents in each water sample to Peruvian water quality standards established by the General Water Law (Ley General de Aguas) as follows:

- **Class II** - Raw water used for domestic purposes that is made potable by treating with coagulation, sedimentation, filtration and chlorination, as approved by the Department of Health)
  - Streams in the Porcon Basin, including the sub-basins Porcon and Grande and all tributaries.
- **Class III** - Raw water used for vegetable irrigation and animal (livestock) consumption.
  - Streams in the Rejo, Chonta and Honda (Llaucano) basins and all tributaries; Canals in the Porcon, Rejo, Honda and Chonta basins.

Then we compare measured concentrations to international guidelines that have been developed to protect drinking water and agricultural resources when the water is used every day. The international guidelines we use were established by: the World Health Organization (WHO); the U.S. Environmental Protection Agency (EPA); the State of Nevada Division of Environmental Protection, United States; Environment Canada; and the Food and Agriculture Organization of the United Nations (FAO).

When concentrations exceed these guidelines it does not necessarily mean that there will be problems. For example, in describing their drinking water standards, the World Health Organization states that "short-term deviations above the guideline values do not necessarily mean that the water is unsuitable for consumption." When assessing whether to be concerned about water quality at a location, we determine:

- Which analytes exceed a standard or guideline because different elements affect water use in different ways.
- The 90th percentile of the concentration because an occasional exceedance of a standard is generally acceptable. The 90th percentile value means that 9 out of 10 samples will have a concentration below this value.
- The amount that a concentration exceeds the standard or guideline.
- The number of times that the concentration at a location exceeded a standard or guideline.

The Mesa technical team and a Technical Commission consisting of representatives of institutions that participate in the Mesa review the data and interpretation on a quarterly basis and these results are given to the community. The Mesa technical team prepared this report which summarizes data collected between July 2004 and August 2005.

For this annual monitoring report, we evaluated over 1,000 individual water quality samples collected by the participating institutions and analyzed at their chosen analytical laboratories, and 120 duplicate samples collected by the Mesa technical team and analyzed at laboratories selected by the Mesa staff and Technical Commission.

5.1 Data Quality Assessment Summary

One of the primary purposes of the participatory monitoring program is to evaluate the quality of data collected by participating institutions in Cajamarca. This data quality review increases confidence in the water quality data collected by the participating institutions. We do this in two ways:

- First we collect duplicate samples at a subset of the total number of locations that the participating institutions monitor and send them for analysis to a laboratory we selected.
- Next we determine the quality of the data by evaluating quality control samples. We evaluate blank and duplicate samples collected by the institutions. We also evaluate blank, standard reference, and duplicate samples that we collect and send to our own laboratory.

5.1.1 Mesa Duplicate Samples Compared to Institution Samples

We collected 120 duplicate samples for this study. We accompany the participating institutions on their sampling trips and collect a sample at the same location and time as the institution. We use our own collection procedures and bottles and give the sample a different name than the institution so that only the Mesa technical team knows from which location we collect the duplicate samples.

After we receive the analytical data from the laboratory, we compare concentrations of each analyte in our duplicate sample to the concentration in the sample from the institution and calculate the relative percent difference. The relative percent difference is the difference between the results from the two samples divided by the average value. In this way, we compare the two samples and determine:

- If the samples have been changed in any way by the institutions or the laboratory
- If the quality of the data is acceptable for the purposes of the study.

We evaluated relative percent differences for each analyte in each sample. For all duplicate samples:

- The water the institution sampled was the same as the water the Mesa technical team sampled.
- Different sample collection methods yielded similar results.
- The samples were not altered during handling and shipping to the laboratory.
- The samples were not altered at the laboratories.
- Laboratory results were comparable.

Relative percent difference values were generally within an acceptable range for each duplicate pair of samples. Based on this assessment, we know that the data collected by the Mesa and the institutions is valid. Therefore, we know that we can rely on all data collected by the institutions for our water quality assessment (over 1,000 total samples).

5.1.2 Quality Control Samples

Each institution collects duplicate samples and blank samples to evaluate how samples are collected and the quality of data from the laboratory. The two samples for the duplicate are collected in the same manner, given a different name, and analyzed at the same laboratory. Results from these two samples are compared to each other. Blank samples are pure water that is placed in bottles and labeled like a regular sample and sent to the laboratory. These samples should have very low or non-detect concentrations.

The Mesa technical team also collects duplicate and blank samples. In addition, we prepare a standard reference sample. This sample has a known concentration of each element analyzed by the laboratory. We compare the results of the laboratory analysis to the known concentrations.

All of the quality control samples are sent to the laboratory "blind" so that the laboratory does not know that they are analyzing blank, duplicate, or standard reference samples. Relative percent differences for all duplicate samples were within an acceptable range. All blank samples had very low or non-detected concentrations of the analytes the laboratory measured. The relative percent differences between standard reference sample concentrations and the known concentrations were also within an acceptable range. Therefore, we conclude from the quality control samples results that all of the data collected by the Mesa technical team and the institutions can be used for the water quality assessment.

5.2 Water Quality Assessment Summary

In this section we present a summary of our water quality assessment for each basin and for different uses (human consumption, livestock and irrigation). We also summarize water quality at "critical points" we identified in the 2003 Mesa study and at groundwater and discharge points for the mine.

5.2.1 Porcón Basin

The water quality in the Sub Basin Río Porcón and Sub Basin Río Grande complies with the standards of the Peru General Water Law Class III, with the exception of the presence of lead in the canal Encajón Collotán.

5.2.1.1 Water Quality for Human Consumption

Water quality for human consumption in the Sub Basin Río Porcón and Sub Basin Río Grande, complies with the standards of the Peru General Water Law Class II, with the exception of fecal coliform bacteria, which are not the result of mining operations, but can be due to agriculture and human activities in the area.

The quality of potable water at the exit of the El Milagro and Santa Apolonia treatment plants, Supply Reservoir and Network complies with the standards of SUNASS and international guides (OMS, USEPA) for treated potable water.

5.2.1.2 Water Quality for Agriculture

For canals without mining influence (Carhuaquero Yacuchilla), water quality meets international guide values for irrigation.

Water quality in canals with indirect influence of the mine (Arcuyoc Potrero, Atunmayo, Colpa, Hermanos Cueva, Hermanos Cueva derecha, Hermanos Cueva izquierda, Salvador Coremayo, Cince de las Vizcachas y Quilish) meets the international guide values for livestock and irrigation, with the exception that manganese exceeds the international guides for irrigation in Canal Atunmayo (2 of 9 samples) and in canal Salvador Coremayo (1 of 9 samples).

Water quality in canals with direct mine influence (Tual, Encajón Collotán, Quishuar and Llagamarca) exceeded the international irrigation guide values for manganese and copper and occasionally exceeded the international guide values for livestock for arsenic and lead (Encajón Collotán and Quishuar).

5.2.1.3 Water Quality in Critical Points

We consider three critical points close to the mine boundary in the Porcon Basin (Qda Encajón, Qda Callejón and upper Río Grande). Water quality in Qda. Encajón frequently exceeded the international guide values for irrigation for TDS and manganese. The guide value for manganese for irrigation was also exceeded in Qda Callejón and upper Río Grande.

5.2.2 Rejo Basin

The water quality of the basin complies with the standards of the Peru General Water Law Class III, with the exception of fecal coliform bacteria. These are not the result of the mining operations, since the concentrations found are low near the limit of the mine and increase down the river.

The water quality related to the international guide values for livestock and irrigation complies with the international guide values.

Water quality in the canal without mining influence (Chorro Blanco) complied with international guide values for animal drinking and irrigation

Water quality in the canal with indirect mining influence (Capa Rosa) complies with international guide values, with the exception of Canal Tual which slightly exceeded the irrigation international guide values for manganese (1 of 6 times).

Water quality in the canal with direct mining influence (Tual) complies with international guide values for livestock, and slightly exceeded international guide values for manganese in irrigation water (1 of 6 times).

5.2.2.1 Water Quality in Critical Points

Three critical points have been considered (Qda Shoclla, Río Tinte and Río Rejo). Water quality in these points complies with the international guide values for livestock. Only manganese exceeded the international guide values for irrigation in the Qda Shoclla (3 of 11 times).

5.2.3 Honda Basin

Water quality for the basin complies with the standards of the Peru General Water Law Class III, except for Canal Campanario, which slightly exceeds the national standard for lead (1 of 6 samples) and Qda Pampa Larga (2 of 5 samples).

Water quality in canals complies with international guide values for livestock except for the presence of arsenic and lead in Canal Campanario (1 of 6 samples). The international guide values for irrigation water were exceeded for TDS, copper and selenium in canal Tual (4 of 14 samples); and arsenic and manganese in Canal Campanario (1 of 6 samples).

5.2.3.1 Water Quality in Critical Points

Critical points in this basin included Qda Pampa Larga and Qda Honda. Water quality in Qda Pampa Larga exceeded the international guide values for total dissolved solids (TDS), lead, manganese and selenium (2 of 6 samples). Quebrada Honda complied with all the international guide values.

5.2.4 Chonta Basin

Water quality in this basin complies with the standards of the Peru General Water Law Class III except for occasional exceedance for lead in Qda Chaquicocha (1 of 3 samples) and copper in Qda San José (1 of 5 samples)

Water quality in canals which do not have mining influence (Cocán, Quihuila Quecher Pabellón and Uñigán Tornuyoc) complies with the international guide values for irrigation.

Water quality of the canals with indirect influence of the mine (Tres Tingos, Azufre Ventanilla and Azufre Ahijadero) complies with the international guide values for livestock and irrigation.

The quality of the canals with direct mining influence (La Shacsha, Azufre Atunconga, Shacsha Uñigán and Tomacucho) exceeded the international guide values for irrigation for manganese and aluminum in Canal La Shacsha (12 of 13 times) and in Canal Azufre Atunconga (1 of 9 times); manganese in canal Shacsha Uñigan (1 of 4 times) and in canal Tomacucho (1 of 4 times).

5.2.4.1 Water Quality in Critical Points

Four critical points have been considered in this basin (Qda Arnacocha, Qda Chaquicocha, Qda Ocucha Machay and Qda San José). The concentration of manganese occasionally exceeds the international guide values for irrigation in Qda. Arnacocha (1 of 5 times). Water quality in Qda San José exceeded for TDS, aluminum, copper and manganese (4 of 5 times). For international guide values for livestock, aluminum, arsenic and lead were above the guide value in Qda Chaquicocha (2 of 3 times) and aluminum and copper in Qda San José (4 of 5 times). Water quality in Qda Ocucha Machay did not exceed the values of the international guidelines.

5.2.5 Mine Monitoring Points

Minera Yanacocha takes simples in three ground water monitoring wells (Pozo Maqui Maqui, Pozo Cerro Yanacocha and Pozo La Quinua) quarterly,. They also monitor two treated water discharge points (Discharge Point La Quinua and Discharge Point Pampa Larga). Water quality in these wells and discharges complies with the Peru Water Law Class III with the exception of the occasional presence of copper in Pampa Larga (1 of 5 times)

When evaluating water quality of mine points in comparison to the international guide values for irrigation, manganese was found in Maqui Maqui Well (2 of 5 times) and in La Quinua Well, and manganese and TDS in Cerro Yanacocha Well (3 of 5 times). For Discharge Points, La Quinua exceeded international guide values for manganese and TDS (4 of 5 times), and selenium, copper and TDS exceeded guide values in Pampa Larga (2 of 5 times).

5.3 Conclusions

Validation and Qualification of the data

Between July 2004 and August 2005, the Mesa technical team evaluated over 1,000 samples collected by participating institutions (COMOCA Sur and Este, SEDACAJ, Minera Yanacocha, the community of Granja Porcon and the Centros Poblados Yanacancha and Llaucan) from 112 locations in the Porcon, Rejo, Honda and Chonta basins. We collected 120 duplicate samples to conduct an extensive review of the validity and quality of the data collected by the participating institutions. From this analysis, we conclude that the data collected by the institutions is valid and can be used for the water quality assessment.

Evaluation of the Water for Different Uses

First, we compared sample results for surface water in the Porcon Basin to:

Peru General Water Law Standards for raw water that supplies drinking water systems (Class II). Then we compared sample results for surface water in the Chonta, Honda, and Rejo basins to Peru Water Law standards for agricultural water (Class III). Finally, we compared the water quality existing the two drinking water plants to potable water criteria from SUNASS. We found that:

1. For the Porcon Basin:
   - All 20 streams meet Class II standards.
   - Fourteen out of 15 canals meet Class III standards.
   - Potable water for the City of Cajamarca meets the standards of SUNASS.

2. For the Rejo Basin:
   - Surface water quality in streams and the three canals we evaluated meets Class III standards.

3. For the Honda Basin:
   - Surface water quality meets Class III standards.
   - Water quality in two out of three canals meets Class III standards.

4. For the Chonta Basin:
   - Surface water quality in streams and the 10 canals we evaluated meets Class III standards.

5. Fecal Coliform bacteria resulting from human and animal waste often exceeds Class II and III standards and is a concern in all basins.

We then compared sample results to ***International Guidelines*** developed for human consumption, livestock and irrigation. Although these guidelines are not enforceable, comparison to them allows us to determine if there could be any short or long-term concerns for water quality. We conclude:

1. There are no imminent risks to people, animals or plants from using the water for drinking, livestock or irrigation.

2. The quality of *potable water* leaving the treatment plants for the City of Cajamarca does not exceed international guidelines for treated drinking water (OMS and U.S. EPA).

3. When evaluating all streams and canals together, water quality in the Porcon, Rejo, Honda and Chonta basins generally does not exceed international guidelines for *irrigation*.
    - o Manganese exceeds these guidelines in the Porcon, Rejo and Chonta basins in streams and canals with and without influence from mining.
    - o Total dissolved solids exceeds these guidelines in the Honda basin.
    - o With the exception of manganese, water quality exceeds guidelines the following specific locations:
        - Four of the 15 canals in the Porcon basin
        - None of the 3 canals in the Rejo basin
        - Two of the 3 canals in the Honda basin
        - One of the 10 canals in the Chonta basin.

4. When evaluating all streams and canals together, water quality in the Porcon, Rejo, Honda, and Chonta basins generally does not exceed international guidelines for *livestock*.
    - Water quality exceeds guidelines in the following specific locations:
        - Two of the 15 canals in the Porcon basin
        - None of the 3 canals in the Rejo basin
        - Two of the 3 canals in the Honda basin
        - None of the 10 canals in the Chonta basin.

5. Minera Yanacocha has implemented measures to improve water quality since the 2003 Mesa study was completed, including installation of reverse osmosis treatment for the mine water discharge in Quebrada Pampa Larga and installation of sediment control dams in Rio Rejo and Rio Grande. Water quality in the Honda, Rejo, and Grande sub-basin of the Porcon basin has generally improved after installation of these facilities.

6. Areas where we have concerns about water quality include:

- The upper part of Quebrada Honda (Quebrada Pampa Larga, Canal Tual).
    - o Although mine discharge water quality in Quebrada Honda has improved since 2003 (after implementation of reverse osmosis treatment), some elements exceed international guidelines for livestock and irrigation.
- The upper part of Rio Grande in the Porcon basin (Quebrada Encajon, Quebrada Callejon, Canals Tual, Encajon Collatan, Quishuar and Llagamarca).
- The upper part of Rio San Jose in the Chonta basin (Rio San Jose and Canal La Shacsha).

We describe our recommendations for addressing these concerns in the following section.

5.4 Recommendations

Our participation over the last year in the water monitoring efforts of institutions in Cajamarca has been very positive. The institutions we have worked with (COMOCA Este and Sur, SEDACAJ, MYSRL, the community of Granja Porcon, and the Centros Poblados Yanacancha and Llaucan) have made a great contribution to the understanding of water quality in Cajamarca.

Recommendations for Specific Water Quality Concerns

We have also seen improvements in water quality since the previous Mesa study was completed in 2003. Based on the results of this annual monitoring report, we recommend that the following specific water quality concerns be addressed:

- **Quality of Water for Agriculture:**

1. Evaluate water quality concerns in streams and canals in the upper Rio Grande in the Porcon Basin. This would include a more frequent evaluation of water quality in the mine's discharge point, Punto Descarga La Quinua, as well as an evaluation of other potential sources.
2. Evaluate water quality concerns in streams and canals in the upper Quebrada Honda. This would include a more frequent evaluation of water quality in the mine's discharge point, Punto Descarga Pampa Larga, as well as an evaluation of other potential sources of metals.
3. Evaluate water quality concerns in the upper Rio San Jose and Canal La Shacsha in the Chonta Basin.
4. Determine if manganese is a significant concern for irrigation. This evaluation could include:
   - Determination of manganese concentrations in agricultural soils and soil chemistry
   - Determination of whether crops grown in the region are sensitive to manganese.
5. Develop procedures to mitigate and improve water quality if necessary.

- **Water quality for human consumption:**

1. Survey rural populations within the four basins to determine which people do not have access to potable water sources.
2. If a potable water source is not available, determine whether water quality in specific canals and streams that may be used for human consumption meet water quality standards and guidelines (including those for fecal coliform bacteria).
3. If water quality does not meet standards and guidelines, determine alternative sources.

Recommendations for future water monitoring:

1. Because water quantity is a major concern, develop precise standards and procedures for measuring stream flow that are adhered to by the sampling teams. Overall, there needs to be more focus on water quantity issues.
2. Evaluate trends in data from month to month and incorporate graphics that show changes in water quality over time into the presentation of results.
3. Improve disclosure and dissemination of information to the public in urban and rural areas.

4. Encourage the active participation of veedores, especially people living in the areas where water monitoring occurs. Possible ways to encourage participation include:
   - Developing a schedule for monitoring that better accommodates participants.
   - Telling people in the field about the purpose and procedures for the monitoring.
   - Telling people in the field where and when they can find out about monitoring results.
5. Develop standardized data quality control procedures between monitoring programs, including criteria for collecting and analyzing duplicate, blank and standard reference samples and reporting the results.
6. Improve coordination and cooperation between institutions that monitor water.

We hope that these recommendations provide a path forward for future water monitoring and improvement of water resources in Cajamarca.

For more information on specific water quality issues, please contact:

Ing. Luis Ara Valera, Coordinator
Carlo Calderon, Technical Coordinator

La Mesa de Dialogo y Consenso CAO-Cajamarca
Jr. Los Cerezos 127, Urbanizacion El Ingenio
Cajamarca
Tel: (076) 36-5946, 34-3271
Email: mesadialogcao@hotmail.com, calderoncarlo@yahoo.com