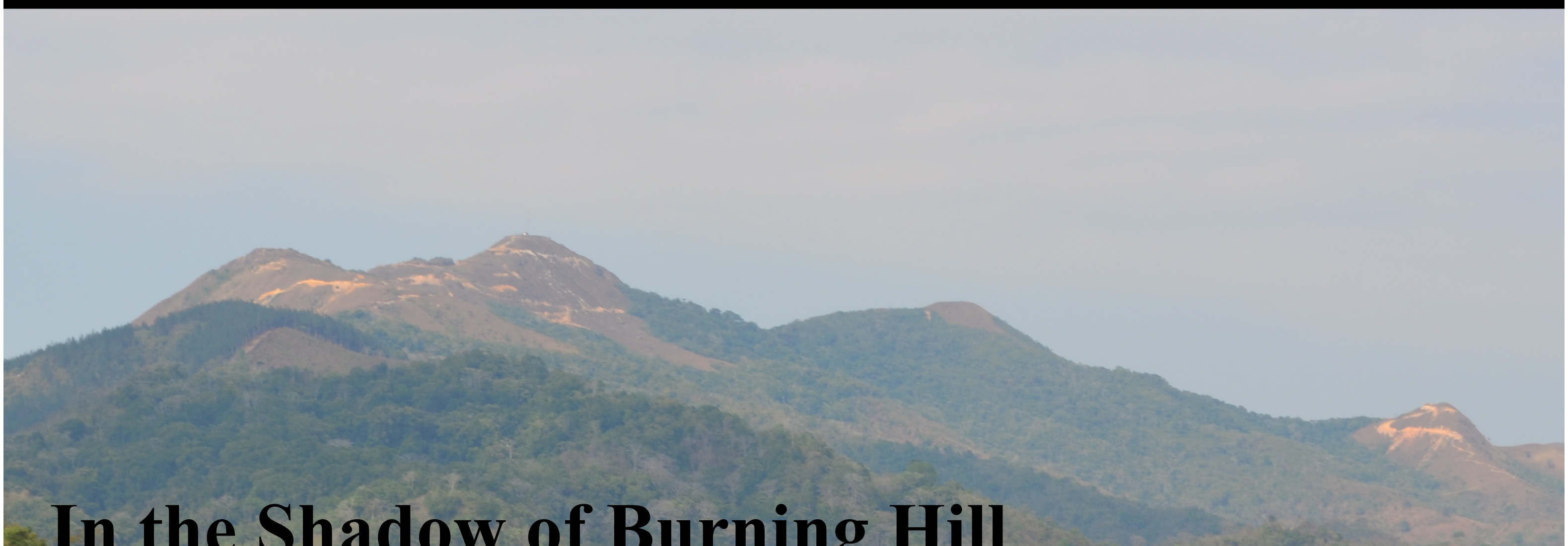

In the Shadow of Burning Hill

An Analysis of the Hydrological and Socioeconomic Impacts of the Cerro Quema Open Pit Mine

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ENVR 451: Final Report
April 25th, 2014
Prepared for McGill University and Centro de Incidencia Ambiental (CIAM)

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EXECUTIVE SUMMARY

Panama in the past decade has opened its doors to foreign-owned mining companies, specifically Canadian mining companies, despite strong resistance, violence, and scandals, which have been prominent features in its development. Policy changes under the amended Mining Code of 1988, Law 13, and the recently signed Panama-Canada Free Trade Agreement have facilitated the current mining surge by reducing or eliminating taxes and allowing foreign states to invest directly in Panamanian mining projects. These policies have helped the mining sector to become one of the fastest growing in the country. A genuine question is, with only small fractions of the profits from mining destined to return to the Republic of Panama and even less to the affected communities, how much benefit is the country and people of Panama gaining from this boom?

Protests have become commonplace in communities surrounding mining concessions, on one occasion escalating to violence which resulted in the deaths of two protesters blockading the Cerro Colorado copper project in January 2012. After Greenstone Resources Ltd. declared bankruptcy and abandoned the Santa Rosa gold mine in Cañazas after only three years of production, uncertainty remains as to who is responsible for the ongoing environmental contamination resulting from the operation. The environmental record of the Molejón gold mine in the Donoso region has been marred on multiple occasions, to the point that the National Environmental Authority in Panama (ANAM) slapped the company responsible, Petaquilla Minerals Ltd., with its highest fine of $1 million in addition to nearly $1 million more in damages, though the fine was later annulled due to "lack of notification in due form" to the company. These examples set concerning precedents, and many people living nearby to developing mining projects are skeptical about the whether the benefits will outweigh the costs.

Cerro Quema is a mid-sized gold mine currently under construction in the Tonosí district of the southern province of Los Santos. Exploration has occurred on-and-off in this area since 1990, and has not been free of controversy. Exploration activity prompted the establishment of an organized opposition group to the mine *El Frente Santeño Contra de la Minería* in 1997, composed mainly of local campesinos, who have staged multiple protests and even implemented attempts to blockade the mine. The Cerro Quema project is owned by Pershimco Resources Inc., another Canadian company, and has recently announced its plans to begin production in 2016. The company has also begun a deep-drilling program on the same site, and if a significant deposit is found through this endeavor the scale of the mine will likely increase substantially.

Our aim was to independently assess the current environmental and social issues surrounding Cerro Quema, specifically through the lens its local community members. We achieved this by conducting 33 interviews along the highway *Llano de Piedra-Tonosí,* which holds communities both upstream and downstream of the mine site. Specifically, the interviews began in Bajos de Güera, located to the north and outside of the Cerro Quema watershed and ended in Rio Güera, located to the south and downstream of the mine site. Every third house was approached for a potential interview, occurring between February and March of 2014. During our interviews, it was repeatedly reported that the river downstream of Cerro Quema had experienced increased sedimentation, with many people attributing this phenomenon to erosion from construction activities in the concession. Based on this information, we conducted a comparative analysis of the riverbed sediment in Rio Güera in an attempt to verify these claims. Sediment from point and mid-channel bars was collected at three sites upstream of the mine and three sites downstream, and then compared for the proportion of fine sediment, the component attributable to construction activities.

The interview results demonstrated a lack of support for the mine across the study area, with 40% openly expressing their position against the mine, 39% not responding to the question, and 3% openly stating they were in support. This sheds an interesting light on Pershimco's claim from its corporate website of strong community ties, considering most respondents knew little of their activities.

Our results from the sediment analysis showed a trend towards higher proportions of fine sediment below the mine, but our small sample size did not show statistically significant results. We also found several confounding variables in our sample area in the presence of riverbed vehicle crossings and disturbance from cattle use. Unfortunately, due to time and access restrictions, we were unable to conduct the study in an area free of either of these confounding variables, but the results are interesting nonetheless.

Because the Cerro Quema project has not yet begun production, it is important to gather research data on the condition of the watershed prior to the extractive mining operations in order to establish a baseline. Our sediment results suggest that construction at the mine may have already had an effect on the morphology of Rio Güera. Looking ahead, by gathering as much information as possible on the current state of the river can help build a timeline of how a mining project can affect a river at which points in development.

Resumen Ejecutivo

En la última década, Panamá ha abierto las puertas a las empresas mineras extranjeras, específicamente a las empresas Canadienses, a pesar de su resistencia fuerte, violencia, y unos escándalos que han ocupado un papel prominente en su desarrollo. Cambios en la política en el Código de los Recursos Naturales de 1988, la Ley 13, y el reciente acuerdo de libre comercio entre Panamá y Canadá han facilitado la corriente ola en la minería en Panamá, por la reducción o eliminación de los impuestos y permitiendo a los estados extranjeros la capacidad investir directamente en los proyectos mineros Panameños. Estas políticas han ayudado al sector minero hacerse uno de los sectores de mayor crecimiento del país. Solamente un porcentaje minúsculo de los beneficios vuelve a Panamá e incluso menos a los pueblos ubicados en las zonas mineras. Por esto, una pregunta pertinente es: ¿los beneficios de la minería vale la pena para el pueblo Panameño?

Las manifestaciones contra de la minería son eventos comunes en las comunidades afectados por las minas. A veces las manifestaciones pueden llegarse a ser muy violentas, al punto que en enero 2012 la policía mató a dos manifestantes durante un bloqueo en el camino para el enorme proyecto de cobre Cerro Colorado en Chiriquí. En otros proyectos, el problema no era la violencia, era la responsabilidad de las empresas sobre sus propios impactos ambientales y sociales. Desde la empresa Canadiense Greenstone Resources Ltd. se declaró insolvente y abandonó su mina de oro Santa Rosa en Cañazas, después de solamente tres años de producción, ya existe incertidumbre sobre quien tiene responsabilidad de la contaminación que continua en el región por los desechos minerales. La historia ambiental de la mina de oro Molejón, en el región Donoso, está llena de la controversia. Es verdad que Autoridad Nacional del Ambiente (ANAM) dio a la empresa encargada de la mina, Petaquilla Minerals Ltd., su multa más grande que posible ($1 millón) además casi $1 millón en daños y perjuicios por la inobservancia de las normativas ambientales. Luego, esta multa fue anulado por “la falta de notificación en la forma adecuada” a la empresa. Estos ejemplos hacen malos precedentes, y entonces mucha gente viviendo cerca de los proyectos mineros en desarrollo tiene preocupaciones sobre su futuro al lado de las minas.

Cerro Quema es una mina de oro de tamaño medio bajo construcción en el distrito Tonosí de la provincia meridional de Los Santos. Desde los años noventa, unas empresas han intentado desarrollar esta mina, y con frecuencia encontraban resistencia del pueblo rodeando la concesión minera. Por eso un grupo de campesinos se organizó contra de la mina y estableció *El Frente Santeño Contra de la Minería* en 1997. En los últimos anos, la actividad de la empresa que tiene derecho de la mina, Pershimco Resources Inc. de Canadá, ha escalado. El Frente ha efectuado unos manifestaciones en los últimos anos, incluso hizo un bloqueo en el camino para la mina con sus tractores. A pesar del malestar social, Pershimco está planeando empezar producción en 2016. Además, la empresa espera un depósito de cobre abajo del oro, y hoy en día está haciendo perforaciones de gran profundidad para verificar su sentimiento. Si es verdad, el proyecto se convertiría en una escala enorme.

Nuestro propósito era hacer una evaluación independiente para entender cuáles son los asuntos sociales más importantes de los pueblos en la zona minera, como está la relación entre el pueblo y el proyecto minero, y también como está la situación corriente de los recursos hídricos. Para implementar este propósito, hicimos 33 entrevistas por la carretera *Llano de Piedra-Tonosí*, en cual hay unos comunidades arribas de la cuenca de la mina y otras abajas. Específicamente, empezamos en la comunidad Bajos de Güera en el corregimiento Altos de Güera, e hicimos entrevista con cada tercera casa hasta Río Güera, en corregimiento La Tronosa. Durante las entrevistas, mucha gente nos dijo que los ríos bajos de la mina contienen más sedimento y lodo desde unos años, y la mayoría de esta gente creía que este cambio era por la construcción de los caminos y las perforaciones encima Cerro Quema. Pensando en esto, hicimos también un análisis comparativo del sedimento en Río Güera. Sacamos tres muestras del sedimento del fundo de río arriba de la cuenca de la mina, y también sacamos tres muestras del sedimento en el parte del río bajo. Comparamos las muestras para ver si exista una diferencia en la proporción de los sedimentos finos arriba y bajo de la mina. Elegimos comparar los sedimentos finos porque son los tipos atribuible a las actividades de construcción.

Los resultados de las entrevistas muestran que hay una falta de apoyo para la mina en toda la zona de investigación, con 40% dicen que son en contra de la mina, 39% no respondieron, y solamente 3% (un hombre) dice que es a favor del proyecto. Nuestros resultados son en contra de las reclamaciones de Pershimco en su sitio web, que dice que el proyecto tiene el apoyo del pueblo. En realidad, la mayoría de las personas con quienes hablamos nos dijeron que la empresa no les ha dado nada información sobre sus actividades en el área.

Los resultados del análisis del sedimento muestran una tendencia hasta una proporción alta en las muestras en el parte del río bajo de la mina, pero porque no había suficientes muestras, no encontramos resultados estadísticamente significativas. Además, la presencia de dos cruces de los vehículos en el fundo del río entre los sitios de muestras y un área en que la ganadería tiene acceso al río presentan las variables de confusión. Nuestros resultados son interesantes, pero otras investigaciones harían nuestro análisis y conclusiones más robustos.

El proyecto Cerro Quema ya no ha empezado producción, y por eso es importante acumular tanta información sobre el estado del región, ambos ambiental y socialmente, antes de la apertura de la mina. Esta información puede mostrar a cuales aspectos les afecta la mina con el tiempo, y agregan a los conocimientos de los impactos de la minería. Esperamos que estos conocimientos puedan ayudar influir la política para elegir una dirección responsable para toda la gente.

HOST INFORMATION

Founded in 2006, *Centro de Incidencia Ambiental* (CIAM) is the only non-governmental organization working specifically on environmental litigation in Panama. The organization seeks to defend Panama's natural resources, with a mission of promoting environmental protection and increasing public participation in decision-making (Centro de Incidencia Ambiental [CIAM], 2014). From its involvement in marine and coastal protection to green urban planning, CIAM is working on a full spectrum of pressing environmental issues in Panama (CIAM, 2014). Its Board of Directors consists of members independently recognized for their expertise in their respective fields and their resolute integrity to environmental and human rights (CIAM, 2014).

CIAM's "CONTAMINAS" campaign was an outreach project attempting to shed light on the risks of open-pit mining development in Panama. The campaign was supported by local artists, civil society activists and communities affected by mining, to declare a country free of mineral mining, as its social and ecological costs are not justifiable (CIAM, 2014). Further, CIAM played a key role in organizing changes to the national mining code in

February 2011, presenting a draft moratorium on open-pit mining during the legislative debates.

INTERNSHIP WORK LOG

	Work Days in Panama City	**Work Days in Altos de Güera**	**Work Days Elsewhere**
January	6	0	1 (Las Tablas – Meeting with Según Milciades Pinzón, leader of *El Frente Santeño Contra de la Minería*)
February	4	2	2 (Macaracas – *Taller de Formación de Capacidades de Comunidades*)
March	3	7	0
April	10	0	0

Total Work Days: **35 days**

INTRODUCTION

From 1990 to 2001, 12 of the world's 25 largest investments in mining were made in Latin America (Urkidi & Walter, 2011). Specifically, mining has become one of the fastest growing sectors in the Panamanian economy (Jamasmie, 2014). Zorel Morales, chairman of Mining Chamber of Panama (CAMIPA), recently disclosed that mining-related activities jumped to 25% in 2013, but with the mineral reserves estimated at $200 billion, that's only the beginning (Jamasmie, 2014).

The study area, the Cerro Quema mine, is situated in the central part of the Azuero Peninsula in the province of Los Santos. The Cerro Quema open pit mining project has received much attention and resistance, most notably by the *El Frente Santeño Contra la Minería*, a grassroot organization of local *campesinos* established in 1997 (MICLA, 2013). With this in mind, this project intends to contribute to the current body of literature of mining in Latin America. The primary goal is to gain a comprehensive understanding of the ways the Cerro Quema mine has affected the local communities in which it operates.

STUDY AREA: CERRO QUEMA

The Cerro Quema concession is located 20km northwest and upstream of the town of Tonosí, Los Santos and 45km southwest of the city of Chitré, Herrera. Cerro Quema is one of the highest peaks on the Azuero Peninsula, a large, mountainous peninsula on the Pacific side of Panama. The mining concession contains headwaters from three major Azuero rivers: Río Tonosí, Río Joaquín, and Río Oria. The river valleys of these rivers are important agricultural areas on the national level, producing significant volumes of milk, beef, rice, vegetables, and fruit. According to the 2010 census data, 51% of citizens over 15 years old in the Azuero worked in agriculture or agriculture-related jobs, and Tonosí's municipal website proclaims itself as " *[…] una región cien por ciento agrícola*." with agriculture as the principle economic activity and income source (Instituto Nacional de Estadística y Censo [INEC], 2014; Municipio de Tonosí, 2014). For comparison, only 6% of citizens over 15 years old worked in the mining sector (INEC, 2014). The Azuero is marked by a distinct dry season of four months between the end of December and the end of April during which water scarcity is problematic, and a wet season with varying levels of rainfall across the remaining 8 months.

The majority of the population lives along highway *Llano de Piedra-Tonosí* running between Macaracas in the north and Tonosí in the south. The highway in the study area follows the general path of Río Güera, a major tributary of Río Tonosí. The low-lying Tonosí river valley periodically experiences large flooding events due to heavy rains, most recently in 2012, and has been listed as one of the most vulnerable areas to flooding in the country (La Prensa, 2012). Additionally, it should be noted that two of the previously mentioned rivers, Río Tonosí and Río Joaquín, flow into an extremely important protected area: *el Refugio de Vida Silvestre Isla Cañas*. This is an extensive beach and system of mangroves, which together are crucial to the breeding success of many species of fish, shrimp, and Pacific sea turtles (Corredor Biológico Mesoamericano del Atlántico Panameño [CBMAP], 2014).

The Cerro Quema project consists of three mining concessions stretching across 14 900 hectares in a rural and relatively inaccessible mountain landscape in the central area of the Azuero (Pershimco Resources Inc., 2014). Gold exploration began in 1990 at two adjacent mountaintop sites, *La Pava* and *Quema/Quemita*, until drilling ceased in 1994 (Pershimco Resources Inc., 2014). Renewed interest revived the project in 2008, and since 2010 exploration and preparation efforts have markedly intensified. Recently, Pershimco Resources Inc. has obtained all necessary permits to open its first pit at La Pava and is expected to begin production in 2016 (Pershimco Resources Inc., 2014). The current estimates suggest that the La Pava and Quema ore bodies together may hold as much as 728 000oz of gold at a minimum of 0.15g/tonne, or roughly 62% of what was estimated to be at the infamous Santa Rosa mine in Cañazas (Simms & Holtby, 2012; Pershimco Resources Inc., 2014).

Recent developments, however, have fundamentally altered the trajectory and future expectations of the project. Drilling results at Idaida, a third potential pit extension, have been proclaimed as Pershimco's most significant discovery to date. The company has consequently applied to double its production capacity to 10 000 tonnes of ore a day and has identified 9 more nearby sites it hopes to explore (Northern Miner, 2014; Pershimco Resources Inc., 2014). Further, there is another nearby gold project owned by Bellhaven Copper & Gold Inc. at Pitaloza, approximately 15 kilometres to the northwest of Cerro Quema, which is currently under exploration (Bellhaven Copper & Gold Inc., 2012).

Drilling performed since 2012 has raised hopes amongst investors and owners that an extensive copper porphyry may be located underneath the proven gold deposits, some of them describing similarities between core samples from Cerro Quema with those from the Tuhuj Bukit project in Indonesia (Pershimco Resources Inc., 2014). This extremely deep Indonesian deposit holds an estimated 25 million oz gold and 15 billion lbs copper (Pershimco Resources Inc., 2014). Even if this is a bold comparison, it clearly illustrates Pershimco's high aspirations regarding the future of the Cerro Quema project.

OPEN PIT MINING

Large deposits of low-grade metal ore (ore containing less than 1.5 g/tonne Au) are often exploited by drilling and blasting directly into the mineral body, creating enormous open-air pits (Environmental Law Alliance Worldwide [eLAW], 2010). Referred to as *Open Pit Mining*, this is a form of strip mining in which the mineral of interest is located at a significant depth below the surface, and is preferred to underground mining as it is usually easier logistically, cheaper, and faster to bring into production (Norgate & Haque, 2012). To access the ore, the cap of economically worthless rock covering above it, called ‘overburden’ or ‘wasterock’, must be removed and stored first (eLAW, 2010).

The volume of overburden rock depends on the geology of the mine site, often occupying many times the volume of the ore deposit it sits above. This necessarily requires the removal or destruction of all vegetation and soil in the extraction, storage, and processing areas. Because open-pit mining often involves the removal of natively vegetated areas, it is considered to be among the most environmentally destructive types of mining, especially in tropical forests (eLAW, 2010). The Azuero Peninsula has historically experienced heavy deforestation from cattle ranchers creating new grazing lands, which has resulted in Panama’s dry tropical forest becoming nearly extinct (Griscom, Griscom, & Ashton, 2009). The slopes of La Pava and Cerro Quema support rare patches of remaining Azuero dry tropical forest whose existence could be in jeopardy by the large land requirements of mining activities.

If Pershimcos’ estimates of 728 000oz of gold held within 30 864 000 tonnes of ore are correct, and taking 2.77 tonnes/m^3 as an average density of the ore (inferred from geology reports that indicate andesites and dacites surrounding the deposits), the volume of ore would make a solid cube with each side measuring approximately 479.2m, or nearly a half a kilometre cubed (Pershimco Resources Inc., 2014; The Engineering Toolbox, 2014). All of this spent ore, not to mention all of the overburden covering it, must then be stored somewhere on site, obviously spreading out and taking up much more land area than would a cube of the same volume. For perspective, if every ounce of gold contained within this ore were made into a solid cube, each side would measure only 1.07m long.

When an ore contains a low concentration of desired minerals, companies must devise ways to separate the microscopic particles of metal from the host rock, called *beneficiation* (eLAW, 2010). The beneficiation process includes physical and/or chemical separation techniques such as gravity concentration, magnetic separation, flotation and leaching (Environment Canada, 2013). Once the mineral of interest has been removed, the remaining material is stored in dry tailings heaps similar to overburden, or in large slurry pools of wet tailings impounded by earthen dams (eLAW, 2010). The rock in both overburden and tailings is highly reactive, especially when considering sulfide-rich rocks like those of Cerro Quema, as well as easily infiltrated by air and water. This combination of sulfides, air, and water produces a phenomenon known as *Acid Mine Drainage* (AMD), where sulfuric acid is produced within the waste heaps and pools, dissolving heavy metals and other minerals from the rocks as it drains. The effluent from these heaps is highly acidic, high in sulfate, metal-rich, and can enter the surrounding environment through surface runoff and groundwater infiltration (Lachmar, 2006). AMD can also occur from the walls of open pits themselves (eLAW, 2010). Air quality in the area of open pit mines can also be negatively affected from drilling, blasting, trucks driving on unpaved roads, and material handling. These activities have been shown to increase the total suspended particulate matter, specifically particles with diameter less than 10μm (Chakraborty, Ahmad, Singh, Bandopadhyay, & Chaulya, 2002).

Cyanide Heap-Leach Process

Currently, the dominant process used for gold separation is *cyanide leaching* which is economically viable for low-grade gold ores (eLAW, 2010; Environment Canada, 2013). To recover the gold, the ore is ground, mixed with lime, stacked on top of an impermeable surface, and sprayed with millions of liters of a dilute sodium cyanide (NaCN) solution (Korte, Spiteller, & Coulston, 2000; Eisler, 2000). The gold then reacts with and forms a complex with the cyanide, drains into a large pool at the bottom of the heap, and is collected via pipes (Eisler, 2000). This ‘pregnant’ solution, or *leachate*, is processed on site to separate and collect the gold while the cyanide is reapplied on the heap to repeat the cycle. Gold recovery from the heap-leach method is generally around 70%. This is how the process works in theory, though in reality leach pads are prone to leaking and containment of cyanide and metal-rich leachate in tailings is extremely difficult, especially in climates with variable weather and high rainfall (Eisler & Wiemeyer, 2004).

During leaching and processing, many other harmful elements contained in the ore are mobilized and can escape into the environment along with the leachate including lead, cadmium, copper, arsenic, and mercury (Da Rosa & Lyon, 1997; Korte & Coulston, 1998; White & Schnabel, 1998; Korte et al., 2000; Tarras-Wahlberg, Flachier, Fredriksson, Lane, Lundberg, & Sangfors, 2000). Cyanides, includine NaCN, are extremely toxic as they act as rapid-asphyxiants once they have entered the blood stream via skin contact, inhalation, or ingestion (Eisler et al., 2004). Staggering numbers of animals have been poisoned from drinking from or coming into contact with cyanide-laced waters in holding lagoons from gold mines, including mammals, reptiles, amphibians, and birds (Leduc, Pierce, & McCracken, 1982; Alberswerth, Carlson, Horning, Elderkin, & Mattox, 1992). These lagoons are especially dangerous for birds when located in migratory areas, and entire flocks have been wiped out after having landed in contaminated water (Pritsos & Ma, 1997).

Major releases of contaminated water causing extensive ecological devastation have been recorded in countries including Romania, Guyana, The United States, South Africa, Kyrgyzstan, Latvia, Zimbabwe, and New Zealand, often as a result of containment dam failures. These failures have been attributed to a variety of factors, most notably events of heavy rainfall, flooding, earthquakes and/or landslides, design flaws, and human error (Greer, 1993; Da Rosa & Lyon, 1997; Yasuno, Fukushima, Shioyama, Hasegawa, & Kasuga, 1981; Koenig, 2000; Kovac, 2000; Laitos, 2012). The first four factors aforementioned are natural and for the most part completely unpredictable, and all four have occurred at least once in or near the Cerro Quema concession site since local record holding began.

The Cerro Quema deposit is flanked by the Río Joaquín fault on its southern side, and is within 25 km of the Azuero-Soná fault to the southwest. The Azuero-Soná fault is suspected to be the source of two earthquakes of magnitude Richter 7.0 in recorded history, causing liquefaction and landslides in the mountains as well as severe structural damage as far as Villa de Los Santos (Cowan, 2001). Prolonged periods of heavy rains are also precedented in the concession area, most notably in the month of October 1974 when 448.7mm of rain was recorded at the nearest weather station, Los Santos 128-001 (Ruiz de Leon, 1994).

Major failures of gold tailings containment dams have resulted in several instances of human death by drowning, loss of all fish in stretches of river up to 80km, severe effects on animal life in stretches of river up to 1000km, as well as contamination of agricultural lands and subsequent accumulation of heavy metals in crops destined for human consumption (Garcia-Guinea & Harffy, 1998; Da Rosa & Lyon, 1997; Kovac, 2000). At the end of a mine's lifecycle, companies treat the leachate to convert cyanide into less toxic cyanate, and any leftover cyanide is left to break down, over time, from exposure to the sun (Laitos, 2012). The environmental and public health threats of cyanide leach-heap process has led Turkey, Germany, Czech Republic, Hungary, Montana, Wisconsin, and several Argentinian states to ban the practice, while Greece and Romania are considering passing similar legislation (Korte et al., 2000; Laitos, 2012).

Alternative leach reagents to cyanide have been found, such as thiourea and thiosulphate which both have demonstrated comparable or better leaching rates than NaCN, but none of these alternatives are expected to replace cyanide in the near future due to their higher cost (Hilson & Monhemius, 2006).

Mining and Local Hydrology

Portions of the open pit that are below the water table require the use of pumps to maintain a dry working area (eLAW, 2010). This intensive pumping lowers the water table for kilometers around the mine site, causing the drying of springs, streams, and lakes, exacerbating droughts, destroying agricultural area, and causing economic hardships for the local population dependent on stable water resources (Da Rosa & Lyon, 1997; Plume, 1995; U.S. Bureau of Land Management [USBLM], 2000; Garcia-Guinea & Harffy, 1998). Considering that such a high proportion of the Tonosí region depends on agriculture and is already experiencing summertime water shortages, such a significant lowering of the water table would have extreme ramifications for the neighbouring communities. It is important to note however that when pumping ceases, following mine closure, small lakes form by groundwater infilling the pit. The water of these lakes can become acidic and laden with toxic elements due to AMD, which are then able to seep into groundwater. It has been estimated that AMD can potentially continue for thousands of years (Fields, 2001; Kuipers & Maest, 2006). The duration of the AMD effects is even more staggering when considering the worldwide average lifespan of open pit mines is estimated to only be 4 to 5 years (Norgate & Haque, 2012).

The huge water demand of heap leach mines themselves can also displace substantial amounts of water from the local hydrological regime. The United States Geological Survey

(USGS) estimates that an average heap leach mine with a capacity of 5 million tonnes of ore per year requires between 15 and 30 billion liters of water per year, not counting what is needed for dust suppression (Bleiwas & United States Geological Survey [USGS], 2012). If Pershimco succeeds in expanding its capacity to 10 000 tonnes/day i.e., 3.65 tonnes/year, a rough estimate for the water requirements at Cerro Quema mine would be between 11 and 22 billion liters per year, adjusted from the USGS estimate of a 5 Mt/year mine.

SOCIAL ANALYSIS

Corporate Social Responsibility in Latin America

Corporate social responsibility (CSR) is defined as

"*the voluntary activities undertaken by a company to operate in an economic, social and environmentally sustainable manner*" (Government of Canada, 2014).

When operating abroad, Canadian companies are expected to respect all applicable laws and international standards. In addition they are expected to operate transparently and in consultation with host governments and local communities, and to conduct their activities in a socially and environmentally responsible manner (Government of Canada, 2014). Canadian mining companies have long had a questionable reputation for social responsibility, especially in Latin America. The recent defeat of Bill-C300 in the House of Commons, which sought to establish prescriptive CSR for Canadian mining companies, further questions if Canada truly seeks to abide by its code of conduct when operating in foreign countries. Mining activities have been associated with social disruption, human rights violations, environmental contamination and generating conflict with and among local communities (Keenan, 2010).

In Coclesito, Panama, the Molejón gold mine and the Cobre Panama mining project illustrate how Canadian mining companies do not always follow the CSR framework. Throughout its entire lifecycle, the Petaquilla Gold mine was largely rejected by local communities for its failure to consult, unfulfilled development promises and repeated environmental contamination (Simms & Holtby, 2012). In 2008, ANAM charged Canadian mining company Petaquilla Minerals Inc. with its maximum fine of $1 million for starting operations without an Environmental Impact Assessment and for failing to comply with environmental regulations (Simms & Holtby, 2012). Instead of complying with ANAM's ruling, suspending its operations, and obtaining the appropriate environmental permit, Petaquilla denied all allegations and tried to have the fine lifted in the Supreme Court (Simms & Holtby, 2012). The Supreme Court ultimately lifted fine in 2010 on the basis of ANAM's "lack of notification in due form" to the company (Simms & Holtby, 2012). Further, it was found that Petaquilla had begun mining operations without proper certification from the International Cyanide Management Institution and that its tailings ponds contained levels of cyanide, mercury and other heavy metals above acceptable limits (Simms & Holtby, 2012). Neighboring communities of the mining project reported that the mine was responsible for violent destruction of property, forced eviction, an increase in alcohol and drug consumption, and for creating tension between community members (Simms & Holtby, 2012).

Cobre Panama is a large open-pit copper project currently under construction which lies adjacent to the Molejón gold mine (Mining Watch, 2013). The mining concession is largely owned by First Quantum Minerals Ltd., a Vancouver based mining and metals company (First Quantum Minerals Ltd., 2014). First Quantum has been the subject of many allegations concerning human rights abuses relating to its operations in other countries

(Mining Watch, 2013). To illustrate, the company has been involved in the eviction of squatter communities in Zambia and has been alleged to play a role in the illegal exploitation of natural resources in the Republic of Congo (Mining Watch, 2013). The company recognizes that the Cobre Panama project will have a large environmental footprint including massive deforestation, the displacement of three indigenous communities, and increased in-migration, and rise in associated social problems (Mining Watch, 2013).

Mining and Socioeconomic Impacts

It is a well-known fact that mines have positive socioeconomic impacts on local communities (Hilson, 2001). Hajkowicz et al. found that mining activities have positive impacts on incomes, housing affordability, communication access, educational attainment, and employment across regional and remote Australia (Hajkowicz, Heyenga & Moffat, 2011). Further, a study found robust evidence that the Yanacocha gold mine in Peru has generated a positive effect on real income for local residents and its surrounding rural hinterland (Aragon & Rud, 2011). Mining projects served as a major source of employment for local people and triggered the rise of a wide range of small businesses such as catering, cafés and cleaning services (Hilson, 2001; Aragon & Rud, 2011).

However, despite bringing a wealth of socioeconomic benefits, mines are also associated with a wide range of social problems (Hilson, 2001; Hajkowicz et al., 2011). For example, mining activities stimulate population influxes, namely the migration of foreign and non-local male employees (Hilson, 2001). This is primarily because mining operations draw on highly skilled mining engineers and heavy machinery operators. Consequently, the influx of mostly male, non-resident employees have been associated with increased alcohol consumption in local communities experiencing the mining boom. Midford and colleagues found that the frequency and quantity of alcohol consumption at mining related worksites in Australia was greater than that of the national level (Midford, Marsden, Phillips, & Lake, 1997). In addition, in one Western Australian mining community the number of reported violent crimes was 2.3 times higher than the state average and had risen almost threefold since the beginning of the mining boom (Carrington, Hogg, & McIntosh, 2011). Thus, rapid population changes and the increase in the number of unacquainted, unfamiliar, primarily male residents often disrupt the social balance of local communities (Hilson, 2001; Petrova & Marinova, 2013).

Cerro Quema: A Rocky Past

The Cerro Quema mining project has seen its share of resistance from local communities. In 1997, mining explorations led to rising protests and the establishment of *El Frente Santeño Contra la Minería* (Gandásegui, n.d.). On September 17th, 1997 several members of *El Frente* were arrested after attempting to block the road to the mine with tractors (McGill Research Group Investigating Canadian Mining in Latin America [MICLA], 2014). Police fired tear gas into the crowd that included women and children (MICLA, 2014; Gandásegui, n.d.). The group also delivered a petition with over 5000 signatures demanding the permanent closure of the mine to the legislative assembly (MICLA, 2014). On October 5th, 1997, over 3000 people including environmentalists, church authorities, and local community members took to the streets of Tonosí demanding the closure of the mine site (MICLA, 2014). In November of the same year, the home of *El Frente* leader Segün Milciades Pinzón was burned down by arsonists (MICLA, 2014; Gandásegui, n.d.) More recently, *El Frente* dubbed 2008 as *El Año de Lucha Antiminera* and identified six reasons as to why they are opposed to the Cerro Quema mining project (The Panama News, 2010).

1. In 2007, the extraction of gold became an extremely profitable activity
2. As a consequence, mining companies are eager to get their hands on the gold of the Panamanian people
3. They believe that the national government often turns a blind eye, as was seen with the Petaquilla gold mine. The government is shredding Panama to threads: it is taking the country's vast mineral resources and selling them elsewhere. Representatives of mining companies are deceiving the poor with false promises of employment, health and housing.
4. Mining companies seeking to exploit Cerro Quema are promising to generate 400 thousand ounces of gold with a gross profit of $320 million. The government will only receive 2% of this profit and the municipalities will receive 15% of that 2%.
5. Mining companies are getting tax exemptions by importing machinery and are using "gifts" to the communities (i.e., helping schools) as tax deductions.
6. Mining activities will affect the Herrera and Los Santos watersheds and in turn threaten the water supply of the region. Mining activities are unacceptable: they destroy forests; they pollute rivers and have the potential of adversely affecting mangroves.

Most recently, *El Frente* picketed in front of the governing body of Los Santos as a result of increasing construction and excavating activities at the mine site (Gandásegui, n.d.). The group has threatened to take action if mine re-activation is pursued (MICLA, 2014).

Another Canadian Footprint

The company who holds the rights to exploit the Cerro Quema deposit is Pershimco Resources Inc., a Canadian exploration and development company based out of Rouyn-Noranda, Québec, and listed on the Toronto Stock Exchange. In 2010, the junior mining company acquired 100% of the Panamanian Gold Corporation Minera Cerro Quema, S.A. (Pershimco Resources Inc., 2014).

The company also holds 14,000 ha of exploration concessions located near the Val d'Or mining camp in the Abitibi region of Québec (Pershimco Resources Inc., 2014). The Courville project, like the Cerro Quema gold project, has the potential to host a world-class deposit (Pershimco Resources Inc., 2014). Further, Pershimco has a joint venture agreement with Sierra Metals, a Latin American precious and base metal producer, for the San Miguel and La Bamba properties in the Cusi Silver Mining Camp, Mexico. In 2009, Sierra Metals began producing silver dores at the Cusi Mine and has recently discovered higher-grade silver, zinc and gold deposits in the region (Pershmico Resources Inc. 2008).

Pershimco considers itself to have a strong relationship with the local community and according to its President and CEO, Alain Bureau, the company's vision is

"[...] to develop our projects within a framework that utilizes the highest standards to ensure the creation of a better future for all of our stakeholders, including the communities in which we operate."

METHODOLOGY I

With this in mind, the study developed a questionnaire to address the multifaceted issues surrounding the Cerro Quema project.

First, the study aimed to gain perspective of the communities' general attitude towards the project. Specifically, we wanted to investigate possible differences in opinions depending on the communities' proximity to the mine site, as well as the communities' location either upstream or downstream from the operation.

Second, the study explored Pershimco's level of involvement in the communities in which they operate and whether the residents had been consulted.

Third, the study explored the communities' water sources and usage in addition to any recent observations of changes in water quality and quantity.

Finally, the study explored if the Cerro Quema mining project had led to changes in the local social structure.

We conducted a semi-structured community survey, carried out between February-April 2014, using a systematic sampling method. The survey contained a total of 28 questions addressing two main themes: water usage and the Cerro Quema mine (see Appendix C).

Every 3rd house along the highway *Llano de Piedra-Tonosí*, specifically between the communities of Bajos de Güera and Río Güera were approached for an interview (see Appendix B). If the house was unoccupied, the immediate house over was approached until a participant was found. From here we continued to canvas the next third house as per the above methodology. These locations were chosen based on their proximity to the Cerro Quema mine and are the communities that will be most directly impacted by the mining project.

All research was carried out following the McGill University *Code of Ethics.* All pertinent information regarding the study's purpose and goals was addressed verbally, and we allowed the potential participant ample opportunity to ask questions. The participant was informed that we were McGill University students investigating the water resources in the area as well as the Cerro Quema mine. We made it clear that we were not representatives of a mining company or the government. Due to the sensitive nature of the topic, participants were informed that they could withdraw at any point and that all information collected was confidential. They were also informed that the interview was completely optional. Verbal consent was given to perform interviews, and all interviewees were above 18 years of age. Conversation was allowed to flow naturally during interviews, with periods of candid discussion, until all questions had been covered.

Informal interviews were also conducted to help build a stronger case study but were not included in the following quantitative analysis. These informal interviews will only be presented in the discussion.

RESULTS

Demographics

A total of 41 people participated in the study, of which 33 were formal interviews. Out of the 33 formal interviews, 15 females and 18 males were interviewed. The interviews lasted between 15 and 75 minutes in length. The majority of the male participants (83%) practiced subsistence agriculture. The remaining male participants were unemployed, retired, or mine workers. All female participants considered themselves as housewives. Four of the male participants had been previously employed or were currently working at Cerro Quema mine. The majority of the interviewees had completed the first seven years of primary school (see Appendix D).

Cerro Quema

The majority of the respondents were against the mining project or were uncertain (40% and 39%, respectively). One individual was in favor of the mine and the remaining participants did not respond to the question (3% and 18%, respectively (see Appendix D).). Twenty-four of the participants stated that the mining company had not provided any information regarding the mining activities. The majority of residents in each community interviewed agreed that mining activities would affect their lives except those in Bajo Bonito, where all participants said that they were uncertain about the impacts of mining on their livelihood.

Water Usage

Every community had its own respective aqueduct. No one interviewed reported using the river as a source of drinking water, though some older residents reported using it in the past. Fourteen of the participants (43%) did not use the river for any purpose; the remainder used it for irrigation, bathing, and recreation.

The participants stated that animal waste (61%), deforestation (58%), industrial mining (52%), human waste (42%), and artisanal mining (36%) affected water quality (see Appendix D). The majority of the participants reported they had witnessed at least one change in the river water quality and quantity in the past 5 years. Increased sedimentation, contamination, and dropping water levels were amongst the main changes in the river. All participants indicated a lack of water especially during the dry season.

DISCUSSION

Pershimco in Tonosí

Pershimco Resources Inc. deems to have an excellent relationship with local communities, however, the interviews carried out in this study paint a very different picture of the company's involvement. The majority of the respondents stated that the company has provided little, if any, information about its mining activities in Cerro Quema. For those members who had attended local meetings held by the company, they said that the mining representative had given a biased account of the mining impacts and had emphasized only positive aspects. The open pit mine, according to the representatives, was not going to affect the water quality, and many respondents stated that the company had declared no pitfalls of this project whatsoever. Among those who were uncertain, the main reason was primarily because the mining company had only told them one side of the story: all pros and no cons. They wanted Pershimco to be transparent and engage in public consultation. *"There needs to be a dialogue between both parties, the community members deserve to have a say and voice their opinions,"* voiced a community member. "*Canadian companies come to countries like Panama, where the legislation is loose, deprive people of their human rights and degrade their environment,*" stated another farmer. Although a strong statement, it encompasses all of the reasons why most community members were against mining.

The majority of the particpants acknowledged that Pershimco has improved the infrastructure of the primary school and that it had recently implemented a meal plan for the school children. Interestingly, one participant mentioned that although these services were beneficial to the community, it should be the government providing these services, not Pershimco. He specifically stated that the government should provide more support to the farming community. There was a general consensus among the farming community that there was a lack of communication between the government and the agricultural sector. There was also talk about a reforestation program from the part of Pershimco to mitigate its environmental footprint, however none of the participants had personally witnessed it or were aware of the scale of the project.

The lack of job opportunities within the region served as a major catalyst towards the mining sector. People either saw no other alternative or saw it as an opportunity to increase their income. Many people explained that being a subsistence farmer was becoming increasingly difficult and that without the help of the government, many of them were no longer making ends meet. This had been the case with one of the interviewees: he used to be a small-scale farmer but because of increasing production costs, he no longer broke even, and in turn decided to work for the mine.

Participants mentioned an influx of non-local employees and increasing alcohol consumption within the area. Although in this study mining operations cannot be directly attributed to increased alcohol consumption, it was clear that many residents were noticing changes in their local environment – there was more traffic, the local *cantinas* were getting louder, and drinking was increasing. As suggested in the literature, this increased "drinking culture" is because many of the workers find themselves isolated from their families for an extensive period of time, with increased disposable income and few constructive recreation activities in which to participate. Moreover, many respondents believed that the younger generations were more inclined towards working at the mine.

On several occasions, interviewees reported that the mining project had led to a strong divide between community members, especially among the older generations. *"There is bad blood, even within families,"* voiced one participant. For many, the agricultural sector is a way of life and the mining project threatens their livelihood. For others, the mining sector was a way to get ahead, even if it is at odds with the rest of the community.

Finally, when asked if they would like more information about the mining activities along with its environmental and social impacts, almost all participants responded yes.

Water Usage in Tonosí

Each community has its own respective aqueduct, some of which were reported to supply high quality drinking water while others were reported to not be properly maintained, consequently affecting water quality. It is important to note that the aqueducts' water quality was never attributed to the mine.

As previously mentioned, the Azuero Peninsula is one the driest regions in Panama and the main occupation within the Tonosí river valley is agriculture. Almost all participants stated that the dry seasons within the last few of years had been significantly drier and hotter than any in recent memory. In addition, it was reported that Río Güera's water levels had reached an all time low within the last five years. This drop in water level was a concern amongst the farmers because most of them used the water for irrigation purposes and as a water source for their animals. "*Not only do mining activities require huge volumes of water to operate but they also they contaminate our water*," described one farmer. He said that withdrawing water from Rio Güera or its watershed would only exacerbate the water shortage in the area.

Participants reported water quality issues such as allergic reactions, parasites, and contamination. Though many people reported 'contamination', few were explicit in what exactly they meant, and when questioned almost always described the river as simply "*sucio*" (dirty). For those participants who were more informed about the adverse effects of mining operations, it was repeatedly mentioned that heavy metals in particular would affect the water quality of Río Güera. As one participant stated "*These harsh chemicals have ways to seep into the groundwater or reach the river [via surface runoff]*". Participants described two instances when Río Quema and Río Güera "turned red." The first time was when Campbell

Resources began production in January of 1997 and the rivers had been affected by an accidental chemical spill. More recently, Río Güera reportedly turned red and murky for a period of 6-15 days. Some believed that this was due to an influx of sediment into the river from 'earth moving' at the mine.

Another important issue which many people described was the use of herbicides and pesticides throughout the region. Most farmers did acknowledge that some of their agrochemicals were affecting the water quality, and consequently some of them had considered organic farming. Ultimately, many farmers reported that because the economic costs were too high, they saw no incentive to switch practices.

Upon field observations, the cultural importance of the rivers was clearly evident, as with the case of *La Angostura* and local waterfalls being frequently occupied by local community members. Each time we visited any of these sites we were always among families or groups of teenagers enjoying themselves, swimming, and fishing together. These sites, as suggested by several participants, could also be important if the Tonosí region wishes to continue growing its tourism sector,.

Lastly, the most common and consistent reported change people had noticed was the increasing mud accumulation in the riverbed of Río Güera. The cause of this, according to the same people, is the large-scale earth-moving activities such as road construction and exploratory drilling on La Pava, Quema/Quemita, and more recently at Idaida. It was because of the consistency and frequency of these reports that we decided to do a river sediment study in order to provide concrete evidence for these claims.

SEDIMENTATION ANALYSIS

Background Information

Mining and construction activities are known to contribute excess fine sediment into fluvial environments, altering the morphology of rivers, estuaries, and the near coastal-zone (Owens et al., 2005). Erosion and resulting sediment loading can occur from open pit sites, heap sites, overburden and waste-rock piles, haul roads, tailings piles, and exploration areas (Lachmar et al., 2006). This occurs due to the high amount of disturbed and exposed earth at these sites. Erosion is most evident during periods of storm flow, high precipitation, and snowmelt (Lachmar et al., 2006). Corresponding changes in water turbidity and substrate composition can have detrimental effects on stream and river habitats, fundamentally altering the community composition of river systems (Owens et al., 2005). Sediment originating from mining tailings and waste rock can also carry heavy metals into the environment, a phenomenon most closely attributed to silts and clays under 63μm in diameter (Owens et al., 2005; Foster & Charlesworth, 1996). These negatively-charged fine sediments have large surface areas and can easily bind to negatively-charged metals, so much so that metal concentrations in the fine sediment of rivers can be as much as 100 000 times higher than the dissolved metal load of the river water (Foster et al., 1996). Therefore, fine sediment can effectively transport heavy metals into any area of the river floodplain, which acts as a long-term sink for these elements (Foster et al., 1996). Once in the soil, metals including As, Cd, Pb, Cu, and Zn, can enter the food chain through primary producers, and in several mining-affected environments these have been found in every trophic level of the local food webs (Saiki, Castleberry, May, Martin, & Bullard, 1995; Lachmar et al., 2006). The reduction in interstitial space in streambed environments due to deposition of fine sediment in the form of clays and silts has also been shown to negatively impact the biodiversity of rivers, eliminating crucial fish breeding habitat and altering the species composition of macrophytes, amphibians, and macroinvertebrates (Conor & Goforth, 2012). One study demonstrated a 90% reduction in the number of benthic macroinvertebrates after significant sedimentation from a mining operation, subsequently altering the entire food web and eliminating large fish from the study area (Duda & Penrose, 1980).

As the Tonosí river valley is dependent on agricultural products such as rice, maize, and milk, it is important to understand how the use of metal-laced mining effluent or the deposition of mining sediment into agricultural areas could affect crops. All of these agricultural products have been shown to contain elevated levels of metals if grown in metal-contaminated soil or fed contaminated feed (Fayz, 2012; Kovac, 2000). During our interviews, many residents reported that the community used the river water for irrigation and to water their cattle. Keeping in mind the periodic flooding of the valley, this suggests several entry points of contaminants into human food resources if the mine were to begin operation. Many reports also mentioned an increase of mud and sand in the riverbed downstream from the mining area, as well as the recent disappearance of shrimp from Río Güera downstream from the confluence of Río Quema. It is possible that sediment eroding because of construction on La Pava, Quema/Quemita and Idaida is affecting the physical characteristics and habitats in Río Quema, Río Güera, and ultimately Río Tonosí.

METHODOLOGY II

With this in mind, the objective of our ecological study was to determine whether there was a higher proportion of fine sediment in Rio Güera downstream of the Cerro Quema watershed relative to upstream. The sedimentation study was located along a three-kilometre reach of Río Güera, incorporating sections both upstream and downstream of the confluence with Río Quema, a tributary draining a large portion of the mining concession. It is important to note that the entire La Pava site and the majority of Quema/Quemita drain into Río Güera via Río Quema.

Samples were collected in Río Güera at three locations upstream and three locations downstream from the confluence of Río Quema. Originally we aimed to collect samples from only point bars for consistency. However, while investigating our study reach, we discovered the presence of confounding variables such as streambed vehicle crossings and large areas of riverbed disturbed from cattle. Consequently, we decided to incorporate one mid-channel bar into our downstream sample to minimize our potential for error.

At all six sites, we removed approximately 20 kg of wet sediment from the upstream side of the bar, beside the riffle, as near to the river edge as possible without losing fine sediment to the flow. At the mid-channel bar, we located our sampling site in the same manner as described above, removing the sediment from beside the route of the main thalweg. At each site we first removed the pavement from a $1m^2$ area as described by Gomez et al., and then dug out sediment with a spade to a depth of 40cm until 20kg had been gathered. According to Carling & Reader, 40 cm is a standard depth of riverbed gravel accumulation (Gomez, Rosser, Peacock, Hicks, & Palmer, 2001; Carling & Reader, 1982).

The samples were then dried on tarps in the sun on a day with little wind. Once dried, we filtered each sample through a Screen Sieve Kit, made by American Educational Products, which separated the sediment into particles >250µm, 250µm>x>68µ, and <68µm. Using approximately 1.0 kg at a time, sediment was placed in the separator and vigorously shaken for 30 seconds, after which the various size samples were removed to be weighed or compiled along with previous batches to be weighed en masse. The precision of our Pesola MS500 scale was 0.1g and had a maximum capacity of 500.0g. In order to reduce error we compiled enough of each size sample in to minimize the number of individual weighing's necessary.

Once the data was collected, we used R 3.0.2 to perform a Welch Two Sample t-test to compare the weight proportion of fine sediment in our samples upstream from the confluence of Río Quema with our samples from downstream. Individual rocks bigger than 150g were excluded from our study. We chose 150g as an upper limit because we wanted to investigate the composition of the finer sediments, and since the relative amount of fines was already so low, the presence of even one large rock would have skewed the results from the sample significantly. This was a threshold which was large enough to exclude only a very few, noticeably larger rocks from our samples.

RESULTS AND DISCUSSION

Our upstream sites consisted of the first three point bars in Río Güera that we encountered (see Appendix B). We found similar proportions of sediment <250μm and <68μm in our upstream samples with average weight proportions of 1.63% and 0.29%, respectively. The standard deviation between the three upstream samples was 0.15 for sediment <250μm and 0.09 for sediment <68μm, showing little variation in the three samples.

Our downstream samples consisted of the first point bar directly downstream of the confluence of the two rivers, and of one mid-channel bar and another point bar approximately 2km further downstream. Between our first downstream sampling site and the latter two, Río

Güera falls through a series of semi-bounded and bounded limestone gorges. The final two downstream sampling sites are located after these gorges where a meandering pattern re-establishes itself in a manner similar to our upstream sampling sites. The downstream sites showed more variation (see Appendix D). The average proportions of sediment <250μm and <68μm in our downstream samples were 4.15% and 0.72% respectively, but the corresponding standard deviations were calculated as 1.84 and 0.49. By comparing the standard deviation values between our upstream and downstream sites, it is clear that the downstream sites are less consistent in their sediment composition.

Due to our small sample size we found no statistically significant difference in the fine sediment proportion between the upstream sites and downstream sites despite the profound disparity between the averages (see Appendix D). From our results there is a clear trend suggesting that higher proportions of fine sediments exist in the riverbed below the river discharging the mining concession. The proportion of fine sediment from Downstream 2 is by far the highest of the five samples, accounting for the large standard deviation and high average in our downstream samples (see Appendix D).

It would be interesting to examine more sediment to determine whether such a high fines proportion could be found consistently in downstream samples, or whether this result is in reality out of the ordinary. At this point, however, we must recognize the possibility of skewed results due to several factors. Vehicles commonly ford the rivers in this area during the dry season, and there are many instances of these crossing points along Río Güera both above and below our study reach. Vehicles crossing directly on the riverbed are known to re-suspend fine sediment, which accumulates downstream (Brown, 1994). Two of these crossings were located within our study reach: one separating our upstream sites from our downstream sites, and the other above our latter two downstream sites.

Cattle are also given access to small areas of the river along its length, which visibly disturbs the riverbed and also kicks up fine sediments. We chose our sites to minimize this phenomenon, but there was still one noticeable livestock-watering site at the mouth of Río Quema. The vehicle crossings and the cattle-watering site present confounding variables that we could not control against.

The trend towards higher sedimentation below the river confluence is interesting nonetheless and is worth investigating further. Ideally, we would have chosen to take water samples from Río Quema itself after a rain event, both upstream and downstream of the mine site, to analyze suspended sediment load. Several persons interviewed recounted having seen or heard of the water in the both Río Quema and Río Güera turning brown, red, or yellow after rains, most attributing this to erosion caused by work being done at the mining sites. This would be a better representation of any potential sedimentation caused by construction activities in the concession since the steeper stream prevents vehicle crossings and there are fewer animals in the headwaters. Unfortunately we were unable to perform this experiment due to the lack of rain during our internship period, which falls over the dry season.

CONCLUSIONS

It is clear that the mine at Cerro Quema is having profound effects on the communities surrounding its operations. Our interviews indicated a widespread lack of support for the project because of concerns regarding pollution, disruption to the existing social fabric, and fears that the mine will affect both water quality and quantity in the region. We spoke with several men who worked for the mine, and although only one of them was openly in support for it the consensus amongst them was that the mine was the best way to provide a reliable income to support their families. Farmers are already concerned about their futures because of the year-to-year drop in water levels in the region's rivers as well as the rising production cost of food, and the contamination implications of a gold mine are only creating tensions between the agricultural sector and those benefiting from the mine. Already many people have reported witnessing contamination from the exploration and construction in the concession in the form of increasing mud washing into the rivers. Our analysis of this phenomenon did find a trend suggesting this may be the case, but the presence of confounding variables and the lack of statistically significant results prevent us from making concrete conclusions.

Recommendations

We hope this report can provide a foundation for future research studies and community action. During the interviews, we specifically asked each interviewee what they knew about the effects of open pit gold mining, both environmentally and socially. Knowledge ranged substantially, but it was clear that many people knew very little of what to expect and had no way of accessing information to educate themselves on the subject. We followed this by asking whether they would like to learn more on the topic, and an overwhelming 85 % responded that they were interested in learning more.

We took part in a CIAM presentation in Llano de Piedra in February, which clearly outlined these effects to an audience, and included several community members from our study site. It became clear during our interviews, however, that many of the people who expressed interest in attending a similar educational meeting did not have the ability to attend the presentation because of its location in Llano de Piedra, or they simply did not know about it in the first place. We believe it is important to find a way to make future meetings like this more accessible to the communities directly surrounding the concession, in turn giving the people most directly affected by Cerro Quema a more rounded education on what is going on in their own backyard.

Because of the uncertainty surrounding the results from our sedimentation study, we feel that it would be beneficial for the community, as well as to add to the body of knowledge of the area, that future studies be performed to investigate the trend we observed. Construction activities are planned to continue in the mining concession, and it is important to know whether this is having an effect on the rivers which are so important to the communities downstream. Future studies could also incorporate Río Joaquín, as mineral exploration has recently moved into this watershed as well. Río Joaquín could give more insight into the big picture of Cerro Quema, as well as provide alternate sampling and control sites. Investigations on water quality would also be beneficial for understanding the long-term changes in the rivers due to the mine. Since mineral exploration seems to be expanding and Pershimco has just initiated a deep-drilling program with the hopes of finding a large deposit, setting up a foundation for a long-term monitoring program would be prudent if one seeks fully capture the impacts of this project.

Limitations

This project presented many challenges and limitations. Our plan from the beginning was to conduct a comparative study investigating an aspect of the water resources in the mining area, but since our initial knowledge of the Tonosí region was limited we had to first rely on information gathered from interviews. This required a contact in the area as well as accommodation, which was not found until February 8th, 2014. Our interviews did not begin until this time, and hence we did could not begin to develop an environmental study until enough information had been gathered to understand what was both relevant and feasible. This in turn limited the time we had to implement the study itself. The interviews proved a challenge as they were all conducted in Spanish, and more time and diligence was required on our part to ensure we understood the responses to our survey, especially during more candid discussions.

The small community size, our recognisability, and our visibility on the main highway while conducting interviews quickly made our presence known to many people, even known by name to some. Throughout the periods we were conducting our fieldwork, we were staying with an outspoken community member against the mine, and often in the company of other anti-mining community members. It is possible that some people may have assumed we were anti-mining as well, and indeed we often sensed a strong reluctance to engage in conversation from households who had visible evidence showing their connection to the mine. Some refused interviews, and this may result in our sample being weighed in favour of those against the mine.

The variation in the answers to our study questions also presents a problem, as many interviewees directly contradicted each other on many topics, dates, and events. Care had to be taken when compiling our interview results to try to gain an accurate picture of the state of affairs in the area.

Our river study was constrained by time, the inaccessibility of river sites, manpower, lack of rain, and lack of technical expertise, all of which affected our study design. Additionally, an outbreak of Hantavirus in the area during our fieldwork required us to use more consideration to reduce our risk of exposure.

ACKNOWLEDGMENT

Official acknowledgement letters should be sent to the following individuals:

1. Tania Aresemena
2. Isaías Ramos
3. Antonio Chang Kruell
4. Sonia Montenegro

The letters should be addressed to:

Urb. Los Ángeles, Calle Los Periodistas
Casa G-14 Planta Alta.
Panamá, Rep. de Panamá

We would like to extend our gratitude to Tania Arosemena, Sonia Montenegro, Isaías Ramos, Antonio Chang Kruell, and everyone at the CIAM team for sharing their resources and providing support and advice over the course of this project. The hospitality and warmth of Ernestina Saez González truly made our field visits a pleasure, and Rigoberto Martínez was invaluable in his support throughout our time in Altos de Güera. We would also like to thank Professor Michel Lapointe for his feedback from Canada.

BIBLIOGRAPHY

Alberswerth, D., & United Stated National Wildlife Federation. (1992). Poisoned profits : cyanide heap leach mining and its impacts on the environment. *National Wildlife Federation*, [Washington, D.C.].

Aragon, F.M., & Rud, P.B. (2011). Natural resources and local communities: Evidence from a Peruvian Gold Mine.

Bellhaven Copper & Gold. (2012). Pitaloza high-sulphidation Gold Project, Panama.

Bleiwas, D. I., & United States Geological Survey [USGS]. (2012). Estimated water requirements for gold heap-leach operations. Reston, Va: U.S. Dept. of the Interior, U.S. Geological Survey.

Brown, K. J. (1994). Riverbed sedimentation caused by off-road vehicles at river fords in the Victorian Highlands, Australia. *Jawra Journal of the American WaterResources Association,* 30(2), 239-250.

Carling, P. A., & Reader, N. A. (1982). Structure, composition and bulk properties of upland stream gravels. *Earth Surface Processes and Landforms,* 7(4), 349-365.

Carrington, K., Hogg, R., & McIntosh, A. (2011). The resource boom's underbelly: Criminological impacts of mining development. *Journal of Criminology.* 1-20

Chakraborty, M., Ahmad, M., Singh, R., Pal, D., Bandopadhya, C., & Chaulya, S.(2002). Determination of the emission rate from various opencast mining operations. *Environmental Modelling & Software,* 17(5), 467-480.

Conor, K., Goforth, R. (2012). Response of stream-breeding salamander larvae to sediment deposition in southern Appalachian (U.S.A.) headwater streams. *Freshwater Biology,* 57(8), 1535-1544.

Contraloría General de la República de Panama (2014).

Corredor Biológico Mesoamericano del Atlántico Panameño (2014).

Cowan, H. (2001). Design rarthquakes for the Southeast Area of the Canal Basin, Panamá. *Autoridad del Canal de Panamá*. HC-ACP-01.

Da Rosa, Carlos D., Lyon, James S. (1997). Golden dreams, poisoned streams : how reckless mining pollutes America's waters, and how we can stop it. *Washington, DC : Mineral Policy Center.*

Duda, Alfred M, and David L. Penrose (198). Impact of mining activities on water quality in Western North Carolina. *Journal of the American Water Resources Association*. 16(6), 1034-1040. Print.

Eisler, R. (2000). Cyanide. In: Handbook of Chemical Risk Assessment: Health Hazards to Humans, Plants, and Animals, Vol 2: Organics. 903-959. *Journal of the American Chemical Society, 122,* 48, 12067.

Eisler, R., Wiemeyer, S.N. (2004). Cyanide hazards to plants and animals from gold mining and related water issues. *Reviews of Environmental Contamination and Toxicology,* 183, 21-54.

Environment Canada (2013). Environmental Code of Practice for Metal Mines. *Government of Canada.*

Environmental Law Alliance Worldwide [eLAW]. (2010) Guidebook for Evaluating Mining Project EIAs, 1st ed.

Fayz, A. E. (2012). Contamination of cows milk by heavy metal in Egypt. *Bulletin of Environmental Contamination and Toxicology,* 88(4) 611-613.

Fields, S. (2001). Tarnishing the earth: gold mining's dirty secret. *Environmental Health Perspectives,* 109(10), 474-81.

Foster, I. L., & Charlesworth, S. M. (1996). Heavy metals in the hydrological cycle: Trends and Explanation. *Hydrological Processes,* 10(2) 227.

Gandásegui, M.A. (n.d.). La minería y los movimientos de resistencia popular in Panamá. Director del Departamento de Sociología en la Universidad de Panamá e investigador asociado del CELA

Garcia-Guinea, J., & Harffy, M. (1998). Bolivian mining pollution: past, present and future. *Ambio Stockholm,* 27(3), 251-253.

Government of Canada. (2014). Corporate Social Responsibility. *Foreign Affairs, Trade and Development Canada*

Greer, J. (1993) The price of gold: environmental costs of the new gold rush. *Ecologist.* 23(3), 91–96.

Griscom, H. P., Griscom, B. W., & Ashton, M. S. (2009). Forest regeneration from pasture in the dry tropics of Panama: effects of cattle, exotic grass, and forested Riparia. *Restoration Ecology,* 17(1), 117-126.

Hajkowicz, S. A., Heyenga, S., & Moffat, K. (2011). The relationship between mining and socio-economic well being in Australia’s regions. *Resources Policy,* 36(1), 30–38

Hilson, G. (2001). An overview of land use conflicts in mining communities. *Land Use Policy.* 19, 65-73

Hilson, G., & Monhemius, A. J. (2006). Alternatives to cyanide in the gold mining industry: what prospects for the future? *Journal of Cleaner Production.*14, 1158-1167.

Jamasmie, C. (2014). Panama holds $200 bn in mineral resources waitin to be mined – Government. *Mining.com*.

Keenan, K. (2010). Canadian Mining: Still Unaccountable. *North American Congress on Latin America.*

Koenig, R. (2000). Wildlife deaths are a grim wake-up call in Eastern Europe. *Science New York Then Washington.* 5459, 1737.

Korte, F., & Coulston, F. (1998). Some considerations on the impact on ecological chemical principles in practice with emphasis on gold Mining and cyanide. *Ecotoxicology and Environmental Safety,* 41(2) 119.

Korte, F., Spiteller, M., & Coulston, F. (2000). The cyanide leaching gold recovery process is a nonsustainable technology with unacceptable impacts on ecosystems and humans: the disaster in Romania. *Ecotoxicology and Environmental Safety,* 46(3) 241-245.

Kovac, C. (2000). Cyanide spill could have long-term impact. *British Medical Journal.* 320, 7245

Kuipers, J., Maest, A. (2006). Comparison of predicted and actual water quality at hardrock mines: the reliability of predictions in environmental impact statements.

Lachmar, T., Burk, N., & Kolesar, P. (2006). Groundwater contribution of metals from an abandoned Mine to The North Fork of The American Fork River, Utah. *Water, Air & Soil Pollution,* 173, 1-4.

Laitos, J. (2012). The Current Status of Cyanide Regulations. *Engineering and Mining Journal.*

La Prensa. (2012). Informes revelan que Tonosí es vulnerable a las inundaciones.

Leduc, G., Pierce, R. C., McCracken, I. R., & National Research Council Canada. (1982). The effects of cyanides on aquatic organisms with emphasis upon freshwater fishes. Ottawa: National Research Council of Canada, NRCC Associate Committee on Scientific Criteria for Environmental Quality.

McGill Research Group Investigating Canadian Mining in Latin America [MICLA]. (2014). Cerro Quema, Panama.

Midford, R., Marsden, A., Phillips, M., & Lake, J. (1997). Workforce alcohol consumption pattern at two Pibara mining-related worksites. *The Journal Occupational Health and Safety Australia and New Zealand* . 13(3). 267-274

Mining Watch (2013). Supporting Communication to the Special Rapporteur on the rights of indigenous peoples. *Submitted on behalf of the Congreso General Ngäbe Bugle y Campesino by the Justice and Accountability Project, MiningWatch Canada and Professor Daviken Studnicki-Gizbert at McGill University.*

Municipio de Tonosi (2014).

Norgate, T., & Haque, N. (2012). Using life cycle assessment to evaluate some environmental impacts of gold production. *Journal of Cleaner Production,* 53-63.

Northern Miner. (2014). More big things to come from little Panama. 100(5).

Owens, P. N., Batalla, R. J., Collins, A. J., Gomez, B., Hicks, D. M., Horowitz, A. J., Kondolf, G. M., ... Trustrum, N. A. (2005). Fine-grained sediment in river systems: environmental significance and management issues. *River Research and Applications,* 21(7*)*, 693.

Pershimco Corporate Presentation (2014). The Next Gold Producer + Copper/Gold Discovery in Panama.

Panama News (2008). 2008, año de lucha antiminera por el Frente Santeño Contra la Minería. *Spanish Opinions. 14(2)*

Petrova, S., & Marinova, D. (2013). Social impacts of mining: Changes within the local social landscape. *Rural Society*, 22(2), 153-165

Plume, R. W., Nevada., & Geological Survey (U.S.). (1995). *Water resources and potential effects of ground-water development in Maggie, Marys, and Susie Creek basins, Elko and Eureka counties*. Carson City, Nev: U.S. Dept. of the Interior, U.S. Geological Survey.

Pritsos, C. A., & Ma, J. (January 01, 1997). Biochemical assessment of cyanide-induced toxicity in migratory birds from gold mining hazardous waste ponds. *Toxicology and Industrial Health, 13.*

Ruiz de Leon, I. (Febuary, 1994). Estudio de Recurso Hídrico. ANAM Library, Panamá.

Saiki, M. K., Castleberry, D. T., May, T. W., Martin, B. A., & Bullard, F. N. (1995). Copper, cadmium, and zinc concentrations in aquatic food chains from the Upper Sacramento River (California) and selected tributaries. *Archives of Environmental Contamination and Toxicology,* 29(4), 484.

Simms, R. & Holtby, D. (2012). The Pillage of Panama: How multinational mining companies are rupturing Panama's environmental and social fabric.

Tarras-Wahlberg, N. H., Flachier, A., Fredriksson, G., Lane, S., Lundberg, B., & Sangfors, O. (2000). Environmental impact of small-scale and artisanal gold mining in Southern Ecuador. *Ambio: a Journal of the Human Environment,* 29(8) 484-491.

The Engineering Toolbox (2014). Densities of Miscellaneous Solids.

Urkidi, L., & Walter, M. (2011). Dimensions of environmental justice in anti-gold mining movements in Latin America. *Geoforum*. *42*(6), 683-695

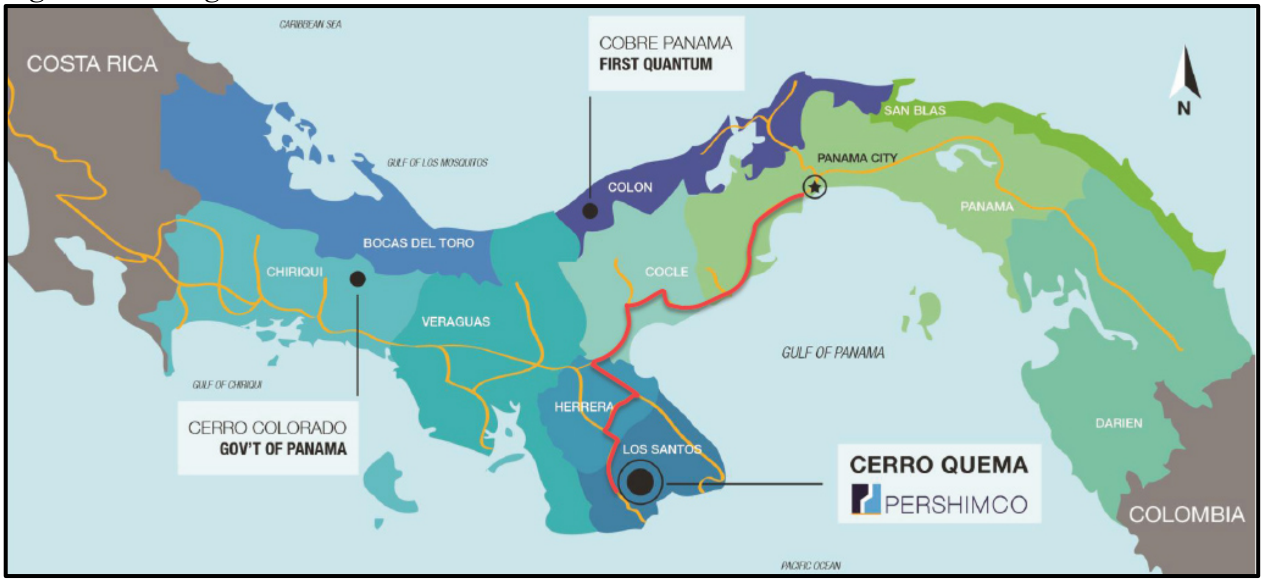
U.S. Bureau of Land Management [USBLM]. (2000). Cumulative impact analysis of dewatering and water management operations for the Betze Project, south operations area amendment, and Leevile Project. USBLM, Elko, NV.

White, D., & Schnabel, W. (January 01, 1998). Treatment of Cyanide Waste in a Sequencing Batch Biofilm Reactor. *Water Research,* 32(1), 254-257.

Yasuno, M., Fukushima, S., Shioyama, F., Hasegawa, J., Kasuga, S. (1981) Recovery processes of benthic flora and fauna in a stream after discharge of slag containing cyanide. Verhand Int Verein Theor Ange Limnol, 21, 1154–1164.

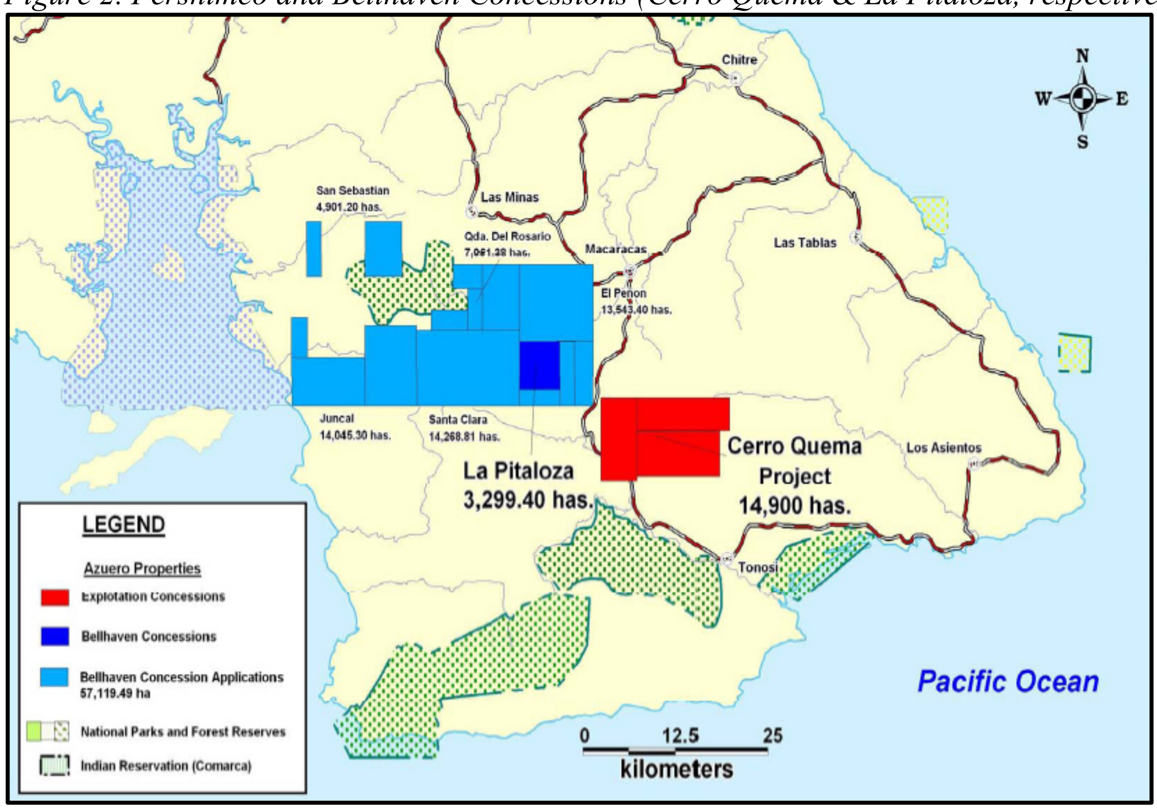
APPENDIX A. CERRO QUEMA MINING PROJECT

Figure 1. Mining in Panama



Source: Pershimco Resources, Inc. (2014)

Figure 2. Pershimco and Bellhaven Concessions (Cerro Quema & La Pitaloza, respectively)

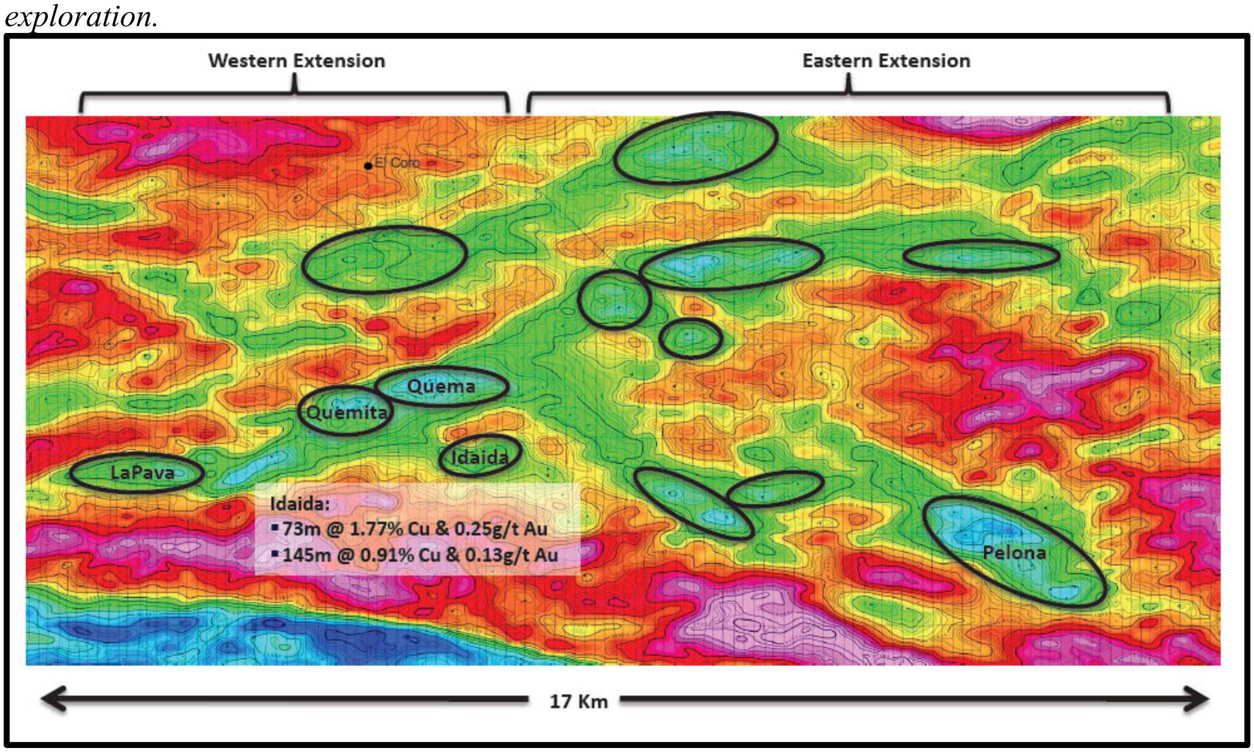


Source: Bellhaven Copper & Gold, Inc., 2014

Figure 3. Cerro Quema Project: La Pava Site

Source: Pershimco Resources, Inc. (2014)

Figure 4. Map highlighting current operation sites as well as areas of interest for future exploration.



Source: Pershimco Resources Inc., 2014

Figure 5: Mineral Resource Estimate on the Cerro Quema Property

NI 43-101 Resource Estimate

NI 43-101 Mineral Resource Summary: La Pava, Quema & La Mesita Zones (as at September 20, 2012)					
Resource Category	Au (oz)	AuEq (10) (oz)	Tonnes	Grade	
				Au (gpt)	Cu (%)
In-Pit Oxide Resources Estimate at 0.15 g/t Au Cut-Off					
Indicated	513,100	Nil	20,189,000	0.79	Nil
Inferred	50,600	Nil	4,492,000	0.35	Nil
In-Pit Sulphide Resource Estimate at 0.3 g/t Au Cut-off					
Indicated	57,000	Nil	2,750,000	0.64	0.24
Inferred 1	30,400	Nil	1,963,000	0.48	0.32
Inferred 2	Nil	76,900	1,470,000	1.63	0.86

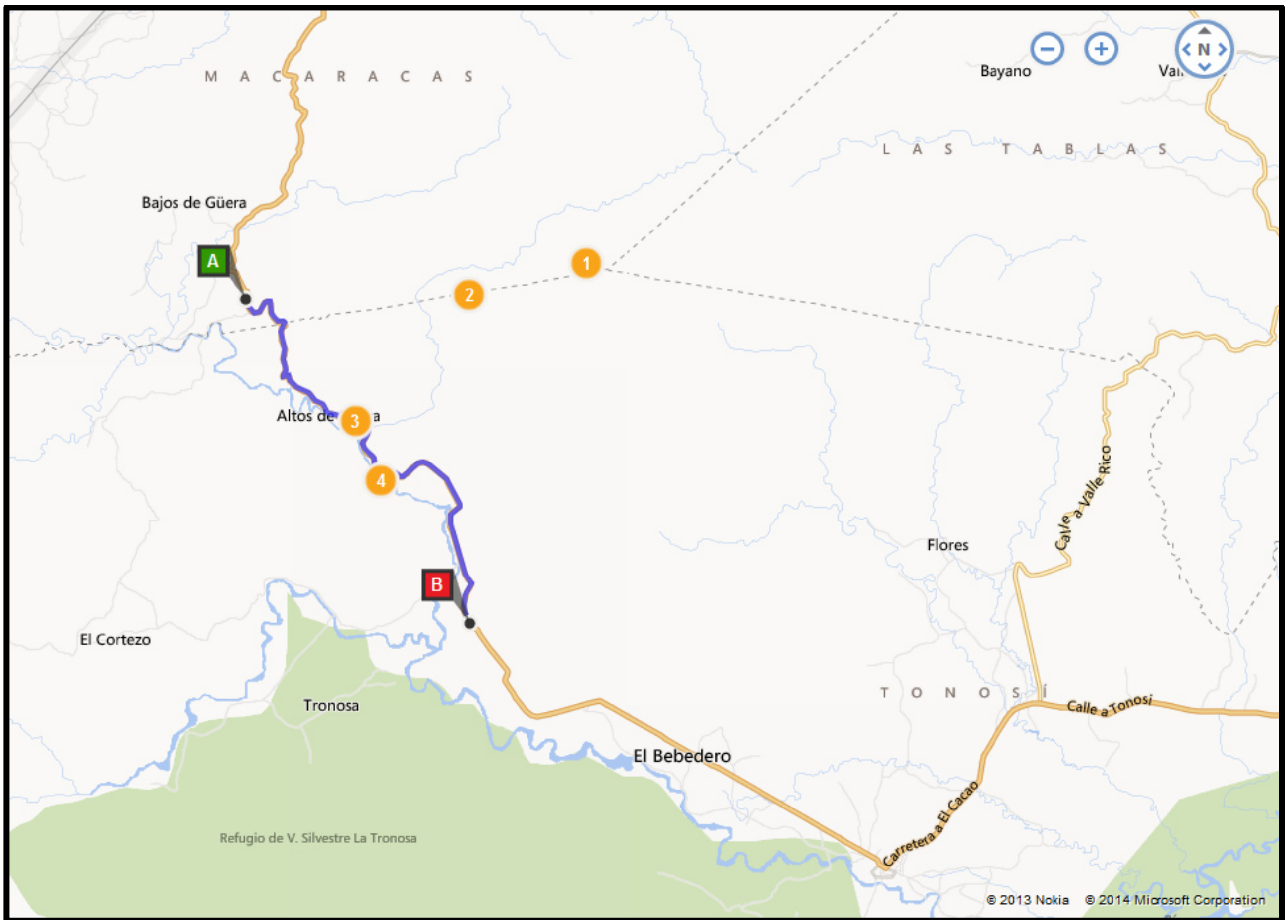
Source: Pershimco Resources Inc., 2014

Appendix B. Study Methodology

Figure 1. Carretera Llano de Piedra.

1. Cerro Quema
2. La Pava
3. Sites of sediment analysis
4. Sites of sediment analysis

a. Bajos de Güera
b. Rio Güera



Source: Google Maps, 2014

Figure 2. Sediment Study Sample Sites U1, U2, U3, D1

Source: Google Earth, 2014

Figure 3. Sediment Study Sample Sites D2, D3

Source: Google Earth, 2014

Appendix C. Survey Questionnaire

Entrevistador:
Lugar y fecha:

<u>Persona entrevistada:</u>

Nombre:

Sexo:

Edad:

Educación: ¿Cuál fue el último año que completo en el colegio?

Estado Civil:

Soltero(a) ___________ Casado(a) ___________

Sitio donde Resides:

¿Por cuantos años ha vivido en este domicilio? ¿En la Comunidad?

¿Dónde vivió antes?

Ocupación: (Marca todas las que corresponden)
Agricultura _____
Ganadería _____
Pesca _____
Comercio _____
Industria _____
Otra_____ Especifique _______________________

¿Trabaja tiempo completo? Sí_____ No_____

¿Trabaja para sí mismo? Sí_____ No______

¿Tiene empleados? Sí_____ No_____

<u>Información sobre el núcleo familiar</u>

Estado civil:

¿Cuantos niños tiene usted?

¿Cuantos están en la escuela?

Uso del Agua:

1. ¿De dónde saca el agua que consume?

____
____
____
____

2. ¿Cómo utiliza usted el río? ¿De qué manera su comunidad utiliza el río?

____
____
____
____

3. ¿Cuánta agua, aproximadamente, usa cada día? (en latas o galones)

4. ¿Hay alguna limitación para que usted use el agua?

____
____
____
____

5. ¿Tienen baño sanitario o letrina? ¿Esta dentro o fuera de la casa?

____
____
____
____

6. ¿Ha observado alguna vez agua contaminada?

Sí ____ No____

7. Si la repuesta a la pregunta anterior es sí,
¿Dónde? ¿Cuál fue el problema? ¿La comunidad reconoció el problema?

____
____
____

____
____

8. ¿Alguien experimentó cambios en la calidad del agua?

Sí ____ No____

9. Si la repuesta para la pregunta anterior es sí. ¿Este problema se arregló? ¿Cómo se arregló el problema? En su opinión, ¿qué factores causan estos cambios?
____
____
____
____

10. En su opinión, ¿considera que el agua que usa usted es buena? ¿Por qué?
____
____
____
____

11. ¿Ha oído usted hablar de problemas del agua en otras comunidades?
____
____
____
____

12. ¿Alguien ha hablado en su comunidad sobre la calidad del agua?
____
____
____
____

13. ¿Actualmente tiene preocupaciones acerca de la calidad o cantidad de agua? ¿Cuáles son estas preocupaciones?
____
____
____
____
____
___

14. Piensa que algunas de las siguientes actividades afectan la calidad del agua?
Sí ______ No_____

Coloca un "gancho" a las consideres:

La deforestación _______ La minería artesanal ______ La minería industrial ______
Los desechos humanos ________ Los desechos animales ________
Otro________ Especifique______________________

La minería CERRO QUEMA

15. ¿La empresa minera ha dado información acerca de las actividades que realiza?
____
____
____
____

16. ¿A usted qué tipo de información le han hecho llegar?
____
____
____
____

17. ¿A usted le han preguntado alguna vez sobre sus opiniones acerca del proyecto minero en Cerro Quema de alguna manera? De que manera?
____
____
____
____

18. ¿Ha asistido a reuniones de la comunidad acerca de la mina?
____
____
____
____

19. ¿Piensa que la actividad de la minería cambiaría la calidad de vida de las personas en su comunidad? Si es así, ¿cómo?
____
____
____
____

20. ¿Sabe de alguien que estaría dispuesto a trabajar en la mina?
____
____
____
____

21. ¿La compañía encargada de la mina ha apoyado algún proyecto comunitario? ¿Cuál?

22. ¿A favor o en contra de la mina?

Favor _______ Contra _______ No sabe__________ No respondió_________

23. ¿Piensa que la minería afectará su modo de vida?

24. ¿De qué manera se afectaría?

25. ¿Conoce los daños al ambiente que podría causar la minería?

26. ¿Sabe usted si la compañía encargada de la mina ha tomado acciones para disminuir los impactos sobre la naturaleza?

27. Le gustaría aprender más sobre los impactos ambientales de la minería a cielo abierto?

28. ¿En su opinión, cuales son los asuntos o problemas más importantes de su comunidad? No es necesario que estén relacionados por la mina.

Appendix D. Tables and Charts of Study Findings

Table 1. Level of Education Attainment

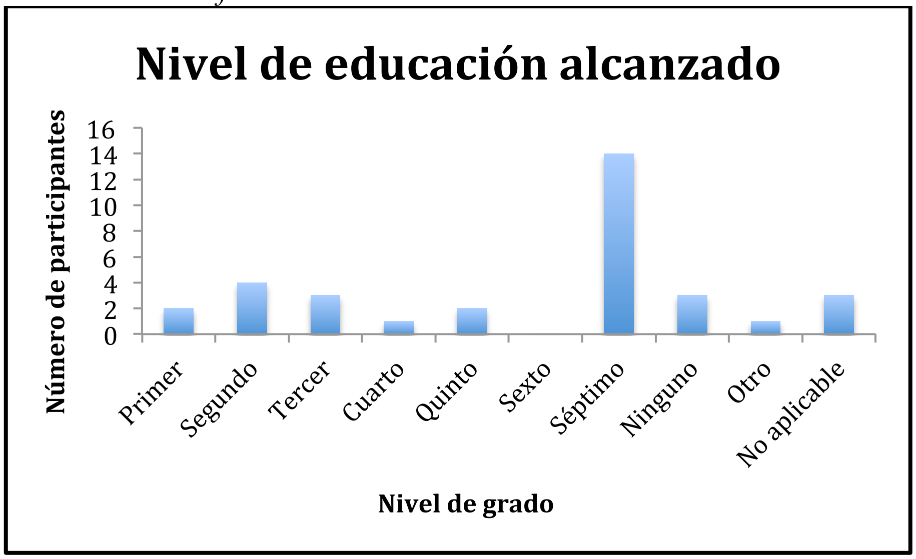


Table 2. Activities Affecting Water Quality

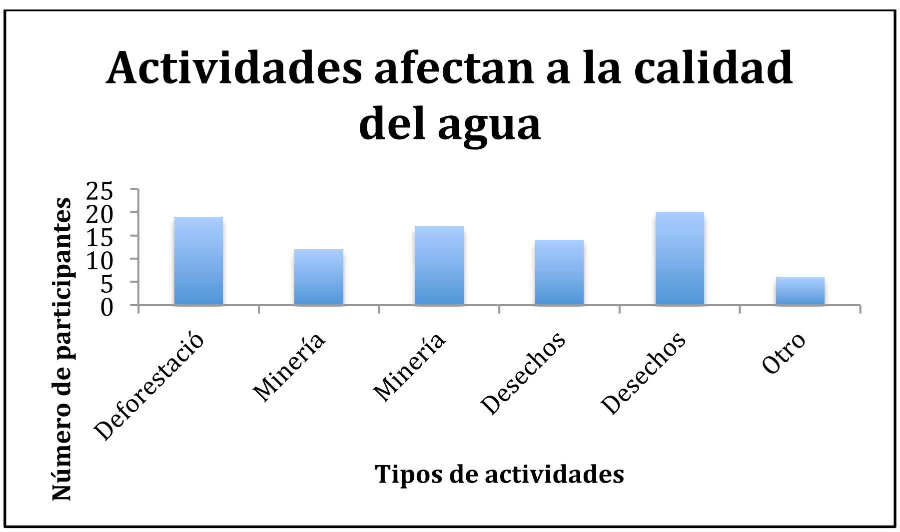


Chart 1. Local Opinions of the Cerro Quema Mining Project

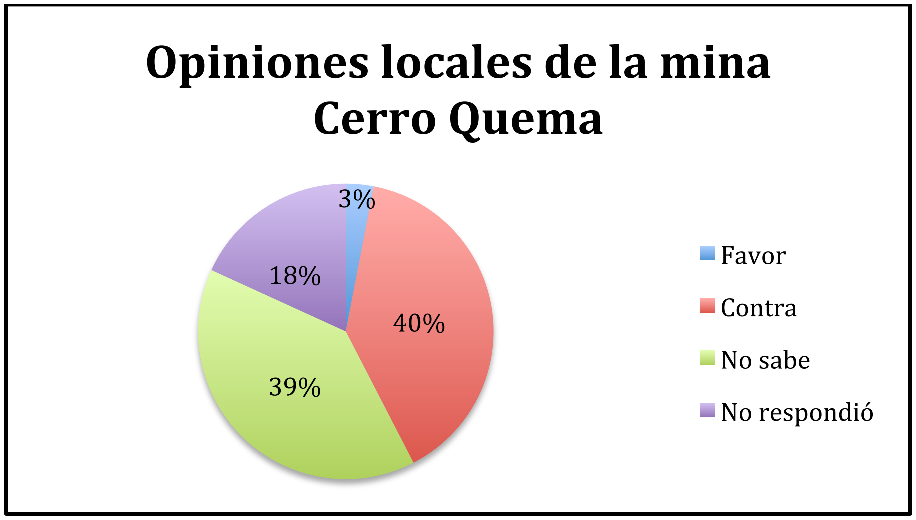


Figure 1. Graph comparing the percentage weight of sediment <250µm in all samples

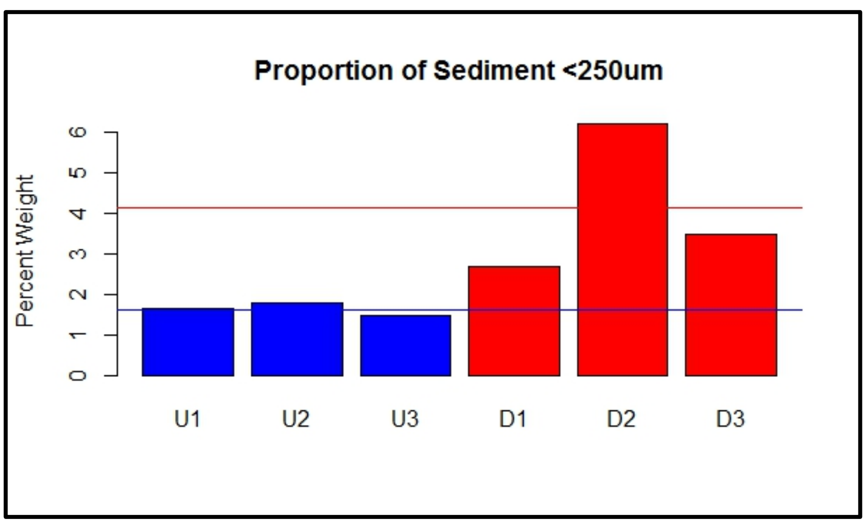


Figure 2. Boxplot comparing percent weight of sediment <250µm between upstream and downstream samples

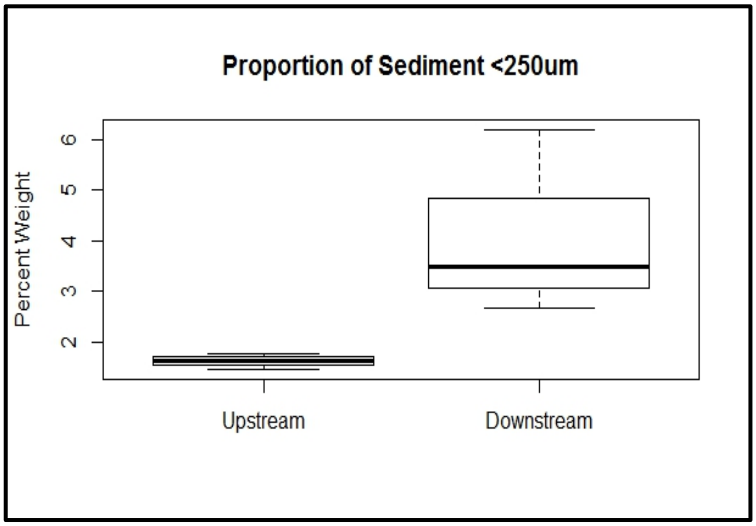


Figure 3. Graph comparing the percentage weight of sediment <68µm in all samples

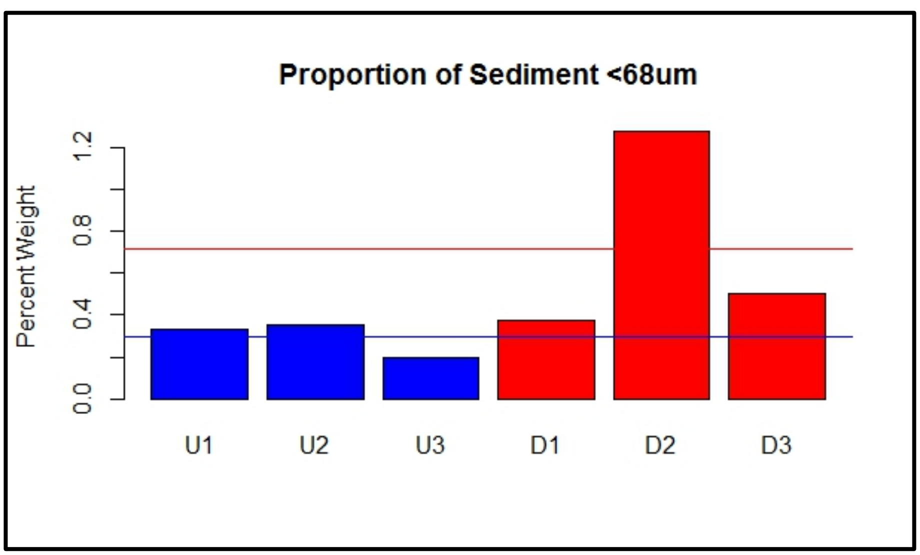


Figure 4. Boxplot comparing percent weight of sediment <68µm between upstream and downstream samples