The Conga Mine, Peru: Comments on the Environmental Impact Assessment (EIA) and Related Issues.

Robert E. Moran, Ph.D., Michael-Moran Assoc., L.L.C.
Colorado, U.S.A.
remwater@gmail.com

Prepared for the Environmental Defender Law Center

Summary.

1. The Conga EIA does not represent independent, disinterested science and opinions. It is important to note that the Conga EIA was produced by companies having a financial interest in ensuring that the Conga project goes forward. All publicly-available technical data and information for these proposed operations were collected by the mining companies or by consultants / contractors paid and directed by these companies. The opinions in the EIA on future impacts also come from the companies or their paid contractors.

2. The Conga EIA includes much useful information, but frequently leaves out "inconvenient" details and contains half-truths and incorrectly interpreted opinions. In many senses, this EIA is basically a public relations (PR) document, intended to promote the acquisition of permits. All of the opinions in the EIA are "colored" by this lack of a financially-disinterested approach.

3. This EIA fails to provide the quality of testing and data necessary for the public, regulators and investors to adequately evaluate future impacts. Such a technically-inadequate EIA would not be acceptable for permit approval in highly-developed countries.

4. All comparable mine projects inevitably generate significant, negative impacts to water resources over the long-term and there is no reason to believe the Conga project would not.

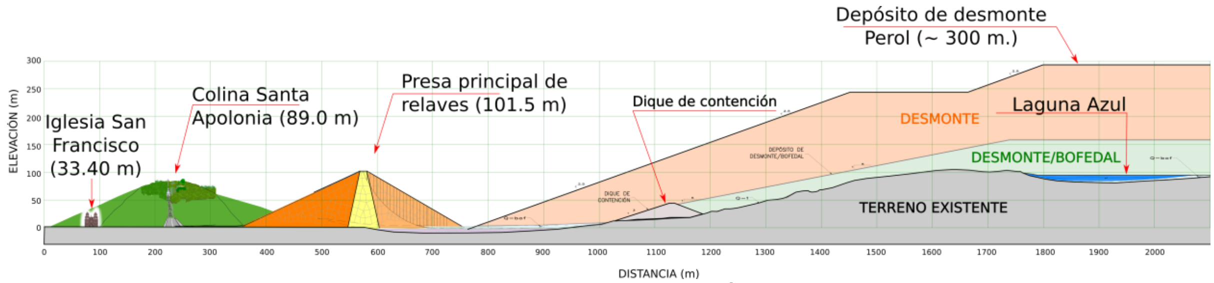
   - The EIA Executive Summary states and implies that no significant, long-term impacts to water resources will occur. This is incorrect, as will be discussed below.

   - The EIA authors describe overly-optimistic, future impacts using theoretical predictions, promises, and subjective rankings, *rather than focusing on actual Conga data and actual experiences and impacts from hundreds of similar mines around the world.*

   - The EIA states that topography will not be significantly impacted. Yet it reports the following:

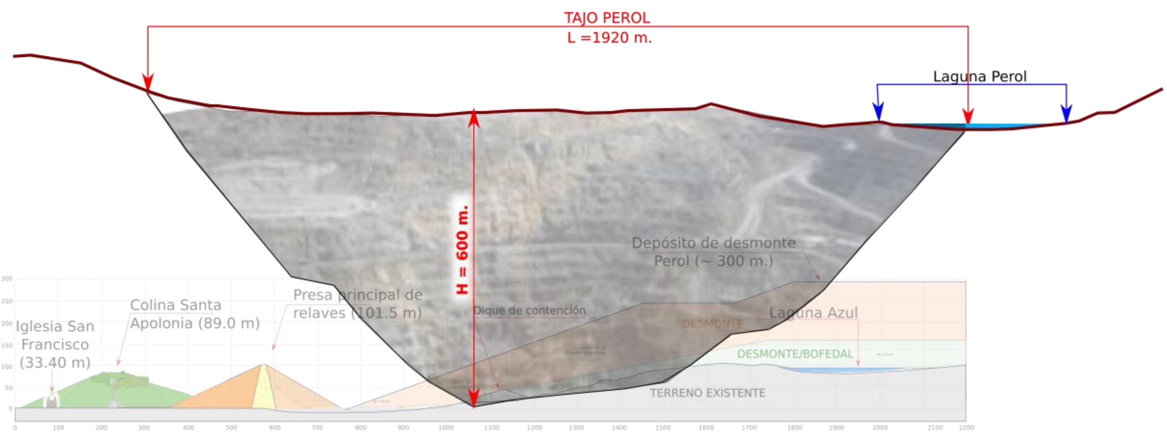
- Perol waste rock piles = 180 to 200 m high.
- Chailhuagon waste rock piles = 165 m high.
- Open Pit Perol = 660 m maximum depth.
- Open Pit Chailhuagón = 468 m maximum depth.
- Principal Tailings dam = 101.5 m high.
- Toromacho Tailings dam = 66.5 m high.

FIGURE Nº 1: Comparison of heights: San Francisco Church – Mt. Santa Apolonia – Principal Tailings Dam – Perol Waste Rock Piles.



Source: Ing. Carlos Cerdán, 2012

FIGURE Nº 2: Comparison of heights: Figure Nº 1 – Open Pit Perol.



Source: Ing. Carlos Cerdán, 2012

Thus, it is most important for the public to focus on the “big picture” and, implement financial assurance and auditing mechanisms that will assure that the inevitable impacts will be paid for by the mine operators, not the public.

5. The EIA focuses on short-term impacts—of roughly 10 to 30 years in the future—but consistently avoids discussing the long-term consequences, those likely to occur hundreds and thousands of years (+) in the future, when the impacts and costs will be left to the public sector.

6. The electronic version of the EIA has at least 9,030 pages, undoubtedly more exist when all oversized figures are included. The most important information is scattered in a disorganized fashion throughout these thousands of pages, making it difficult for the public or regulators to understand it. Some might argue this disorganization was intentional.

   The most important water-related information and data are not mentioned or summarized in the Executive Summary in easily understandable ways, such as via tables and figures. The Executive Summary is the only portion of the EIA most of the public will ever read. Thus, it must summarize all of the most important data and issues. This EIA does not. Many potential investors in Conga will be from English-speaking regions, yet the only publicly-available portion of the EIA in English is the totally inadequate Executive Summary.

7. With respect to the water-related subjects, over the years the tasks have been divided between so many different participants that there is no continuity in the procedures and even less responsibility for the specific conclusions in the EIA. The authors of some of the annexes are specifically named, but the reader is not told who are the specific authors responsible for the final wording of the EIA itself.

8. Numerous EIA sections discuss hydrogeology, yet the Peruvian government has allowed Yanacocha Mining (MY) to delay release of the “official” hydrogeology studies until 30 March 2013, despite official approval of the EIA on 27 October 2010.

9. In November 2011, the Ministry of Environment submitted a report to the Peru Cabinet Chief, which presented many water-related criticisms and recommendations similar to those in this report. In essence they stated that the EIA needed to be redone. This report was disregarded and the subsequent Minister of the Environment later claimed it did not exist officially. Through this approach, the Peru government has essentially gelded the Ministry of Environment (and other agencies), damaging the supposedly transparent public review process.

   The EIA was approved even though it lacked any detailed hydrogeologic or seismic information for the Azul Lake area, where one of the main waste rock facilities was to be located. According to a Multisectoral Meeting held in Lima, 18 January 2012, the Peruvian government will have this information on the Azul Lake region in September 2012, long after the approval of the EIA.

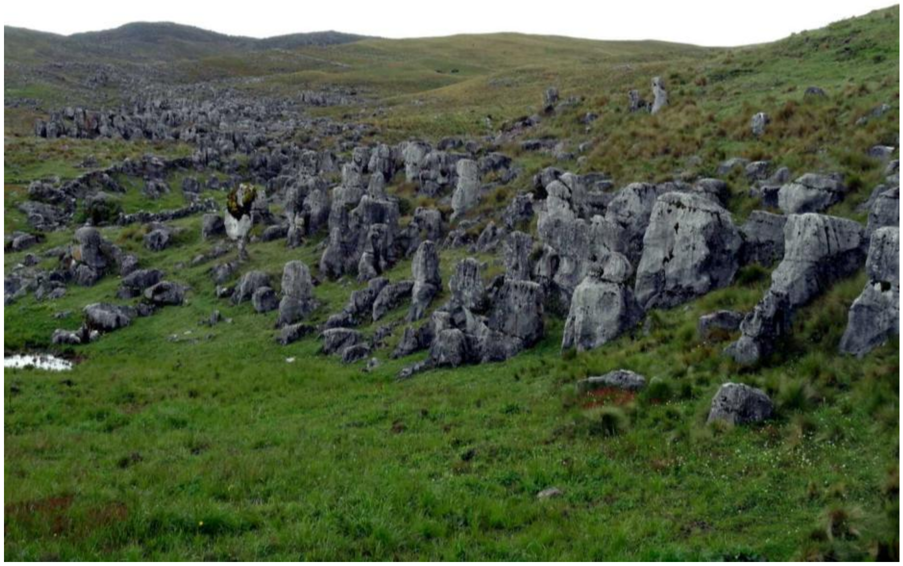
IMAGE N° 1: Lake Azul

Source: Ing. Segundo Sánchez Tello, 2010

10. Much of the area is considered by Peruvian Law to be "fragile ecosystems". The Conga project is located at the headwaters of five major river basins, is a wet area (average precipitation is about 1150 mm / year) covered with wetlands and lakes. Unlike many metal mine sites it is not arid and isolated. Ground water levels are generally shallow (often less than 2.0 m below the land surface) and the project area contains more than six hundred springs, which are used by the locals. The rivers contain rainbow trout (planted) in places; the meadows offer pasture for livestock; the region is a source of water for many villages and cities.

11. Surface waters, ground waters, and springs in the Conga project area are all ultimately interconnected. Much of the project is underlain by fractured and faulted, karstic and volcanic rocks, together with glacial sediments---all of which transmit water. Satellite images and structural geologic studies indicate that many of the local lakes are located on faults and fracture zones, some possibly related to collapsed volcano structures (calderas). All such information indicates that ground and surface waters are interconnected when stressed hydraulically over the long-term.

IMAGE N° 2: Karstic landscape in Jadibamba River Basin



Source: GRUFIDES Archive, 2012

12. Numerous factors combine to provide long-term pathways for the migration of contaminants into local Conga waters: natural permeability of the rock due to fractures and faults; increased fracturing due to mine blasting; open or leaking boreholes and blastholes; high permeability in the nearby sediments; long-term degradation of tailings and other mine structures; and seismic activity.

13. The EIA provides no evidence that boreholes have ever been adequately plugged or abandoned. The Conga site has had at least hundreds of boreholes drilled during the decades of exploration activities. These have provided vertical pathways for the movement of water from one zone to another, which then can move laterally.

14. The EIA provides inconsistent data on the volumes of water that will be pumped from the pits to allow mining. Conga ores will be mined from two open pits (possibly others also), one having a maximum depth of roughly 468 m (Chailhuagón pit), the other of roughly 660 m (Perol pit). One prediction for sustained flows from the Chailhuagón pit is 10 liters / sec. = 315,360,000 liters per year. Another estimate for pumping from the Perol pit is between 158 liters per second (year 2014) and 379 liters per second (year 2026), which are equal to between 59.8 and 143.4 Billion liters over only 12 years of dewatering. Dewatering rates would likely increase up to the 17-year life-of mine. Experience from numerous similar sites around the world indicates that reliable pumping volumes will not be known until after several years of actual operation.

IMAGE N° 3: Lake Perol

Source: Ing. Segundo Sánchez Tello, 2010

The EIA states that the acid water treatment plant can treat 850,000 liters per hour. If the Conga project must pump 379 liters per second, that implies treating roughly 1.4 Million liters per hour, which far exceeds the capacity of the treatment plant. Clearly the proposed plant could not treat all of this water, nor would it be treated to chemical quality suitable for human consumption of aquatic life purposes.

15. The Conga EIA fails to present reliable data to indicate that the rock materials below the waste facilities (waste rock and tailings) are impermeable. In fact, essentially all such structures at comparable mine sites, worldwide, release contaminated effluents, long-term. Such contaminated effluents may be adequately collected during active operations (at comparable metal mine sites), but frequently generate contamination following mine closure.

16. The EIA hydrogeologic data indicate that the lakes are zones of ground water discharge, yet the authors fail to adequately quantify the rates of discharge, and fail to define the recharge areas and recharge rates. The EIA contains no integrated hydrogeologic discussions regarding the extent and characteristics of the water-bearing zones and the overall surface water-ground water interactions, including those with local and regional springs. As a result, it is not possible to develop a reliable project water balance.

17. The EIA fails to demonstrate that the local and regional ground water-surface water system is not interconnected, acting as one system, given long-term stresses. Because the Conga site is located at the headwaters of five separate basins and because the EIA data (and those from many similar sites) indicate that the ground water-surface water systems are interconnected, the Conga project has the potential to negatively impact both the quantity and water quality in all or some of these basins. As a minimum, the EIA has failed to reliably demonstrate that such impacts will not occur, long-term.

18. Experience from numerous comparable metal mine sites indicates that dewatering activities are likely to dry up many (or most) of the surrounding springs and possibly degrade the spring water quality. Unfortunately, the EIA presents no data for either spring flow rates or spring water quality. Hence there

will be no way for the public to demonstrate such potential changes.

19. Waters pumped from both pits will be contaminated by chemical interaction with the mineralized rocks, facilitated by increasing populations of microbes, which increase the rates of the chemical reactions. The EIA admits this for waters from the Perol pit. However, waters from the Chailhuagón pit will also be contaminated when compared to the nearby baseline ground water chemical (statistical) composition. The EIA authors disregard the experiences from numerous similar deposits around the world where neutral and alkaline-pH pit waters routinely become contaminated, long-term. Furthermore, the predictions of future pit water quality are based on unreliable, geochemical techniques [use of synthetic leaching procedures (SPLP) and short-term humidity-cell tests], and present overly-optimistic predictions of long-term water quality.

IMAGE N° 4: Chailhuagon River Valley

Source: Archivo GRUFIDES, 2012

20. Newmont reports that a Bankable Feasibility Study has been completed, yet none of the contents have been made public in this EIA. Mineralogical testing data from such Feasibility Studies would have provided much more reliable estimates of future tailings and waste rock effluents than the predictions provided in the EIA. Yet these detailed feasibility test results have not been revealed.

21. On average, Conga will use from 2,026,890 to 2,239,920 cubic meters per year of fresh water (from the reservoirs) for process water and other uses.

    The specific prices paid for water in the Conga-Yanacocha-Cajamarca region are not known, and apparently, the EIA fails to discuss such topics. However, in most parts of the world, it is normal for farmers and municipal water users to pay some commercial rate for water, while frequently in developing countries, mining companies pay little or nothing, especially when the water is extracted from the subsurface via wells.

22. Conga project area ground and surface waters will likely be contaminated, long-term, by a combination of the broken natural rock materials, tremendous quantities of toxic process chemicals, toxic fuels, explosive residues (like toxic ammonia), oils and greases, and other toxic chemicals (herbicides, pesticides, etc.). These are inevitably released into the environment, long-term, at comparable mine sites. Because the Conga baseline data are so inadequate, it will be difficult for the regulators or public to demonstrate the presence of such contamination if and when it occurs.

    Effluents from similar copper-gold-silver operations routinely contain the following chemical constituents of concern: excessively high or low pH, aluminum, antimony, arsenic, barium, cadmium, copper, chromium, cobalt, iron, lead, manganese, mercury, molybdenum, nickel, selenium, silver, thallium, vanadium, zinc, sulfate, nitrate, ammonia, boron, fluoride, chloride, and natural radioactive constituents (uranium, thorium, potassium-40, gross alpha and beta, in general), cyanide and related breakdown compounds (metal-cyanide complexes, cyanate, thiocyanate), organic carbon, oils and greases, and numerous other organic compounds. Many of the constituents listed above are not reported in the Conga EIA baseline data.

    Statistically-adequate and sufficiently-detailed baseline data for ground and surface waters and springs (water quality, quantity, etc.) are not presented in the EIA. Thus, the public has no adequate basis on which to define pre-development conditions, nor do they have a "yardstick" against which to demonstrate that changes have occurred, or have not.

23. The EIA unreasonably compares baseline water quality only to Peruvian water quality standards (ECAs)[1] for irrigation and livestock watering purposes, but does not compare these data to human consumption or aquatic life standards, which are more restrictive.

    Apparently Conga waters from pit dewatering and effluents from the waste rock piles and tailings will be collected and treated at the Acid Water Treatment Plant, but only to water quality standards suitable for irrigation waters. Thus, treated waters are not likely to be suitable for human consumption and are not likely to meet aquatic life criteria. Unfortunately, the EIA fails to report the expected, detailed chemical composition of the treated waters. Because most of the natural Conga waters are quite pure chemically, this means that the Conga operations would be allowed to degrade the existing water quality.

    The EIA disingenuously states, repeatedly, that the water quality in existing

[1] Table 1: Peru and International Water Quality Standards and Guidelines

Conga rivers, lakes and springs is already contaminated and of no use. This is untrue. Most of these waters have very low concentrations of dissolved chemical constituents (TDS). Some of the wetland and bog area waters have slightly-acidic pHs, which is normal due to the release of organic acids. Many of these waters undoubtedly contain elevated concentrations of fecal bacteria, impacted by livestock and human wastes. Nevertheless, these waters are presently used by numerous communities for all imaginable uses, including as sources of drinking water.

24. Mine waste sources, that is, waste rock and tailings (and pits) will remain on the site forever. Effluents from the Conga waste rock piles and the tailings will need to be collected and treated forever. Seismic activity at the Conga site is judged to be at least moderate, and rainfall events can be extreme. Thus, the Conga site will require active maintenance of the remaining facilities and operation of an active (not passive) water treatment facilities, not simply for fifty or one hundred years post-closure, but forever.

    MY proposes that four existing lakes will be destroyed and replaced by four engineered reservoirs, thereby increasing the overall supply of available water. Disregarding the obvious loss of the lakes, wetlands and associated environments, the MY explanation fails to discuss the following negative factors: 1-likely drying up of flows from numerous springs; 2-reduction of stream flows in the nearby drainages; 3-likely contamination of both ground and surface waters; 4-This approach gives effective control of local and regional water resources to a private corporation. 5-Once the mine closes, what entity will pay for, operate and maintain this complex engineered system?

    Clearly it is impossible to guarantee that a corporation such as Newmont or Buenaventura, or any other corporation will still be in existence in even one hundred years—certainly not forever. In the United States (and probably in Canada, the E.U., and most developed countries) *it would not be legally allowable to approve the operating permits for a site requiring perpetual water treatment.*

    Thus, future costs related to facility maintenance, and collection and treatment of contaminated waters will be subsidized by the public, and by all future generations.

IMAGE N° 5: Raviatadas Lakes

Source: Ing. Segundo Sánchez Tello, 2010

25. Costs to construct high-technology treatment plants at similar metal-mine sites, with high volumes of effluent, often cost at least $10 to $30 million dollars (U.S.), capital costs. Construction costs at Conga could be much higher given the remote location. Plant operation and maintenance costs vary greatly, but could easily be $1 million to $5 million dollars per year, possibly in perpetuity.

    I have professional experience with several mine sites where water treatment costs have exceeded hundreds of millions of dollars U.S., the contamination problems remain, and the collection and treatment continues (e.g. Summitville, Leadville, Eagle Mine, Crested Butte, Colorado, U.S.A.; Clark Fork and Zortman-Landusky, Montana, U.S.A.; Bingham Canyon-Kennecott, Utah, U.S.A.).

26. The water-related activities proposed in the Conga EIA effectively give control of the collective, regional water resources to a private corporation.

27. There is no credible evidence to indicate that Peruvian regulatory agencies have adequate staff, budgets, or political clout to adequately oversee and enforce the appropriate regulations relating to Conga. There are plenty of regulations, but little evidence of actual enforcement.

28. It is totally unrealistic to consider the water-related impacts from Conga without also considering the cumulative impacts from the several other mining projects presently operating or being developed in the headwaters of the same river basins. These include, as a minimum, Newmont/Buenaventura's (MY) Yanacocha and the future extensions of Amaro and La Carpa; the Galeno Project of Lumina Copper (China); and the Michiquillay Project by AngloAmerican (UK and So. Africa).

29. All of the factors above indicate that the proposed mine water uses do not represent sustainable activities, long-term. Given all of the technical uncertainties, the public and regulators should make truly-conservative assumptions about the future impacts to the water resources, not the unrealistically-optimistic assumptions presented in this EIA.

Introduction.

On February 9, 2012 Reuters News Agency reported the following:

The Conga dispute is one of 200 environmental conflicts nationwide that Humala and Prime Minister Oscar Valdes are struggling to manage.
"I would like it if the march weren't political but rather technical - so that the leaders really make it clear what they see is the water problem," Valdés said.

The following report attempts to present some of those technical details in a manner easily accessible to the public. The Conga EIA is a surprisingly poor and disingenuous document given the scale of the investment—roughly $ 4.8 billion U.S.-- and the involvement of several major corporations (Newmont and Buenaventura), together with investment by the private-sector lending arm of the World Bank, the International Finance Corp. (IFC). The Conga site has been studied by numerous consulting firms for years and the EIA revised and approved at least twice by the Peruvian government, yet it still fails to provide the technical information necessary for the public and regulators to make adequately informed decisions. In many ways, it is an insult to the public and regulators.

Purpose and Scope.

This report presents technical comments focused on the water-related aspects of the Conga EIA and project. It is based on a review of all, or at least most, of the water-related (and water quality / geochemistry) sections of the Conga EIA. Because it has taken several weeks to understand the various water-related aspects in the roughly 9,000 to 10,000 pages of the disorganized, inadequate EIA, I have chosen to summarize the major points in a short Summary---rather than further confuse the public. This report is intended to provide technical support to the general public and to the various levels of the Peruvian government, from a different perspective than that of the financially-interested mining companies, their consultants and their lenders.

This report was prepared during February 2012, written largely in Cajamarca, Peru. The contents of this report were based on the following:

- Review of MY / Conga technical documents and websites during January 2012;
- Travel to Peru from 2 through 21 February 2012;
- Travel to the Conga site and adjacent areas on 15 February 2012 to observe the mine site and present construction activities, and with GRUFIDES, make field measurements of water quality at several lakes, wetlands and stream locations.
- Technical discussions regarding the site hydrogeology, etc. with faculty members at the National University at Cajamarca (Professors Reynaldo Rodriguez and Nilton Deza); and with a member of the Engineer's Association of Cajamarca (Carlos Cerdán); and internet communications with Dr. Luis Javier Lambán, professor and hydrogeologist at the University

of Zaragoza and investigator with the Public Investigation Organizations of Spain [Investigador de Organismos Públicos de Investigación de España]. Many thanks to all of these individuals for their assistance.
- Review of the Conga EIA in the electronic version downloaded from Newmont's website, together with the technical references listed at the end of this report, and numerous others. Review of portions of the printed EIA while in Peru.
- More than 40 years of applied hyrogeological and geochemical experience at hundreds of mining and other industrial sites around the world.

My efforts were performed at the request of, and paid for by, the Environmental Defender Law Center (EDLC), Bozeman, Montana, U.S.A. Local logistical support was supplied by the Cajamarca, Peru-based NGO, GRUFIDES. *Nevertheless, these comments and opinions are my own.*

Background.

Obviously metal mining and Minera Yanacocha (MY) have brought some economic benefits to Peru. The questions are always: for whom and at what price? There is no "free lunch". All such projects involve trade-offs: some economic benefits for significant long-term impacts and costs—often environmental and social. Several additional questions arise: Are these impacts acceptable to those impacted? Who will pay the long-term costs? Who decides?

Since the Peruvian media are inundated with mostly pro-Conga stories, to provide some balance this report attempts to present some alternative information and alternative perspectives. It attempts to consider not simply the short-term benefits, but also the longer-term consequences.

Discussion.

The most important comments and conclusions of this report are presented in the initial Summary. The following sections contain additional details that add to and support those comments.

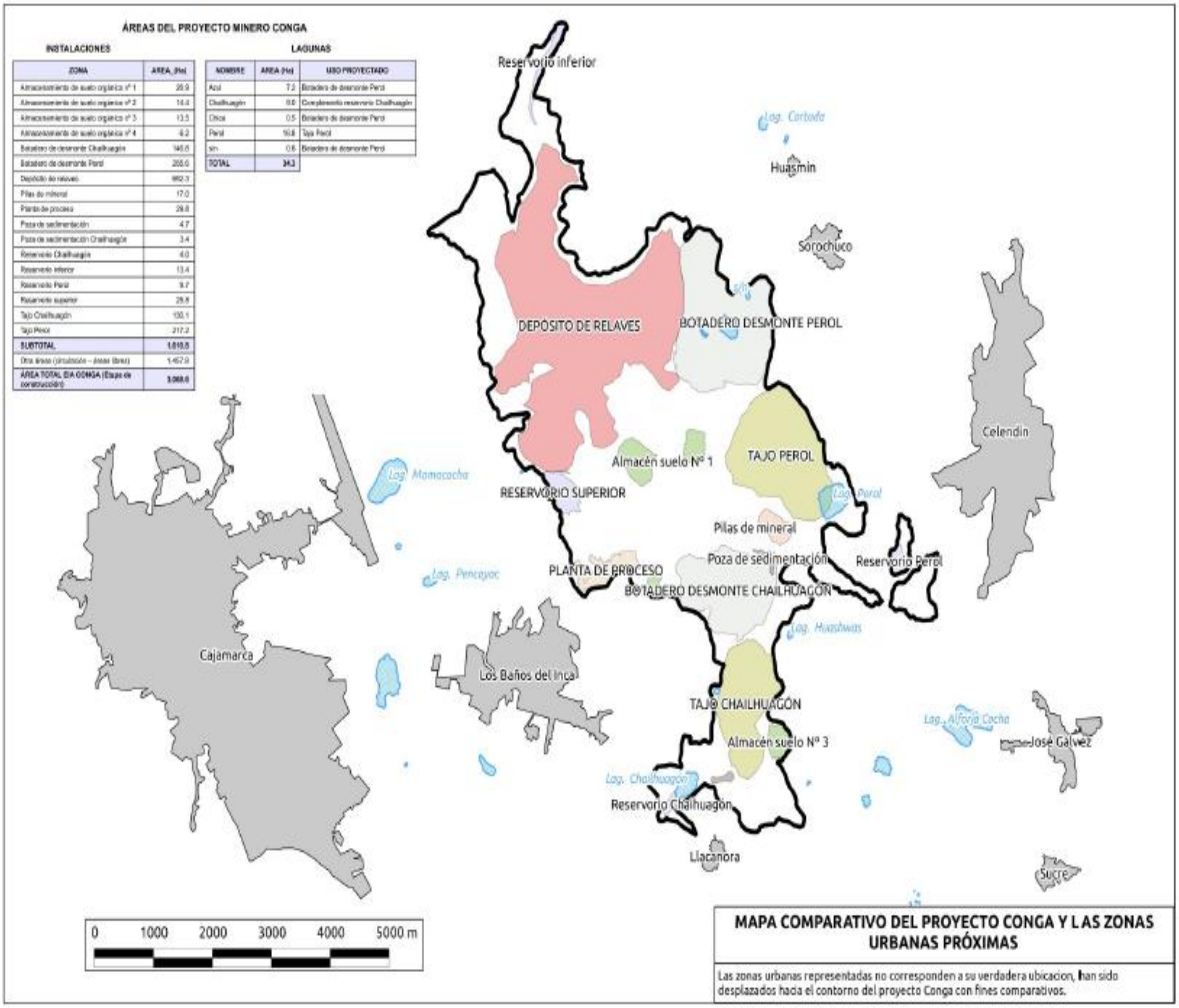
What commercial products will be produced?

Conga operations will produce a copper-silver-gold concentrate, which may contain other valuable metals. The EIA provides no information on other byproducts that might be extracted from the concentrates. Concentrates are likely to be shipped offshore and refined in an overseas plant. **[EIA, Exec. Summ.]**

What is the scale of the proposed mine facilities?

Cerdán (2011) reports the following interesting comparisons:
- *Tailings deposits* will = roughly half the area of Cajamarca (692 ha);
- *Total Conga site* will = roughly twice the area of Cajamarca (3069 ha);
- *Perol waste rock* piles = a bit larger than the city of Baños del Inca (256 ha).
- Perol open pit = roughly the city of Baños del Inca (217 ha).

FIGURE N°3: Comparison of area of Conga project and nearby cities and towns



Source: Ing. Carlos Cerdán, 2012

How much water will the Conga Project use?

We do not know precisely. However, the EIA states that, on average, Conga will use from 2,026,890 to 2,239,920 cubic meters per year of fresh water (from the reservoirs) *for process water and other uses* **[EIA p. 4-78, and Anexo 4.14]***.*

In addition, water will be pumped from the two open pits: Perol pit = max. 660 m deep **(Anexo 4.10, p. 9);** Chailhuagón pit = max. 468 m deep **(Anexo 4.10, p. 5).** The EIA provides *inconsistent data* on the volumes of water that will be pumped from these pits to allow mining. Different pumping rates are presented in: **EIA, Anexo 10.1 (Schlumberger, 2009); EIA, Anexo 3.12 (MODFLOW, Knight Piesold, 2010); WMC (2004c, 2008a); EIA Table 4.4.3.**

EIA, p. 4-54 states that the long-term pumping rates from Perol pit are presented in **EIA Table 4.4.3.** This table reports the Perol pumping rate to be between 158 liter per second (year 2014) and 379 liters per second (year 2026), which equal to *between 59.8 and 143.4 Billion liters over only 12 years of dewatering.* Dewatering rates would likely increase up to the 17-year life-of mine. *Experience from numerous similar sites around the world indicates that reliable pumping volumes will not be known until after several years of actual operation.*

However, in **Anexo 3.12, p.2-14, 2-15**, we are told that these Perol pit studies (**Knight Piesold, 2010),** are based on hydrogeology information from *only the upper 250 m.* As the pit will have a maximum depth of roughly 660 m, it is clear that the EIA is not reporting realistic volumes.

It should be noted that the Table of Contents for the Anexos of the EIA (electronic version) contains no listing of specific subjects for the Anexos. And, when one does find **Anexo 3.12** mentioned above, it is listed as a MODFLOW modeling report, not a hydrogeology report. Also, MODFLOW is a model originally designed to simulate flow in porous, horizontal sediments, not fractured, faulted, and folded rocks.

How do the surface and ground waters (and springs) interact?
The EIA fails to discuss in any integrated manner, the interactions of the site ground and surface waters. Here I consider springs to be ground waters appearing at the land surface, having the water quality of ground waters. The EIA, again, fails to discuss in any integrated fashion, the impacts of pit dewatering on either spring flows or stream flows. The EIA provides inadequate data to support the predictions of minimum stream flows presented in **Table 5.2.13.** The EIA provides no evidence that truly-long-term, high-volume aquifer tests have been conducted. Thus, it is not possible for the EIA to define many of the hydrogeologic details required for such a study. Such long duration, high-volume tests should have been conducted in conjunction with continuous water quality monitoring during the testing.

[There is no table of contents in the electronic version of the EIA Tables, thus there is no simple way for the reader to know what subjects are presented in these 503 pages of tables!]

Nevertheless, given the site geology, the fractured, faulted and karstic nature of these rocks, the evidence of vertical leakage between water-bearing zones during pump tests (**Knight Piesold, 2010),** and experience at numerous similar sites, it seems obvious that the Conga surface and ground waters are hydraulically interconnected, especially when long-term pumping conditions are considered. Pit dewatering will likely produce negative impacts on the flows of site springs and possibly on recharge to local surface waters. These interconnections will also facilitate contamination of the ground and surface waters by effluents / seepage from the tailings, waste rock, ore stockpiles, etc.

Will the Conga project increase the volumes of water available for use by local and regional populations?

It is possible that the proposed "engineered" water program will allow delivery of greater quantities of water to specific locations in the *short-term*. However, the details of this proposal certainly have not been supplied in this EIA. Moreover, there are several other negative consequences that come with such an approach: 1-Many springs will no longer flow, so many local users will now be required to purchase water from a system controlled by Conga; 2-The quality of this water is likely to be degraded (relative to baseline chemical water quality) by contamination from the mine facilities; 3-Long-term, after the mine closes, who will maintain, operate and pay for this "engineered" system—forever? If there will be no funds available to operate this system after mine closure, it is doubtful that Conga's claim of supplying greater volumes of water will be fulfilled.

One should also ask: Since the beginning of operations at the Yanacocha Mine, have the availability and quality of water in the Municipality of Cajamarca improved? Many citizens would answer negatively, and this presents a clue as to how Conga might impact the future regional water supplies.

What are the volumes of the wastes to be generated?

The EIA presents several inconsistent volumes for the various categories of wastes generated. For total *tailings* generated during the life-of-mine, **Table 4.4-11** presents what appears to be the maximum of 650 Million tons.

Total waste rock produced from both pits is estimated to be 581 Million tons **(EIA Exec. Summary, p. 5-1),** although this section seems to confuse waste rock and low-grade ore, so the actual quantities of waste rock are uncertain. Nevertheless, these are huge volumes of contaminant-laden wastes, which will remain on the site forever. Hence they will be subject to weathering reactions and will release contaminants into the environment forever.

Will Conga mining and processing release toxic chemicals?

Obviously, yes. All similar metal mine sites release numerous chemicals into the environment, long-term. Firstly, the operations facilities release contaminants mobilized from the natural rock. These include: excessively high or low pH, aluminum, antimony, arsenic, barium, cadmium, copper, chromium, cobalt, iron, lead, manganese, mercury, molybdenum, nickel, selenium, silver, thallium, vanadium, zinc, sulfate, nitrate, ammonia, boron, fluoride, chloride, and natural radioactive constituents (uranium, thorium, potassium-40, gross alpha and beta, in general).

In addition to the **rock components**, mine waters are routinely contaminated by: cyanide and related breakdown compounds (metal-cyanide complexes, cyanate, thiocyanate), organic carbon, oils and greases, and numerous other organic compounds **(Moran, 2001, 2002, 2007),** explosives, process chemicals, fuels, oils and greases, antifreeze, sewage waste, herbicides and pesticides.

The EIA presents no detailed, reliable discussion of the fact that the Conga processing plant will use massive quantities of toxic **process chemicals**, which at comparable sites, are released into the environment, predominantly as seepage from the tailings, or spills from the tailings pipelines. **EIA, pages 4-81, 4-82 and Anexos 4.4 and Anexo 4.15** all mention the use of such chemicals, but: 1- they imply that all these chemicals are environmentally-harmless, 2-generally provide only the commercial not the chemical names of these products, 3- fail to compile data on the total quantities that will be used over the life of the mine, 4-fail to integrate any of the chemical information of these various sections.

A few details will amplify the story. Over the roughly 17 years of the anticipated plant operations, the following toxic chemicals will be used in roughly the following quantities:

- **Primary Collector:** Aero 3894C Promotor---**9 g/ t ore = 5.13 Million kg / 17 yrs**.
  This reagent is actually composed of the toxic chemicals: isopropylethyl thiocarbamate, Isopropanol, glycol ether. *All have negative effects to aquatic organisms.*

- **Secondary Collector**: AERO 317: **5 g / t = 2.9 Million kg xanthates / 17 yrs.**
  Aero 317 is actually composed of toxic xanthate compounds, e.g. Potassium amyl xanthate, and sodium hydroxide**,** sodium sulfide**,** sodium carbonate. The EIA, including **Anexo 4.15** (the Security Data Sheets), makes no mention of the toxicity of this product, which is documented in Australian government publications **(Australia Gov. Publ. Services, 1995).**

- **Frothers** (2 different): OrePrep® F-501A Frother & OrePrep® F-549 Frother: total use = **25 g / t = 14.3 Million kg / 17 yrs.**
  OrePrep® F-501A Frother is actually composed of the toxic butyraldehyde, 2-metyl-1-pentanol, mixed alcohols, ethers and aldehydes, aliphatic alcohols, phenol. These compounds are very toxic to aquatic organisms.
  OrePrep® F-549 Frother is actually a mix of polyglycols, which are reported to be toxic to humans **(Tusing et. al., 1954),** although the Data Sheets in **Anexo 4.15** fail to mention this. Toxicity testing on fish and other aquatic organisms, like so many process reagents, is largely lacking.

- **Sodium hydrogen sulfide**: **15 g / ton = 8568 tons / 17 yrs.**
  Dangerous for aquatic life and human health.

These are just a few examples of the potentially-toxic process chemicals to be used in the Conga process plant, and which will be discharged in the tailings. A more detailed discussion of common processing reagents (and quantities) used in copper processing are presented in **Ayers et. al. (2002).** *MY baseline monitoring* *does not evaluate the presence of such organic residues in the local waters.*

Fuels. The EIA reports only that the total **diesel use = 751.7 Million liters / 17 yrs (Table 4.3.13).** It seems likely Conga will also use other fuels, but no details are presented. Most fuels contain several components toxic to humans and aquatic life when released, long-term, into the environment.

Explosives. The EIA states only that ANFO (ammonium nitrate-fuel oil) explosives will be used, but no quantities are provided. For comparison, a large-scale open-pit gold mine in Kyrgyzstan, has used *roughly 264 million kg of explosives during the roughly 15 years of operation* ***(Redmond, 2011).*** *The quantities used at Conga will be much greater. Explosives release residues that contain compounds potentially-toxic to aquatic organisms, such as nitrate, ammonia and organic residues. Dissolved ammonia is roughly as toxic to aquatic organisms as free cyanide* ***(US EPA, 1986).***

Will ground and surface water contamination occur?
Both ground and surface waters will be contaminated, long-term, by the proposed Conga activities, as they are at almost all similar mine sites. Unfortunately, the EIA authors have used totally naïve geochemical approaches and assumptions to attempt to demonstrate that most of the rock will not generate acid and that tailings decant waters **(EIA, pg. 3-40, 41),** and future water quality from the treatment plant will be acceptable **(EIA, Chapter 4; Anexo 5.15).** Numerous authors have discussed the unacceptability of using short-term humidity cell tests to estimate future water quality **(Lapakko 1995, 2003; Morin & Hutt 1994,1997; Price 1997; Robertson & Ferguson 1995).**

Likewise, the synthetic leaching procedures used in the EIA (the EPA 1311 / TCLP and EPA 1312 tests), have been used incorrectly. They were originally used by the U.S. EPA to give a very rough indication of the concentrations of selected constituents that could be easily mobilized from industrial wastes---*without any chemical reactions occurring*. These tests were never intended to be used to evaluate the reactivity of mining wastes. Such tests are only suitable to give a rough indication of concentrations of constituents that can be leached rapidly (within 18 hrs.) from geologic materials by rainwater-like liquids. Thus, they do not accurately represent leachates that may develop from chemical reactions between rock and water that require considerable periods of time to occur, such as almost all weathering reactions, depletion of alkalinity, and the formation of acid rock drainage (ARD).

Furthermore, the EIA authors have neglected to explain that waters can be contaminated without generating net acid conditions. For decades, authors have reported increased chemical constituent concentrations in neutral and especially alkaline pH waters (e.g. Banks and others, 2002).

Are the baseline data statistically-reliable?
The Conga EIA contains significant amounts of baseline water quality data---when

they can be located **(See Anexos 3.10, 3.11, 3.13).** Unfortunately, the EIA fails to include much of the baseline data from the early years of sampling; samples were not collected consistently at most sites; and most sites have small numbers of samples (n), such that statistical evaluation of these data is often meaningless **(see Anexo 3.13, p.191).** Most importantly, where the EIA has compiled the data, they are generally hidden in the Anexos, and they fail to combine data from the most meaningful subgroups. For example, why does the EIA fail to present a table combining all the bofedal water quality data, from all sites, for all dates? Or, for that matter, why not compile the statistics for the all the spring water quality data? *Unfortunately no spring water quality data are presented.*

It is likely that the extensive exploration and development activities that have already occurred have already degraded at least the baseline water quality conditions. Hence, it is important to include the early baseline data already collected, to evaluate such changes. [Conga exploration activities began in 1991 **(EIA, Executive Summary, pg.1-2**), but probably even earlier by previous companies.].

Can the destroyed wetlands be successfully reconstructed?

The **EIA Executive Summary, pg. 7-9** implies that, post-closure, MY will attempt to reconstruct wetlands areas on top of the reclaimed tailings. Firstly, we have no certainty that significant revegetation of the tailings can be attained, and maintained long-term, given their high concentrations of numerous chemicals. Secondly, technical literature indicates that all attempts to reconstruct wetlands have been *unsuccessful, long-term*, at restoring the overall complex ecological functions *at all sites studied* (Moreno-Mateos and others 2012).

What is the water supply situation for Cajamarca?

Cajamarca's water supply is already inadequate to meet the present demands. Municipal water is only available certain hours of the day in most of the city. Roughly 70 percent of the city's water is supplied by the El Milagro facilities, which take water from the Rio Grande below the Yanacocha operations. There have been numerous allegations that the municipal waters are periodically contaminated by upstream mine operations, but the city has inadequate resources (analytical, financial, etc.) to strongly support these allegations (Prof. Nilton Deza, U. Nat. de Cajamarca).

Are short-term water treatment costs unreasonable for MY?

MY presently makes a profit from the recovery of gold (and possibly other metals) from its reverse osmosis water treatment plant at the Yanacocha operations (personal communication, confidential source (Jan. 2012).

Will MY pay commercial prices for the Conga water it uses?

The Cajamarca newspaper, El Comercio (20 November 2011) reported that, according to figures supplied by Minera Yanacocha to the National Water Authority (ANA), Yanacocha had used 507 M cubic meters of surface water and 9,113,000 cubic meters of ground water in the previous year (presumably 2010). This same newspaper also reported that Yanacocha paid 0.03 Soles per cubic meter of surface water used, and 0.01 Soles per cubic meter of ground water used. By comparison, this same source reported that farmers in Cajamarca used 216 M cubic meters of water (presumably surface water), and paid 0.0006 Soles per cubic meter of water used (presumably in 2010). Apparently, the Minera Yanacocha data were measured and supplied to ANA by Minera Yanacocha. *The EIA fails to discuss whether MY will pay for the water required to operate the Conga project.*

Who will pay for long-term costs?

The EIA fails to discuss the details of long-term impacts, but experience from numerous similar mines around the world indicates that soon after the active life of Conga is completed, MY will no longer be responsible for the costs of water treatment, etc. These costs, long-term, will be borne by the public sector.

Does Peruvian law require the mine operators to provide some form of financial guarantee for unforeseen costs?

Apparently Peruvian law does not require metal mining companies to provide any form of financial assurance (bonds, insurance, etc.) to cover the liabilities resulting from future, unforeseen, long-term environmental or other costs, such as post-closure water management and water treatment costs.

TABLE 1: Peru and International Water Quality Standards and Guidelines

Parameter	Units	US EPA Drinking Water[v] Standard	US EPA Aquatic Life[i]		Canada Agricultural[ii]		Canada[iii] Drinking Water Standard	Canada[iv], 6 Freshwater Aquatic Life Guideline	Perú[vi]				
			Acute Guideline	Chronic Guideline	Irrigation Guideline	Livestock Guideline			Units	A2 Standard - Water that can be made drinkable through conventional treatment	Category 3 Standard - Irrigation of long- and short-stemmed vegetables	Category 3 Standard - For livestock	Category 4 Standard - Coast and highlands
pH	Units	6.5-8.5	6.5	9			6.5-8.5	6.5-9.0		5.5 – 9.0	6.5 - 8.5	6.5-8.4	6.5 - 8.5
TDS	mg/l	500			500-3500	3000	500			1 000			500
Tot Susp Solids	mg/l												25 - 100
Turbidity	NTU								UNT	100			
COD	mg/l								mg/L	20	40	40	
Bioch Ox Dem	mg/l								mg/L	5 (DBO5)	15	<=15	<10 (DBO5)
Oil+Grease	mg/l								mg/L	1.00	1	1	Absence of a visible oil/grease film
Total N	mg/l												1.6
Total P	mg/l								Mg/L P	0.15			
Sodium	mg/l						200				200		
Chloride	mg/l	250	860	230	100-700		250		mg/L	250	100-700		
Cl, tot res	mg/l		0.019	0.011									
Sulfate	mg/l	250				1000				**	300	500	
Sulfide	mg/l			0.002						**	0.05	0.05	
Nitrate	mg/l	10 (as N)				100	10(N)	13	mg/L	10	10 (NO3-N)	50 (NO3-N)	10 (N-NO3)
Nitrite	mg/l						1		mg/L	1	0.06 (NO2-N)	1 (NO2-N)	
Ammonia (as N)	mg/l		0.002 to 0.325	0.032 to 0.049				0.019					

Parameter	Units	US EPA Drinking Water[v] Standard	US EPA Aquatic Life[i]		Canada Agricultural[ii]		Canada[iii] Drinking Water Standard	Canada[iv], 6 Freshwater Aquatic Life Guideline	Perú[vi]				
			Acute Guideline	Chronic Guideline	Irrigation Guideline	Livestock Guideline			Units	A2 Standard - Water that can be made drinkable through conventional treatment	Category 3 Standard - Irrigation of long- and short-stemmed vegetables	Category 3 Standard - For livestock	Category 4 Standard - Coast and highlands
Flouride	mg/l	4.0 (2.0)			1	1.0-2.0	1.5	0.12	mg/L	**	1	2	
Aluminium	mg/l	0.05-0.2	0.75	0.087	5	5	0.1	0.005-0.1	mg/L	0.2	5	5	
Antimony	mg/l	0.006					0.006		mg/L	0.006			
Arsenic	mg/l	0.01	0.34	0.15	0.1	0.025	0.005	0.005	mg/L	0.01	0.05	0.1	0.05
Boron	mg/l						5		mg/L	0.5	0.5-6	5	
Cadmium	mg/l	0.005	0.002	0.00025	0.0051	0.08	0.005	0.000017	mg/L	0.003	0.005	0.01	0.004
Chromium, hex	mg/l		0.016	0.011	0.008	0.05		0.001	mg/L	0.05	0.1	1	0.05
Chromium (tot)	mg/l	0.1					0.05		mg/L	0.05			
Copper	mg/l	1.3 (1.0)	0.013	0.009	0.2-1.0	0.5-5.0	1	0.002 - 0.004	mg/L	2	0.2	0.5	0.02
Iron(tot)	mg/l	0.3		1	5		<0.3	0.3					
Iron									mg/L	1	1	1	
Vanadium									mg/L	0.1			
Lead	mg/l	0.015	0.065 0.025	0.0025	0.2	0.1	0.01	0.001 - 0.007	mg/L	0.05	0.05	0.05	0.001
Manganese	mg/l	0.05				0.2	<0.05		mg/L	0.4	0.2	0.2	
Mercury	mg/l	0.002	0.0014	0.00077		0.003	0.001	0.000026	mg/L	0.002	0.001	0.001	0.0001
Molybdenum	µg/l				oct-50	500		73					
Nickel	mg/l		0.47	0.052	0.2	1		0.025 - 0.15	mg/L	0.025	0.2	0.2	0.025
Selenium	mg/l	0.05		0.005	0.02-0.5	0.05	0.01	0.001	mg/L	0.05	0.05	0.05	
Silver	mg/l	0.1	0.0032	0.0019				0.0001	mg/L	0.05	0.05	0.05	
Thallium	mg/l	0.002						0.0008					

Parameter	Units	US EPA Drinking Water[v] Standard	US EPA Aquatic Life[i]		Canada Agricultural[ii]		Canada[iii] Drinking Water Standard	Canada[iv], 6 Freshwater Aquatic Life Guideline	Perú[vi]				
			Acute Guideline	**Chronic Guideline**	**Irrigation Guideline**	**Livestock Guideline**			**Units**	**A2 Standard - Water that can be made drinkable through conventional treatment**	**Category 3 Standard - Irrigation of long- and short-stemmed vegetables**	**Category 3 Standard - For livestock**	**Category 4 Standard - Coast and highlands**
Uranium	µg/l	30			0.01	0.2	20	15 – 33.0	mg/L	0.02			
Zinc	mg/l	5	0.12 0.12	0.12	1.0-5.0	50	5	0.03	mg/L	5	2	24	0.03
Alpha, Gross	pCi/L	15											
Radium	pCi/L	5											
Cyanide (total)	mg/l		0.022	0.0052			0.2	0.0005					
Cyanide(free)	mg/l	0.2							mg/L	0.022			0.022
Cyanide WAD	mg/l								mg/L	0.08	0.1	0.1	
Chlor,tot resid	mg/l												
Phenols	mg/l							0.004	mg/L	0.01		0.001	0.001
Fecal Coliform	MPN/100ml						<5	100	NMP/100 mL	0 (Fecal enterococci)			
Escherichia coli										0	100	100	
Tot. Colif.							<5	1000	NMP/100 mL	3000 (35 - 37C°)	5000 (short stem) 5000(3) (long stem)	5000	3000
Temp (increase)													
Salinity (change)													

[i] US EPA Water Quality Criteria for Aquatic Life—acute(Ac)and chronic(Chr): http://www.epa.gov/OST/standards/index.html#criteria
[ii] Canadian Guidelines for the Protection of Agricultural Water Uses(1999)—Irrigation (Irrig.) and Livestock (Livest.): http://www2.ec.gc.ca/ceqg-rcqe/agrtbl_e.doc
[iii] Canadian Environmental Quality Guidelines, Dec. 2004, Summary Table: http://www.ccme.ca/assets/pdf/e1_062.pdf
[iv] Canadian Council of Ministers of the Environment, 2003, Canadian Water Quality Guidelines for the Protection of Aquatic Life.
MERCURY: Inorganic mercury and methylmercury. http://www.ccme.ca/assets/pdf/ceqg_hg_wqg_fctsht_aug2003_e.pdf
[v] U.S. Environmental Protection Agency (US EPA) Drinking Water Standards: http://www.epa.gov/safewater/mcl.html#inorganic
US EPA, 2002, National Recommended Water Quality Criteria: 2002. EPA-822-R-02-047
http://www.epa.gov/waterscience/pc/revcom.pdf
6Canadian Council of Ministers of the Environment, 2011, Canada Environmental Quality Guidelines for the Protection of Aquatic Life. Available at: http://ceqg-rcqe.ccme.ca/
[vi] ESTÁNDARES NACIONALES DE CALIDAD AMBIENTAL PARA AGUA D.S. Nº 002-2008-MINAM - Perú
(**) The parameter is not relevant for this subcategory, except in specific cases where the relevant authorities determine it to be so.

References.

Australian Government Publishing Service, 1995(May), Sodium Ethyl Xanthate, Priority Existing Chemical No. 5, Full Public Report. Available at: http://www.nicnas.gov.au/publications/CAR/PEC/PEC5/PEC5index.htm

Ayres, Robert U., Leslie W. Ayres and Ingrid Råde, 2002 (January), The Life Cycle of Copper, its Co-Products and By-Products. Commissioned by the MMSD project, Rept. 24: International Institute for Environment and Development, 210 pg., London. http://www.iied.org/mmsd/activities/life_cycle_analysis.html

Banks, David, Valery P. Parnachev, Bjorn Frengstad, Wayne Holden, Anatoly Vedernikov, Olga V. Karnachuk, 2002, Alkaline mine drainage from metal sulphide and coal mines: examples from Svalbard and Siberia; Geological Society, London, Special Publications January 1, 2002, v. 198, p. 287-296; http://sp.lyellcollection.org/content/198/1/287.abstract

Cerdán, Carlos, 2011, "EIA Conga: Áreas y Tamanos Relativos, Topographía, y Napa Freática": Prepared for the College of Engineers of Peru (Cajamarca).

Knight Piésold Consultores S.A., Febrero 2010, Proyecto Conga Estudio de Impacto Ambiental, Informe Final, prepared for Minera Yanacocha S.R.L., more than 9,000 pg.

Knight Piesold Consultants, Febrero 2010, Proyecto Conga Modelo MODFLOW; Preparado para: Minera Yanacocha S.R.L., 110 pg.

Lapakko, K.A., Wessels, J.N. 1995. Release of acid from hydrothermal quartz-carbonate hosted gold-mine tailings. In Sudbury '95, Conf. on Mining and the Environment, May 28-June 1, Sudbury, Ontario, p. 139-148.

Lapakko, K.A., 2003, Chapter 7. Developments in Humidity-Cell Tests and Their Application, *in* Environmental Aspects of Mine Wastes (J.L. Jambor, D.W. Blowes & A.I.M. Ritchie, eds.) Mineralogical Association of Canada Short Course Vol. 31.

Moran, R. E., 2001, An Alternative Look at Proposed Mining in Tambogrande, Peru: report prepared for Oxfam America, Mineral Policy Center, and the Environmental Mining Council of British Columbia. [Available at:
http://www.earthworksaction.org/publications.cfm?pubID=68
http://www.oxfamamerica.org/art753.html]

Moran, R.E., 2001, Una Mirada Alternativa a la Propuesta de Minería en Tambogrande, Perú: Informe encargado por: Oxfam America, Mineral Policy Center, Environmental Mining Council of British Columbia (available at:
http://www.oxfamamerica.org/pdfs/tambo_span.pdf
http://www.earthworksaction.org/publications.cfm?pubID=69).
http://www.tierralimpia.net/docs/tambo-grande-informe.pdf

Moran, Robert E., 2002, The Quellaveco Mine: Free Water for Mining in Peru's Driest Desert? [Quellaveco: ¿agua libre de costo para la minería en el desierto más seco del Perú?] Report prepared for Asociacion Civil "Labor", Lima, with funds from Oxfam America / Friends of the Earth Int'l. / Global Green Grants.
[available at: http://www.labor.org.pe/revision%20EIA%20Quellaveco.pdf and
http://www.foei.org/publications/pdfs/quellavecostudy.pdf
http://www.bvsde.paho.org/bvsacd/cd27/quellaveco.pdf
http://www.cdca.it/IMG/pdf/quellavecostudy_1_.pdf].
http://www.cdca.it/spip.php?article325

Moran, Robert, 2007 (September), Pebble Hydrogeology and Geochemistry Issues; submitted to Renewable Resource Coalition, Anchorage, Alaska. Available at: http://www.renewableresourcescoalition.org/MoranSep07.pdf
http://www.savebristolbay.org/atf/cf/%7BE729E68D-22F3-4596-9503-54FE676F2264%7D/MoranSep07.pdf

Morin, K.A. & Hutt, N.M., 1994, Observed Preferential Depletion of Neutralization Potential Over Sulfide Minerals in Kinetic Tests: Site-Specific Criteria for Safe NP / AP Ratios. *In* International Land Reclamation and Mine Drainage Conference and Proceedings of the Third International Conference on the Abatement of Acidic Drainage 1. U. S. Bureau of Mines Special Pub. SP 06A-94, p.148-156.

Morin, K.A. & Hutt, N.M., 1997, Environmental Geochemistry of Mine Site Drainage: Practical Theory and Case Studies. MDAG Publishing, Vancouver, British Columbia.

Moreno-Mateos, David, Mary Power, Francisco A. Comin, Roxana Yockteng, 2012, Restored wetlands rarely equal condition of original wetlands: *PLoS (Public Library of Science) Biology*:
http://www.plosbiology.org/article/info%3Adoi%2F10.1371%2Fjournal.pbio.1001247?utm_source=feedburner&utm_medium=feed&utm_campaign=Feed%3A+plosbiology%2FNewArticles+%28Ambra+-+Biology+New+Articles%29

Newmont, 2012, Conga Mine Fact Sheet:
http://www.newmont.com/sites/default/files/u87/Conga_FactSheet.pdf

Price, William A.,1997, Guidelines and Recommended Methods for the Prediction of Metal Leaching and Acid Rock Drainage at Minesites in British Columbia: B.C. Ministry of Employment and Investment, 141pg. plus appendices.

Redmond, Dan, Henrik Thalenhorst, Jack Seto, 2011 (March 22), Technical Report on the Kumtor Gold Project, Kyrgyz Republic: prepared for Centerra Gold, Inc., 156 pg. Available at: http://www.centerragold.com/properties/kumtor/

Robertson, J.D. and K. D. Ferguson, Dec. 1995, Predicting Acid Rock Drainage: Mining Environmental Management, vol.3, no.4, pg.4-8.

Rodríguez, Reinaldo, 2011, “Proyecto Minero Conga—EIA Inviable” (Hidrología e Hidrogeología): Prepared for the College of Engineers of Peru (Cajamarca).

SWS (2009a). Chailhuagón Pit Dewatering Model. 5391-3 Perol Stage 3, December 15.

SWS (2009b). Perol Pit Dewatering Model 2009 Update. 5391-3 Perol Stage 3, December 18.

Tusing, T.W., J.R. Elsea Jr., and A.B. Sauveur, 1954, The chronic dermal toxicity of a series of polyethylene glycols: J Am Pharm Assoc Am Pharm Assoc (Baltim). Aug;43 (8):489-90.

WMC (2004c). Minas Conga Feasibility Study, Site wide Hydrogeological Description. 5224/R5, November.

WMC (2008a). Conga Pit Dewatering Feflow Model. 5391-3 Conga Stage 3, July 15.

U. S. Environmental Protection Agency, 1986, Quality Criteria for Water 1986: U.S.EPA, Office of Water Regulations and Standards, Washington, D.C.

About Robert Moran

Dr. Robert Moran has 40 years of domestic and international experience in conducting and managing water quality, geochemical and hydrogeologic work for private investors, industrial clients, tribal and citizens groups, NGO's, law firms, and governmental agencies at all levels. Much of his technical expertise involves the quality and geochemistry of natural and contaminated waters and sediments as related to mining, nuclear fuel cycle sites, industrial development, geothermal resources, hazardous wastes, and water supply development. In addition, Dr. Moran has significant experience in the application of remote sensing to natural resource issues, development of resource policy, and litigation support. He has often taught courses to technical and general audiences, and has given expert testimony on numerous occasions. Countries worked in include: Australia, Greece, Bulgaria, Mali, Senegal, Guinea, Gambia, Ghana, South Africa, Iraqi Kurdistan, Oman, Pakistan, Kazakhstan, Kyrgyzstan, Mongolia, Romania, Russia (Buryatia), Papua New Guinea, Argentina, Bolivia, Chile, Colombia, Guatemala, Honduras, Mexico, Peru, El Salvador, Belgium, Canada, Great Britain, United States.

Education

University of Texas, Austin: Ph.D., Geological Sciences, 1974
San Francisco State College: B.A., Zoology, 1966

Professional History

Michael-Moran Assoc., LLC, Partner, 2003 to present
Moran and Associates, President, 1983 to 1992; 1996 to 2003
Woodward-Clyde Consultants, Senior Consulting Geochemist, 1992 to 1996
Gibbs and Hill, Inc., Senior Hydrogeologist, 1981 to 1983
Envirologic Systems, Inc., Senior Hydrogeologist/Geochemist, 1980 to 1981
Tetra Tech Int'l. / Sultanate of Oman, Senior Hydrogeologist, 1979 to 1980
Science Applications, Inc., Geochemist/Hydrologist, 1978 to 1979
U.S. Geological Survey, Water Resources Division, Hydrologist/Geochemist, 1972 to 1978
Texas Bureau of Economic Geology, Research Scientist Assistant, 1970 to 1971