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Artisanal Gold, the Mercury Problem, and Some Ideas on How to Fix It

Kevin Telmer

Caption: Small scale gold mining using mercury and cyanide in North Sulawesi, Indonesia, 2007. The photograph shows a miner measuring out 1 kg of mercury to be used to amalgamate ore in a ball mill before sending the slurry on to be leached by cyanide. To produce the ore miners dig as deep as 50 meters and many are injured or killed by collapsing tunnels. The ore is put into sacks and transported a short distance to processing facilities. There, it is ground and amalgamated with mercury to recover typically around 30% of the gold to pay immediate daily costs. A raw gold product is recovered by heating the amalgam and releasing the mercury to the atmosphere. The remaining slurry is collected into 20 ton vats over the course of a week to a month and then leached with cyanide for 3 days to allow the rest of the gold to be absorbed onto activated carbon pellets. The carbon also absorbs plentiful residual mercury. To recover this gold, the carbon is burnt producing an ash and also releasing any absorbed mercury into the atmosphere. The ash is often again amalgamated with mercury to separate the gold from other ash constituents. This amalgam is similarly heated releasing more mercury to the atmosphere. Additionally, the waste stream from this process is rich in mercury-cyanide complexes which very likely enhance mercury transport, bioavailability, and evasion to the atmosphere (latent atmospheric emissions). In fact, very little is published about mercury-cyanide chemistry, but clearly there is strong reason to be concerned about combined mercury-cyanide ore processing, an increasing trend in small scale mining around the world. There are solutions but they involve a complicated mix of community socio-economics, environmental stewardship, technology adaptation, and policy development, and so far no government has been able to develop a viable and sustainable approach that works for the miners. But awareness and interest has grown and therefore so has the chance for an innovative breakthrough. This report recommends some new and innovative potential solutions to the mercury problem for the ICMM to evaluate.

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For the ICMM Material Stewardship Task Force

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LEGEND: ASGM: Artisanal and Small Scale Gold Mining; **LSGM:** Large Scale Gold Mining; **Member:** a member of ICMM; **Partner:** A management agency with technical expertise; **IGO:** International Governmental Organisation such as UN; **NGO:** Non-Governmental Organisation, can be international (e.g. NRDC) or local; **GO:** governmental organisation such as USEPA or a Ministry (Mining or Finance or Environment, etc.)

Preface

This document has four parts: (1) an introduction including the document's purpose; the relationship between mercury and the larger ASM issue; the overarching approach to the actions recommended; the context of the issue for the public; and a background section on mercury use, reduction scenarios, and other intervention efforts; (2) a list of seven potential actions for local to regional solutions, how they could be initiated, what role ICMM or its members might play, and what synergies might occur with other intervention efforts; (3) two potential actions to create global solutions and what role ICMM or its members might play; and (4) appendixes containing more detailed information. Parts 1 through 3 are 24 pages in length; Part 4 is an additional 183 pages and cites more than 100 literature references.

1 Introduction

1.1 Purpose

The purpose of this report is to discuss what might be done to accelerate ASGM's transition into a low mercury emission industry and into an economically and environmentally sustainable activity that fits into formal economies and societies. The actions to do so are outlined in nine recommendations on how to intervene in Artisanal and Small Scale Gold Mining (ASGM).

1.2 Getting Mercury Right = General ASM Success

The primary aim of the recommended actions in this report are to reduce mercury emissions from ASGM; however, in addressing mercury, relationships are built, and progress is made on many other socio-economic issues involved in ASGM. For this reason, fixing the mercury problem can be a focussed and cost effective entry point for also achieving other less specific intervention goals with ASGM communities. Getting mercury right, therefore, is a strong indicator of general success in ASGM intervention.

1.3 Approach

Asking miners to change their behaviour in a regressive way that induces a pay cut has been a universally unsuccessful approach in ASGM intervention yet it remains a common defect, albeit one not always recognized, of many efforts. Although they have been few, interventions where better environmental practices have come along with increased profits have thrived, and so this is the primary approach recommended here – ***"better practices that bring increased profits"***.

The field based recommendations given here are formed of a leading action that can be begun immediately in order to galvanize progress and to build relationships and communication bridges between the ASGM and the LSGM community and the public in general. This approach is an ***"Engagement-Based Risk Mitigation Strategy".*** It works by using on the ground actions to develop a functioning relationship with miners, provide communication and information, and facilitate the development of a long term blueprint. It is an adaptive approach that evolves, filters out false stakeholders, and allows governments and companies to participate in leading the development of the blueprint following the voluntary principles. This is an important first step that provides the information needed to feed the development of appropriate policies – it brings the ASGM community into the multistakeholder process. This is in recognition that ASGM communities already have a sophisticated system of organisation that must be built upon rather than uprooted and replaced by external concepts. Previous intervention efforts that have ignored this have failed.

The recommendations also aim to (i) avoid long term dependencies on direct subsidies since the problem is a long term one, and (ii) use Large Scale Gold Mining (LSGM) standards and the voluntary principles or movement towards them as a measure for success. This is in recognition that the standards of ICMM members have evolved through a multistakeholder process and will continue to do so, and therefore already contain considerable value.

1.4 Context

This section provides a variety of relevant contextual material useful for evaluating ASGM and potential solutions to the mercury problem.

ASGM and its Broad Relationship to Society

The breadth of society that interacts with Artisanal and Small Scale Gold Mining (ASGM) is much broader than is generally recognized. This will likely change as branding and ethical investing/consumption become more main stream. Linkages and comparisons between large scale gold miners (LSGM) and ASGM are likely to be increasingly scrutinized in the coming years. Some reasons for this are that: (i) of all existing gold (about 135,000 tonnes), minimally 5% is ASGM in origin (about 6750 tonnes), and (ii) current ASGM annual production is estimated to be around 12% – larger than any single producer. If gold branding becomes important, then the origins of gold traded on the market and of that in storage will become important.

Understanding the relationship between large and small scale gold miners is complicated because it involves both environmental stewardship (e.g. mercury emissions) and socio-economic development (e.g. poverty relief) and the lines between the two are drawn differently by different constituencies. Currently, there are many different approaches taken to evaluate the role of small and large scale gold miners in society by various local, national, international, industrial, governmental, and non-governmental bodies. This is further discussed in the background section and in the appendix on case studies.

Risk Mitigation

Companies caught in conflict with artisanal miners face three risks: loss of profit; loss of local and international legitimacy; and loss of shareholder confidence. Ignoring the presence of artisanal mining is not always possible, and does not necessarily mitigate risk. The March 2006 Citigroup report advises that a company's sustainability profile is not an externality. Businesses that place a premium on environmental and social progress are more likely to have long-term growth, and therefore make more reliable investments for shareholders.

Risks of Inaction

Conflict between small-scale and large-scale miners is a growing source of risk in many countries. Once miners have entered an area, there are few ways to remove them. Sustained conflict can incapacitate mining operations, leading to loss of legitimacy, confidence, and profits. The central tenet of this document is that risks can be minimized by taking a proactive approach to the presence of miners. Such actions will strengthen companies by reducing risk, while setting a global standard for relations with small-scale miners that will improve social license to operate around the world.

Ineffectiveness of Security Sector Responses

When artisanal gold has been discovered, there is little that can be done to stop artisanal miners from exploiting it. There is no recorded case of a gold rush ever being pushed back. The reliability of the gold market and low barriers to entry make artisanal gold mining too attractive to discourage. Sweeps conducted by the security sector — often used in the past to remove miners from company concessions — have no long-term benefits. As they have done through history, shortly after being forced out of an area miners return, rebuild settlements, and conditions revert to the way they were, with the exception that relationships have worsened.

Voluntary Principles

The Voluntary Principles acknowledge:

- security is a fundamental need, shared by individuals, communities, businesses, and governments alike
- companies operating globally face difficult security issues
- security and respect for human rights can and should be consistent
- the effect that Companies' activities may have on local communities
- there is a need to mitigate any potential conflict where possible
- the value of engaging with civil society and host and home governments to contribute to the welfare of the local community
- the need to safeguard the integrity of company personnel and property
- companies should act in a manner consistent with the laws of the countries within which they are present
- companies should be mindful of the highest applicable international standards
- companies should promote the observance of applicable international law enforcement principles (e.g., the UN Code of Conduct for Law Enforcement Officials and the UN Basic Principles on the Use of Force and Firearms by Law Enforcement Officials), particularly with regard to the use of force;

Security Forces (Police and Military)

In many cases the police and military are de facto stakeholders in ASGM operations. They can be involved in the supply chain of goods and in the trade of gold and mercury. Trying to influence the military or police involved with ASGM is potentially risky to companies. This is clearly illustrated by the example of Koba Tin who was shut down when they attempted to work with illegal miners (Appendix 5). The recommendations given here attempt to provide solutions that do not need to directly involve the police or military because, in general, altering the dynamic with security forces can only be done by first performing a careful assessment, and exerting influence through high level diplomatic channels such as bilateral aid initiatives for security sector reform and this is beyond the scope of this document.

ASM and Poverty Alleviation

According to the Mining, Minerals, and Sustainable Development Report (MMSD, 2002), "Artisanal gold mining will persist for as long as gold mining drives it." Artisanal gold mining exists wherever gold is the highest value cash crop available. Usually, when it appears, ASGM becomes the central economic activity in a region, and provides alternative livelihoods for people who might otherwise be unemployed or suffering extreme poverty. When there are long-term gold deposits that will take decades to deplete, ASGM has the potential to contribute to local capital development and be a source of poverty alleviation (Pedro, 2002).

1.5 The Role of ICMM and/or ICMM Members

In most regions where ASGM is occurring, the ICMM members' field, technical, financial and logistical capacities, and even in many cases their interactions with local communities, significantly outweigh those of government or international government organisations. As well, the presence of companies (members) in an area typically lasts a decade or more – much greater than the time frame of most government or donor based programs. And, at a national and international level, through its professional network of industry and government partners and associations, ICMM can bear an influence on multistakeholder discourse.

This gives ICMM and its members, relative to agencies that start from scratch and do not have as significant a stake in the problem, a unique low cost opportunity to support and galvanize actions to resolve the mercury problem and other ASGM issues at the local through to the international level, and in doing so, build reputation and reduce risk. The recommendation in this document for ICMM and its members is that they fund both directly and indirectly (through in-kind logistical support), appropriate agencies and existing synergistic programs to implement the recommended actions to reduce the mercury problem in ASGM. Specific roles for ICMM and its members are given at the end of each recommended action. All of the participation recommended for ICMM and its members can be carried out through a multi-stakeholder process – one that might typically involve an IGO like UNEP or CASM, an NGO like NRDC (Natural Resources Defence Council), a GO like a regional or national environmental or resource agency, and local field partners which may be comprised of local NGOs, consultants, and miners.

1.6 Background on ASGM and Mercury Use

1.1.1. Global Trends and Emission Reduction Scenarios

ASGM is currently practiced across a vast geographical area (70 countries) under diverse cultural, political, economic, and physical settings. It generally operates in the informal economic sector, often illegally, and under various levels of organization. The miners have little or no capital yet it is an essential source of wealth. Many different mining techniques are used but most use mercury to process ore – an international environmental concern highlighted by the United Nations Environment Program (UNEP). However, generally, ASGM is poorly understood by international and national government bodies, industry, and many other stakeholders.

It is estimated that artisanal and small scale gold mining releases between 650 to 1350 tonnes of mercury per annum into the environment, averaging 1000 tonnes/a, from at least 70 countries (appendix 2; www.hgwatch.net). 350 tonnes/a of this are directly emitted to the atmosphere while the remainder (650 tonnes/a) are released into the hydrosphere (rivers, lakes, soils, tailings). However, a significant but unknown portion of the amount released into the hydrosphere is later emitted to the atmosphere when it volatilizes (latent emissions). The rate of latent emission is unknown but is particularly high where mercury is used in combination with ***cyanide processing*** – a growing trend. Considering that ASGM is growing, and the use of cyanide in ASGM is growing, and the production of mercury contaminated waste from ASGM is growing (multi-year accumulation of tailings), latent emissions conservatively amount to at least 50 tonnes/a bringing the total emission of mercury to the atmosphere from ASGM to 400 tonnes/a. This is second only to coal burning.

Emission reduction scenarios are as follows: (i) if miners adopted emission control measures (fume hoods and retorts) mercury consumption globally could be reduced by 30%; (ii) learning how to re-activate or clean used mercury for re-use could reduce mercury consumption by 25%, and (iii) elimination of whole ore amalgamation[1] could reduce mercury consumption by 35%. If all three of these approaches were adopted, mercury consumption by ASGM globally could be reduced by 96% (from 1000 to 40 tonnes/a; this is greater than 90% because it includes capturing and recycling mercury from former whole ore amalgamation operations that have transformed), direct emissions to the atmosphere could be reduced by 90% (from 350 to 35 tonnes/a), and losses to tailings, rivers, lakes and soils, could be reduced by 99.2% (from 650 to 5 tonnes/a). The latter would also lead to reduced latent emissions to the atmosphere.

To put this into perspective: if the top 10 countries using mercury in ASGM, were just to adopt fume hoods and retorts and learn how to re-activate mercury, then roughly 500 tonnes less mercury per annum would be consumed. In other words, basic emission control and mercury recycling technologies (both shown to be profitable to ASGM) can reduce mercury consumption by 50% and lower emissions to the atmosphere by around 90%.

However, the elimination of whole ore amalgamation, the practice that uses the most mercury, although it is more complicated to eradicate due to the need to re-organize labour practices, must also remain a focus. This is because the current trend is that this practice is increasing and worse it is increasingly being combined with cyanide processing – a significant environmental concern and a significant reputational concern to the LSGM community. For every 10% of the operations that convert away from whole ore amalgamation, 50 tonnes less mercury would be consumed per annum.

The above are maximum reductions. Realistically, by working towards the three approaches (emission control, recycling, and elimination of whole ore amalgamation) through innovative intervention efforts such as those recommended in this report, a 50to 60% reduction in mercury use in ASGM could be achieved on a time scale of 10 years. This is reasonable particularly because the emission control and recycling have been effectively demonstrated to be profitable to artisanal miners and small scale gold merchants – an important criterion for sustainable change in ASGM.

1.1.2. Some important statistics on ASGM

Scale and Economy of ASGM

- 330 tonnes/a of gold from 70 countries
- 9.6 billion USD/a at 900$/ozt; 5.3 billion USD/a at $500/ozt
- 10 million miners (3 million women and children)
- Annual income (2008) is $960/miner - unevenly distributed
- Secondary economy is perhaps 50 million people at 50 billion USD/a
- This is roughly 2 times the population of Canada at a GDP PPP 40 times lower

[1] Whole ore amalgamation is an ore processing method in which mercury is brought into contact with 100% of the ore rather than with only a *concentrate* (a fraction of the total ore that has been pre-processed). In terms of mercury consumption and emission to the atmosphere, it is the worst practice.

Ecometrics: Consumption/Emission Intensity ASGM vs. LSGM

- ASGM is more energy efficient (joules/unit gold)
- ASGM releases less greenhouse gasses (CO2e/unit gold)
- ASGM produce less waste rock and tailings per unit gold
- ASGM releases 5 times more mercury in total
- ASGM releases 40 times more mercury per unit of gold produced
- Those ASGM who use cyanide (CN) use about twice as much per unit of gold
- ASGM do not practice waste management

Remaining ASGM Gold Resource

- LSGM resource is 50,000 tonnes of gold (USGS, 2007)
- No equivalent estimate of the ASGM resource
- Using 12% of world production (current rate) as a proxy, the ASGM resource would be around 6000 tonnes gold
- This would last for 18 years and would use 18,000 tonnes of mercury under current operating conditions
- The true ASGM resource may be significantly larger
- A better estimate is possible using geological evidence and grade and depth distribution models

1.1.3. Why mercury is used

Mercury is used in ASGM for the following reasons:

1. Mercury use is very easy – the easiest and quickest method to extract gold from many alluvial ores under the existing field conditions. This is sometimes debated by those who have not spent much time in the field, but it is a verity. A simple way to look at this is as follows. In a case study by Telmer and Stapper (2007), the effective ore grade (what is recoverable by the miners) was about 0.1 g/tonne; the miners processed about 100 tonnes of ore per day to produce a gravity concentrate of 10 kg of ore. This represents a concentration factor of 10,000 times. The 10 kg of concentrate contains 10 g gold and so miners need to further concentrate by 1000 times. This can be done by manual gravity methods (like panning) but will require significant time and will lose some gold (particularly the finer fraction). Recreational artisanal miners in Canada often spend 2 or more hours panning up their concentrate. On the other hand, capturing the gold by amalgamating the concentrate takes about 10 minutes and produces more gold. Therefore simply put, in many ASGM sites, amalgam processing produces more gold in less time.
2. Mercury is very independent – the whole mining process can be accomplished by just one person if required, thereby eliminating the necessity of participating in undesirable and unfair labour practices (there is no need to be indentured). Often in more mature ASGM sites the bottom of the labour pool are still indentured to middle men or “a syndicate”, but even so, their salaries are inevitably higher than those from their former occupation, and they always have the chance to strike it rich and the choice to strike out on their own – an important and desirable psychological condition for many people.
3. Mercury is highly effective at capturing gold under the conditions found in ASGM sites. Again, the verity of this statement is occasionally debated by academics but under the circumstances found in ASGM sites, it is indisputably true. That is not to say it is technically always the “most” effective method to capture gold, but it can often be the “optimal” method under the socio-economic and political conditions found in ASGM sites. For example, in the first point (#1) above, a centrifuge or other technology may be more effective than mercury, but at what cost? And what infrastructure is needed to operate it? Often costs and infrastructure are

prohibitive. This is particularly true when operations are illegal, which is most of the cases. Who is going to risk significant investment into an illegal operation?

4. Mercury is typically very accessible – it is as portable and easy to transport as gold and so moves across borders and into camps as easily as many other contraband materials. The current record is that eliminating mercury through local enforcement has never been successful. In fact it often has a detrimental effect. For example, in Indonesia, mercury was made illegal in 2006. This drove mercury trade underground creating more corruption and doubled the price paid in the ASGM sites but did nothing to stem the flow of mercury – in fact it made selling it more lucrative for merchants.
5. Mercury is *relatively* very cheap, as explained through the following perspective:
    - As of Jan 22, 2008, prices were: mercury (US$600/76 lb flask; US$17.40/kg); gold (US$874.00/ozt) – similar to prices in September, 2008.
    - This is close to historical highs for both mercury and gold.
    - Therefore 1g mercury = US$0.017; and 1g gold = US$28.10
    - The mercury: gold price ratio is therefore 1:1,650
    - If 2 units of mercury were used to produce 1 unit of gold, the cost of the mercury would represent 0.1% of revenue. An invisible amount.
    - In the mine fields, the price paid for gold is less than the international price, typically 8 to 10 % less (~US$25/ozt) and the price paid for mercury is higher, particularly where it is illegal making gouging by suppliers easier. Some miners have reported paying as high as US$200/kg (US$0.20/g) (Creporizão, Brazil). Under these prices the cost of using 2 units of mercury to produce 1 unit of gold represents a mercury: gold price ratio of 1:125 or 0.8% of revenue – still remarkably cheap.
    - However, it should be noted that despite the significant difference in mercury and gold prices, mercury can still be a significant cost for the lowest paid labourers and for those who deal in large quantities of mercury – often gold dealers. Therefore mercury price increases are an incentive to conserve mercury (e.g. use it less wastefully and capture and recycle it).
6. Miners are not always aware of the health risks that mercury poses. Appendix 1 contains images that illustrate this – people carelessly exposing themselves to mercury.
7. Miners have no choice – in many cases miners are not aware of alternatives if they do exist, or more commonly do not have the capacity to practice them.
8. Mercury is most commonly used when simple gravity methods cannot produce concentrates greater than 10-20% gold. This is true of many simple hydraulic sluicing operations and many shallow colluvial or hard rock operations. If a concentrate of 20% can be produced, then direct gold smelting is possible but this is rare.
9. Mercury is used when capital (cash) is needed quickly for subsistence or to purchase materials and supplies required for more sophisticated techniques like leaching with cyanide. This point is often a difficult one for citizens of developed nations to fully grasp. The miners – even the middle men – do not have bank accounts or credit cards or much, if any, access to social assistance like health care, and therefore often cannot wait to get paid. For example, miners who have made the transition to cyanide leaching and whom know that the maximum gold can be obtained through cyanide leaching alone, often return to using mercury when an emergency such as a family illness or wedding comes up, simply because they cannot wait for the more time consuming, albeit more efficient, cyanide processing method to be completed. This is often a 1 month cycle.

In summary, using mercury is cheap, simple, fast, independent, and reliable. And so in many settings, it is hard to beat. That is why, as a first line of intervention, it may be more appropriate to try to reduce mercury consumption through conservation practices like retorting, fume hoods, and mercury re-activation or cleaning (making dirty mercury usable again and thereby preventing it from being discarded into the environment), rather than immediately aiming for the total elimination of mercury use. The introduction of conservation practises as discussed above can easily reduce mercury consumption by 50 to 90% and it is an easily accepted change in practice – one that can even have the powerful incentive of being profitable.

1.1.4. How mercury is released to the Environment

Mercury is released to the environment during artisanal gold mining in a variety of ways. When it is used to amalgamate gold, some escapes directly into water bodies as elemental mercury droplets or as coatings of mercury adsorbed onto sediment grains. The mercury that forms the amalgam with gold is emitted to the atmosphere when the amalgam is heated – if a fume hood or retort is not used. As well naturally occurring mercury in soils and sediments that are eroded by sluicing and dredging becomes remobilised and bioavailable in receiving waters. Finally, where a combination of cyanide and mercury are used, the formation of water soluble cyanide-mercury complexes enhances transport and bio-availability. Albeit the fate of mercury in any of these processes is poorly understood, the interactions of cyanide and mercury are the least understood at this time.

- **Whole ore amalgamation.**

Whole ore amalgamation is the process of bringing mercury into contact with 100% of the material being mined. Typically, mercury is either added when the ore is being ground in mills or the slurry produced from grinding is passed over a mercury coated copper plate. Amalgamating the whole ore uses mercury very inefficiently and so between 3 and 50 units of mercury are consumed to produce 1 unit of gold, with an average of around 5. Most of the mercury loss during whole ore amalgamation initially occurs into the solid tailings which are often discharged directly into receiving waters and soils. Importantly, however, it is well documented that this mercury continues to evade into the environment for centuries (Alpers and Hunerlach, 1999; Al et al., 2006; Shaw et al. 2006; Winch, 2006). Further, although little studied, it is certain that mercury in tailings that are subsequently leached with cyanide to recover more gold (a growing trend already observed in 10 countries) undergoes enhanced aqueous transport and emission to the atmosphere. This is because of the complexation of mercury by cyanide. It is well known that mercury and cyanide, like gold and cyanide, readily form soluble complexes, and that when cyanide-mercury complexes degrade, mercury readily volatilizes.

- **Amalgamation of a concentrate**

In cases where only a gravity concentrate is amalgamated, losses are normally about 1 to 2 units of mercury for each unit of gold produced, but can be significantly lower if a mercury capturing system is used when the amalgam is burnt – retorts or fume hoods. For example, if 1.3 g of mercury is consumed to amalgamate 1 g of gold from a gravity concentrate produced by sluicing alluvial ore, typically 0.3 g of mercury would be discharged to water with the tailings and 1 g of mercury would be emitted to the atmosphere when the amalgam is burnt.

- **Fate of Tailings**

Sometimes the tailings of ASGM are rich in other minerals such as zircon which are valuable to the ceramics and abrasives industries and so the tailings are not discarded but rather are further processed and then export (often to China or Korea). During reprocessing the tailings are often amalgamated a second time to recover any residual gold, and then further processed to produce (i) a high grade heavy mineral concentrate which is contaminated in mercury and export, and (ii) a waste which is discarded. The mercury that is export with the zircon is emitted to the atmosphere during later industrial use (when it is heated). The fate of the mercury in the residual waste varies and may end up in aggregate products such as bricks or be discarded into local waterways. As well, mercury contaminated tailings in old ASGM camps that inefficiently processed ores are now being re-worked, often through cyanide leaching.

- **Dirty Mercury**

An additional cause of mercury pollution that is frequently overlooked is the discarding of "dirty mercury". When ore is amalgamated with mercury the products are (i) solid amalgam; (ii) tailings; and (iii) residual liquid mercury. For example, a miner may add 100 g of mercury to 10 kg of concentrate and then recover 20 g of amalgam (50% gold, 50% mercury), and 87 g of residual liquid mercury with 3 g lost to the tailings. They would then re-use the residual liquid mercury to amalgamate the next day's concentrate. However, the effectiveness of the liquid mercury is reduced as it becomes oxidized and contaminated with impurities – this is referred to as "dirty mercury". Typically, after 3 or 4 uses, mercury becomes much less effective at amalgamation and so it is discarded. In many cases miners just throw it into the river. This causes mercury consumption to be higher than, for example, the 1.3 units of mercury for every 1 unit of gold described above. When mercury is not recycled through re-activation (described in the final section), consumption is likely to be at least twice the ratio established by recording only the immediate losses that occur during amalgamation. This practice is unnecessarily wasteful and costly. It can be entirely prevented by re-activating mercury with a simple electrochemical cell made of a 12 volt battery, copper wire, table salt and water for a cost of less than $10.

- **Mercury and Cyanide**

Immediate emissions to the atmosphere during whole ore amalgamation occur when the recovered amalgam is heated to produce the gold. In the simplest case, such as the use of mercury coated copper plates, immediate losses to the atmosphere are therefore roughly equal to the amount of gold produced. However, there can be significant additional emissions to the atmosphere and into waterways on a time scale of weeks to years from tailings – in particular from operations that employ cyanide. For example, in a whole ore amalgamation operation like those in Indonesia documented in Sulaiman et al. (2007), if 20 g of mercury are consumed to produce 1 g of gold, then 19 g of mercury are lost to the tailings and 1 g of mercury is immediately emitted to the atmosphere from amalgam burning. However, additional mercury is released to the atmosphere shortly thereafter from: (i) volatilization from cyanide rich tailings; (ii) during cyanidation gold is adsorbed from the solution by activated carbon. Mercury is also unavoidably adsorbed. To recover the gold, the carbon is burnt and so any adsorbed mercury is emitted at that time; (iii) the "ash" produced by burning the activated carbon is often re-amalgamated with mercury and this amalgam is also thermally decomposed to produce the gold, releasing an additional amount of mercury to the atmosphere equal to the total gold produced. In such cases, immediate emissions to the atmosphere are minimally greater than the total gold produced and this includes the amount of gold produced via cyanide leaching. Emissions to waterways and the atmosphere from tailings are likely significant but unknown.

1.1.5. Where ASGM is Occurring

There is reasonably good information about where ASGM is occurring. The Information sources are: reports from the MMSD (2002); 16 years of archives from the Northern Miner (1992-2008); reports and conference materials from the World Bank's Secretariat on Communities and Small Scale Mining (CASM, 2007) up to 2007 (7 meetings); 5 years of reports and conference materials form the UNDP/GEF/UNIDO Global Mercury Project (GMP) up to 2007; reports from other intervention programs such as the Swiss Development Agency (SDA), the Canadian International Development Agency (CIDA), the World Wildlife Fund (WWF); reports and abstracts from the International Congresses on Mercury as a Global Pollutant (ICMGP) up to 2006 (8 congresses); numerous articles published in the peer reviewed literature; and personal communications with field operatives of intervention programs and people employed in the ASGM economy – miners and gold and mercury merchants.

Table 1 in Appendix 2 lists the countries and column 3 of Table 1 lists the sources of information that identify the presence of ASGM by country. As well, this table can be queried electronically at www.hgwatch.net. According to these sources of information, ASGM has been documented to occur in 70 countries. There are at least 6 more countries that are likely to have ASGM occurring bring the likely total to 76 countries.

1.1.6. Amount of Mercury Used in ASGM

Amounts of mercury consumed in ASGM can be determined primarily in 5 ways.

1. Direct measurements – using a balance to directly weigh amounts of mercury used.
2. Applying a mercury: gold (Hg:Au) ratio based on the style of operation (gravity concentrate or whole ore amalgamation) to estimates of gold production.
3. To get to number 2, estimate the number of miners actively mining and their average gold production.
4. Interviewing miners and gold merchants who buy or sell mercury.
5. Official trade data.

The first four approaches involve directly working with miners and gold merchants and gaining their trust.

Unfortunately, there is very little high quality information on amounts of mercury, size of operations, and what styles of operation are in use around the world in ASGM sites. Much of what exists is anecdotal. In part, this is because of ASGM's highly decentralized and remote nature and because it often exists outside the law. Specifically: (i) there has been a lack of interest from governments about ASGM because miners are marginal citizens – they do not pay tax, do not vote, do not have permanent homes, etc.; (ii) miners are subjected to gold price cycles and gold rushes and unfair labour practices and so are very migratory and dispersed; (iii) many ASGM sites are in remote areas where there is no infrastructure and therefore no information; (iv) many clandestine (illegal) activities are involved in ASGM such as money laundering, tax evasion, weapon acquisition, etc., making it sometimes difficult to access miners and making the quality of information they provide sometimes questionable; (v) miners and mining and the use of mercury are often prohibited – perhaps more than 90% of all miners are operating in illegal ways.

However, by triangulation using a set of independent evidence, an estimate of mercury use and gold production in ASGM, the most robust to date, has been made. Accordingly, mercury use ranges from 650 to 1350 tonnes/a averaging 1000 tonnes/a and gold production is estimated at 330 tonnes/a. See appendix 2 for more details.

1.1.7. Reported Trade in Mercury and Gold

In ASGM, mercury consumption (mercury purchased) is equal to the amount of mercury released to the environment as none that was purchased is ever returned to the commodity market. Notably, although mercury is traded freely as a commodity around the world, it is never (or extremely rarely) officially purchased for gold amalgamation despite the fact that a large amount of what is traded ends up being used for that purpose.

An analysis of the existing global trade using data from the United Nations Commodity Trade Statistics Database (*Comtrade)* covering the five year period 2002-2006 on mercury and gold was made to better understand mercury use in ASGM, and to show how invisible the trade in mercury and gold from ASGM is. The details of this analysis are in Appendix 2 and an online searchable database of the data generated in the analysis is available at www.hgwatch.net, however, some important outcomes are as follows:

1. The number of countries that actively trade in mercury is 119 but there are 190 countries listed in the UN's Comtrade database. Therefore, there are 71 countries that either do not consume any mercury or do not report consumption. Due to dental practices alone (300 to 400 tonnes mercury consumed per annum for amalgam fillings, Maxson, 2008; P. Maxson, Concorde Cons., Belgium, 2008, pers. Comm.), it is unlikely that these 71 countries do not trade in mercury at least for dental use. This suggests that the database represents a minimum amount of trade.

2. Using methods elaborated in Appendix 2, exports of mercury were 3,230 tonnes/a and imports 3,200 tonnes/a.

3. The value of mercury exports per annum is US$26,690,000, and imports US$28,567,000.

4. There are 54 countries that only import mercury and there are 2 countries that only export mercury, Kyrgyzstan and Kazakhstan

5. There is clearly a transfer of mercury from the developed countries and northern hemisphere to less developed countries and southern hemisphere.

6. There are 28 countries with known ASGM sites that do not officially export any gold.

7. There are 16 countries with known ASGM sites that do not officially record any mercury or gold transactions whatsoever.

8. There are 16 main mercury exporting countries (those who export more than 50 tonnes/a)

9. Officially there are 54 countries that only import mercury (a total of 190 tonnes/a).

10. In terms of countries that are potentially significant distributors of mercury for use in ASGM, there are 13 countries with no or few mercury using chloralkali plants that import significant amounts of mercury. Of these, Mexico and Singapore are by far the largest, importing 221 and 138 tonnes/a, respectively.

11. There are 14 countries that import more than 50 tonnes/a of mercury.

12. Estimates of ASGM mercury consumption are greater than official mercury imports in 53 countries of the 70 known to have ASGM sites. The opposite is true for the other 21.

1.1.8. Knowledge Gaps about the Science of Mercury in ASGM

In order to evaluate the significance of mercury emitted from ASGM, and to enable discussion about how best to reduce emissions, it is useful to elaborate the current gaps in our understanding about it.

The fate of mercury in the environment released from ASGM remains poorly understood. For example, of the portion emitted to the atmosphere, how much falls out locally and how much travels long distances and over what time scale has never been adequately investigated and so remains poorly known. This is despite the fact that the long range transport of these emissions and subsequent deposition in other countries is a key interest of the UNEP Mercury Program and other parties concerned about global mercury pollution.

Further, what happens to the mercury emitted from ASGM following deposition is also not well known as most of the high calibre research that has been done on atmospheric mercury and its fate has been done in temperate or polar environments whereas most ASGM occurs in the tropics where hydrology, soils and vegetation, productivity, and rates of chemical cycling are vastly different. The fate of the mercury from ASGM that is directly discharged into water is equally poorly known. How it is transported, how far it travels, how and where it becomes methylated, and ultimately how much of it enters the local versus global fisheries is poorly known. Finally, important health related knowledge is missing. For example, how persistent is the mercury exposure caused by emissions from gold shops or by retort use – how much sticks to local surfaces and how long do they take to de-gas? This is unknown but essential information for evaluating exposure risks and providing safety guidance to those potentially exposed.

In fact many of the general knowledge gaps about mercury that were highlighted by the plenary panellists at the 8th ICMGP (International Conference on Mercury as a Global Pollutant, "Mercury 2006") apply directly to mercury and gold mining. See appendix 2 for details about these gaps, and a table that relates the knowledge gaps identified by the academic community to gaps in knowledge about mercury in ASGM. As well, a figure in Appendix 2 shows examples of mercury being emitted into the environment from ASGM and how these relate to the identified knowledge gaps.

For a variety of reasons, small scale mining is a good place to build knowledge about mercury. Perhaps even the best place as it would additionally bring needed resources, raise awareness, and undoubtedly produce some innovative ideas. The current lack of understanding about mercury in ASGM puts a limitation on the development of innovative solutions towards prevention and remediation. Filling these gaps is required if we are to understand the impacts and costs of mercury emissions from ASGM at local, regional, and global scales.

1.1.9. Inadequate Data for Decision-Making

On an a broader perspective that includes social science and anthropology and human development, the database for evaluating ASGM and mercury use remains far too small, and does not have nearly enough ground-truth to be considered comprehensive. This lack of information is likely a large part of the reason why, so far, no model of intervention has proved sustainable or transferable. At the same time, it needs to be recognized that each situation has unique conditions which cannot be accounted for in a comprehensive grand or integrated model. Nevertheless, as a whole, the mining industry would benefit from further research into the occurrence and dynamics of artisanal and small-scale miners, their use of mercury, and a further evaluation of previous efforts to resolve conflicts. Appendix 5 "Case Studies, Classification, and Evaluation of Different ASGM Settings" discusses some of the known cases but in doing so also makes the paucity of data clear.

1.7 Reducing Mercury Use in ASGM

The amount of mercury consumed by artisanal small scale gold mining (ASGM) depends on three main factors: (i) the type of ore being mined; (ii) the technique used to process the ore; and (iii) the technique used to process amalgam to produce gold. To varying degrees, these factors are interdependent.

1.7.1 Reducing Emissions

In a few cases, mercury consumption has been significantly reduced through the use of fume hoods, retorts, and by re-activating dirty mercury. In Brazil and Indonesia, simple fume hoods have been adapted by some gold shops that trap about 90% of former atmospheric emissions (Sousa and Veiga, 2007; Telmer and Stapper, 2007; Sulaiman et al., 2007; Agrawal, 2007; Chouinard, 2007, Argonne National Laboratory, 2008). The fume hoods in Indonesia are very cheap ($US35) and allow gold shop owners to recover and re-sell mercury, thereby recycling it and greatly reducing overall mercury consumption. They need to recover only 1kg of mercury in order to recover the cost of buying a fume hood. USEPA efforts in collaboration with Brazilian partners, are heading in the same direction but have not yet managed to put the technology into local hands to the same degree - their system minimally costs $400, operates on different principals, and does not currently promote re-use of the mercury and so offers no economic incentive to the operators (Argonne National Laboratory, 2008).

As well, importantly, additional reductions in mercury consumption are occurring by teaching simple mercury re-activation and cleaning methods (Pantoja and Alvarez, 2000; R. Wuerker pers. comm., 2007). Using these methods, so called “dirty mercury” is never discarded and this reduces overall consumption and contamination. Pantoja and Alvarez (2000) use a simple electrochemical cell operated with a 12 volt battery to reduce oxidized mercury to its elemental form. Ralph Wuerker is an astronomer with experience running liquid mercury telescopes which suffer surface oxidation that occasionally needs to be removed. The astronomers (as well as many chemists studying electrochemistry with mercury drop electrodes) simply pass the liquid mercury through a coffee filter to clean it. It is also worth mentioning that retorting mercury (evaporating and then condensing it) produces relatively clean mercury that is able to effectively amalgamate gold. For example, the gold shop owners who operate fume hoods in Kalimantan, sell their recovered mercury with no further cleaning procedure for direct use in mining and this is accepted by the miners.

Retorts also significantly reduce mercury consumption by facilitating mercury recycling. Rickford Vieira, a key person involved with the World Wildlife Fund’s efforts to combat environmental degradation due to small scale mining in the Guyanas and Suriname has stated that overall mercury consumption has been reduced to 1:1 mercury:gold by use of retorts. UNIDO’s Global Mercury Project, as well as other intervention efforts, have also introduced retorts in an effort to reduce mercury releases to the atmosphere. Although even with a reduction of 90%, the levels of mercury released by ASGM are still quite unacceptable by modern environmental laws; such a reduction represents a vast improvement from the status quo.

Capturing direct emissions to the atmosphere is a positive development and can be economically driven, but in order to reduce mercury emissions further, the practice of whole ore amalgamation must also be reduced or eliminated. That is because whole ore amalgamation is (i) the least efficient way to use mercury and so causes the greatest losses; and (ii) is likely to grow as the exploitation of colluvial and bedrock ores becomes more common – these types of ores are the ones that are wholly amalgamated.

Eliminating whole ore amalgamation is a much more complicated endeavour than capturing direct mercury emissions to the atmosphere with fume hood and retorts. Most concepts about how to eliminate it involve: (i) introducing efficient processing which involves increasing the sophistication of the processing technology; (ii) increasing initial capital investment; and (iii) increasing the organisation of the labour pool – all big challenges for poor and transient communities that reside at the margins of legal society. However, if these steps can be accomplished, it is possible that more gold can be captured, or less mercury would be consumed, both of which would have monetary value to the miners and so there are underlying economic incentives for such change.

It is also important to mention that an increased mercury price, which can be driven by a reduction in supply, would induce miners to use less mercury in order to reduce costs. As the price of mercury rises, the economic feasibility of whole ore amalgamation in particular is reduced.

Possible reductions in mercury use in ASGM can be broken down as follows:

1. If fume hoods and retorts are adopted by any singular ASGM site, immediate emissions to the atmosphere can be reasonably reduced by 90% – less for operations that use cyanide. So where 1 g of mercury was emitted to the atmosphere for every g of gold produced, then only 0.1 g of mercury would be emitted.

2. If mercury re-activation or cleaning methods were adopted for any singular operation, then mercury consumption would be reduced by 50%. So where 2 g of mercury were used to capture 1 g of gold, only 1 g of mercury would be used.

3. If an operation is able to stop amalgamating the whole ore, then mercury consumption can be reduced by 90%. So where 10 g of mercury were used to capture 1 g of gold, only 1 g of mercury would be used.

Overall, by working towards the three approaches, it is reasonable to expect a 50% reduction in mercury use in ASGM globally on a time scale of perhaps 10 years. See Appendix 2 for detailed calculations.

1.8 Previous and Ongoing Intervention Efforts

The UNEP Mercury Partnerships Program, UNEP's Strategic Approach to International Chemicals Management (SAICM). The World Bank's Communities and Small Scale Mining (CASM) Secretariat, The World Wildlife Fund (WWF), the Swiss Agency for Development and Cooperation (SDC), USAID (through PACT and other programs), the German Federal Institute for Geosciences and Natural Resources (BGR), the Coordinating Committee for Geoscience Programs in East and South East Asia (CCOP – formerly the Coordinating Committee for Offshore Petroleum, but retaining the acronym), are the main agencies currently active in working on ASGM issues. However, of these only the WWF's Guyana's project has a strong mercury focus. Indeed, the WWF may be an excellent partner for working on ASGM and mercury issues together with ICMM but ironically, they currently only have a program running in a country that contains no ICMM representation and in fact no LSGM at all. However, the government of Guyana is one of the world's most interested and open (and perhaps progressive) about ASGM because of the large significance ASGM plays in the nations economy.

The United Nations Industrial Development Agency (UNIDO), a separate UN agency which with funding from the Global Environment Fund (GEF) and through the United Nations Development Program (UNDP) ran the Global Mercury Project (GMP) for 5 years – which was by far the world's most significant program targeting mercury use in ASGM – is currently operating at a much reduced level awaiting new funding and no longer has any field activities ongoing. Nonetheless, it remains a targeted implementing agency by the UNEP governing council and some of the technical materials produced by the GMP are excellent resources for understanding and working with ASGM and mercury issues.

There are also numerous international, national, and local NGOs active in working on ASGM issues. Some of the more prominent ones are the Natural Resources Defence Council (NRDC) based out of Washington, the Zero Mercury Campaign based out of Europe, the Mercury Policy Project (MPP) based out of Vermont, and the Association for Responsible Mining (ARM) based out of Colombia.

CASM brings many of these groups together through its global networking and coordination facility with a stated mission to “to reduce poverty by improving the environmental, social and economic performance of artisanal and small-scale mining in developing countries.” CASM is currently chaired by the UK's Department for International Development and is housed at the World Bank headquarters in Washington, D.C.; however it is resourced by a multi-donor trust fund receiving supplemental funding from Japan, Canada, France and the US, amongst others. Several companies, trade associations and charitable funds, such as Tiffany & Co Foundation, also contribute finances to CASM.

CASM’s activities range from ASM initiatives in countries by working with companies, governments, civil society and ASM miners through to engagement in international development policy dialogues. A main focus of CASM is its message to international forums and development agencies about the potentially positive development influence that ASM can have – namely poverty reduction and economic development but extending to all of the millennium development goals.

Perhaps the IGO that is most active and engaged in the ASGM mercury problem currently is UNEP Chemicals. It has been recently developing a document intended as guidance for governments in the development of a *National Strategic Plan* relating to improving practices and working conditions in artisanal and small scale gold mining as part of UNEP’s commitment in the Artisanal and Small-Scale Gold Mining Regional Partnership Project in Asia under the SAICM Quick Start Programme. It is one element of UNEP’s response to Governing Council Decision 24/3 paragraph 27.c on mercury “enhancing the artisanal and small scale gold mining partnership…” The guidance documents main objective is continued minimization and elimination of mercury uses and releases in ASGM. It is meant to “complement and supplement existing programmes in key, strategically selected ways that ensure that mercury reductions on the ground are globally significant”… “with the intention of addressing the ASGM in a holistic manner, including a review of legal, educational, economic, regulatory and enforcement frameworks as well as a budget and workplan identifying potential funding sources and partners in moving forward”. I have been told that a project under SAICM was recently funded and will begin in the Philippines.

However, progress from these groups and efforts has often been held up by a lack of basic information and on the ground field expertise in ASGM and mining in general. The differing cultures of various intervention efforts, which is born out of the personnel implementing them has led to many good intentions but also many failures. One of the main problems has been the acquisition of funds for interventions from donor agencies that are driven by strictly ecocentric goals. There have been attempts to create alternative livelihoods or to introduce mercury-free technologies to miners based simply on the ***idea or wish that they should behave differently***, rather than starting by understanding the technical truths and financial burden that such interventions might cause and then building up a solution from there.

Myths of technological miracles have also been a problem. Even just last year at the CASM meting in Mongolia, many were wrongly convinced that there was a new processing method that involved borax coming out of the Phillipines that could completely replace mercury. The truth is that borax has been used in gold mining for centuries and is used at an entirely different stage in ore processing than mercury – it lowers the melting point of silicate impurities when smelting gold concentrates. It doesn't produce gold concentrates, which is the job of mercury. Nonetheless, even after having the flaw in the miracle exposed, a group of prominent people active in ASGM interventions applied for funds to promote the eradication of mercury using the borax method! And perhaps the presentation of the idea that mercury can be readily replaced by borax may have played a role in the Mongolian government's decision to outlaw mercury that week.

Many well meaning attempts to improve the livelihoods and living conditions of miners or to reduce the environmental impacts of ASGM have failed because of lack of appropriate knowledge. A good knowledge base is the required backbone to formulate solutions to the problems associated with mercury and ASGM. Basic information can be used to constrain many other important aspects of ASGM, and then to educate the stakeholders and interest groups involved – including the miners themselves although they often already know many technical truths. This in turn helps immensely in guiding the formulation of appropriate intervention strategies, focusing resources, and avoiding costly and frustrating failures.

2 Local to Regional Solutions

The recommendations below have a **title** followed by a generic list of **partners** (**in parentheses**) that could be involved, this is followed by text describing the action, and then below that in **smaller bold font**, specific potential partners that may be capable of adding capacity or may have ongoing synergistic activities are given, followed by specific partner activities that would be carried out to initiate the activity, and finally a description of the potential role of the ICMM and/or its members is given.

- Taken as a group the recommendations serve to engage local through to international stakeholders, create incentives to get miners to reduce mercury emissions and ultimately eliminate its use, and reduce risk and improve the reputation of ICMM members. However, the recommendations can be evaluated and initiated singly as well.

Leading Actions

A leading action is one that can be carried out almost immediately and serves to provide early information that can be used in discussions to lead other activities forward. It should be simple and acceptable to all potential stakeholders and signals a proactive rather than a reactive direction. It can be performed before or in anticipation of the development of policy in order to facilitate the acquisition of needed information to guide policy development. The first three recommendations can be leading actions.

2.1 Technology Transfer - Sponsor Technology and Business Competitions (ICMM or Member + Partner + IGO + NGO)

Simple, inexpensive, easy to introduce technology, if it is profitable on appropriate times scales (weeks to months for concession and gold shop owners; days to weeks for miners) will be adopted by ASGM quickly. In Kalimantan, Indonesia, within six months of introducing the concept and basic design for capturing and re-using mercury in gold shops using $35 fume hoods, every gold shop had purchased and installed one. Importantly, the local community took the concept and reduced manufacturing costs and improved efficiency using local materials. This reduced atmospheric emissions of mercury by 80 to 90%, reduced mercury imports, reduced occupational and community exposure enormously, and opened a positive line of communication with miners and gold merchants.

I suggest the most effective way to introduce technology to ASGM communities is through sponsoring technology competitions that offer ***cash prizes*** for best progress on resolving important ASGM issues. Essentially a “down to earth” X-prize (“revolution through competition”: http://www.xprize.org/). Primary criteria for judgement would be economic sustainability and environmental performance. This is less complicated, cheaper and much more effective than hiring a local agency to transfer technology by following the external directions of a donor agency. It immediately accesses the innovative capacities of the local community and self-creates an awareness campaign that can help achieve broader goals about awareness and best practices.

Because mercury emissions can most easily be reduced through emission controls (see the introduction or appendix 2 for more details), a logical first competition could target gold shop fume hoods installations. The Kalimantan and USEPA fume hoods could be used as initial starting designs. Many other issues could likewise be addressed. General categories for stimulating technological innovation to address the ASGM and mercury problem could be: (1) waste management (tailings management); (2) ore processing (more gold); (3) product development / diversification; (4) mining methods (safety improvements); and (5) profit distribution.

Holding simple technology competitions could leave a trail of education and awareness up to 70 countries long and stimulate a lot of idea exchange between individual ASGM communities (this is known as "south-south" exchange in the development community). Positive reputation building publicity for ICMM and/or Members would also be an outcome. Rio Tinto has recently launched a competition along these lines with their Rio Tinto Alcan Prize for Sustainability which offers a 1 million dollar first place prize.
http://foundationcenter.org/pnd/rfp/rfp_item.jhtml?id=217500012.

Potential Partners: **(i) ASGM experts/consultants/NGO's with appropriate experience; (ii) regional and national environmental and resource agencies; (iii) UNEP; CASM. For example CASM's global network could be used to find suitable on the ground agencies.**

Partner activity: **Liaise with ICMM, Members, IGO (UNEP, CASM), and GO; Perform feasibility study of sites and approach; Organize and run the competition together with local NGOs.**

Role of ICMM and or Members: **(i) Fund competitions by funding partners through existing structures; (ii) indirectly fund competitions by providing available in-country infrastructure support near or far from company concessions (e.g. transport, offices, staff, lodging, technical support, organisational support, contacts with government; local organisations; miners, etc.); (iii) support/promote/discuss/evolve the idea at multistakeholder meetings and discussions; (iv) advertise the idea through the ICMM professional network, website, etc. – perhaps through a link to an implementing partners website.**

2.2 Build a Knowledge Base and Monitoring System for ASGM
(ICMM + Partner + IGO)

Support the construction of a database that is served publically and used: (a) as an open document for discussions with the ASGM community; (b) to encourage input from stakeholders; and (c) to act as an education and awareness vehicle. A nascent example database was built for this report and is available at www.hgwatch.net. Note that the "Global ASGM database" can be queried to provide basic information by country such as largest mercury exporter, largest ASGM gold production, etc. This website can be upgraded to seek and incorporate stakeholder input and to serve the data in more diverse and effective ways.

Key information that should be included in a central database is: (1) how many people are mining and where (demographic information including total population supported by ASGM)? (2) how much gold are they producing? (3) How much mercury do they use? (4) what is the scale of the impacts they are having on the landscape? – How much habitat (land and water) has been impacted? and basic demographic data such as that available from the economist research unit.

Other site specific data can greatly increase the level of analysis and interpretation that can be done on such a database to produce statistics useful in stakeholder discussions. For example, other information about gold such as grades, grainsize, recovery, liberation, gold remaining in tailings, simple ore deposit models, extraction methods, etc.; set up and operational costs such as sluices, shaft development, mill, buckets, shovels, pans, carpets, screens, chemicals, transportation, food, taxes; refining costs such as: crucibles, borax, benzene, nitric acid, silver, copper, electricity, etc.

This centralized database is currently lacking but can be very effectively used as follows:

- In negotiations and awareness campaigns with all stakeholders.
- To constrain other important aspects of ASGM – e.g. demographic statistics specific to ASGM miners.
- To guide the formulation of appropriate intervention strategies, focus resources, and avoid costly failures.
- To monitor progress on improvements at all levels – field sites through to policy

An effective strategy to build such a database involves combining field work, satellite imagery, reports, research, and stakeholder input (see Appendix 4, for an example of this approach).

Potential Partners: **(i) ASGM experts/consultants with appropriate technical, analytical and information technology experience; (ii) regional and national environmental and resource agencies; (iii) UNEP; CASM; Aid agencies. (iv) a suitable organisation to build and maintain the database – a university or suitable NGO for example.**

Partner activity: **Construct, maintain, and serve database by performing field work, extrapolation using remote sensing tools, web site development, managing stakeholder input, and producing interpretative reports and other appropriate content; Engage stakeholders at all levels to participate. Liaise with ICMM, Members, IGO (UNEP, CASM), and GO.**

Role of ICMM and or Members: **(i) Fund the development of the database by funding partners through existing structures; (ii) indirectly fund the development of the database by providing available in-country infrastructure support – field work (e.g. transport, offices, staff, lodging, technical support, organisational support, contacts with government; local organisations; miners, etc.); (iii) provide feedback on the database as a stakeholder (iv) promote other stakeholders to contribute to the database; (v) link the database to the ICMM website.**

2.3 Monitor Atmospheric Mercury (ICMM or Member + Partner + NGO)

Preventing the arrival and spread of mercury is clearly a priority for all parties but should not rely on a top down strategy of enforcement as that has consistently failed over the past 30 years and in fact has exacerbated the problem in many cases by driving mercury trade underground and out of access to intervention activities. A superior approach is a strategy of economic incentives, education, open dialogue, community involvement, and technology transfer.

As a leading action, an early warning system or monitoring system for mercury is an effective and neutral starting place. This will provide early information about the arrival of mercury or the extent of its use and educate people about its behaviour so that exposures and use can be reduced. It will establish communication and education networks with gold shops, and build awareness by educating miners and communities about the negative aspects of mercury.

- It provides critical and clear information
- It establishes communication and education networks with the gold shops. A single gold shop is visited by many miners and so they are an efficient focal point for the distribution of education. As well gold shop owners are often relatively well educated making them good educators of others.
- Provides a palette upon which to educate about mercury and so build consensus that will resist its use or abuse.

Action: Install mercury vapour analysers on or near ASGM sites as community education and awareness points (not enforcement mechanisms) and as a quantitative method for monitoring mercury use and health risks to people and ecosystems. Presumably these initially would be near company concessions, however, installation remote from company concessions is also a viable strategy. This action protects communities and companies by deterring the *abuse* of mercury by providing real data for all stakeholders to evaluate. For communities and industry it:

- Reduces risk and liability and increases reputation
- In places where mercury has not yet arrived, it acts as an early warning system
- Creates a line of communication with the informal gold sector
- Establishes baseline conditions for regions and reduces conjecture about emissions
- Galvanizes in depth ASGM assessment and development of relationships with the informal gold sector
- Contributes to ICMM commitments about monitoring emissions in the *position statement on mercury* (Feb., 2007)

Existing mercury monitoring equipment is available (e.g. Tekran or Lumex instruments) and effective to begin such an activity but the development of simpler and cheaper systems – through technology competitions or industrial collaborations – could be funded in order to allow more wide spread adoption of this activity.

Potential Partners: **(i) ASGM experts/consultants with appropriate technical, analytical and ASGM field experience working with miners that can site and install monitoring equipment and engage and educate local partners and miners; (ii) regional and/or national environmental and resource agencies; (iii) international mercury monitoring networks; (iv) UNEP & CASM; (v) monitoring equipment manufactures; (vi) equipment innovators – universities for example.**

Partner activity: **Install mercury monitoring and educational systems in ASGM communities in collaboration with ICMM or Member(s). Develop or introduce economically sustainable emission control equipment and low or zero mercury processing techniques. Engage and provide guidance for local and regional stakeholders (governments, NGOs, companies) in building capacity to run the monitor and education program. Stimulate the development of low cost monitoring equipment. Liaise with IGO. For this action UNEP would make a strong partner as this activity could fit nicely into their "**guidance for governments in the development of a 'National Strategic Plan' relating to improving practices and working conditions in ASGM" **allowing a two-way flow of information to occur between highest level policy making and field realities – an important and essential development. As well, feedbacks between the two would likely mutual strengthen each parties interest, performance, credibility, and therefore chance of success.**

Role of ICMM and or Members: **(i) Fund the installation of monitoring equipment, the development of accompanying educational materials, and the training of local partners to gain the capacity to run the monitoring and education system; (ii) directly or indirectly fund the development of cheap monitoring equipment perhaps through technology competitions or grants to innovators (iii) join or liaise with or support the interaction of the partner with, international mercury monitoring networks in fulfillment of the position statement on mercury.**

2.4 Develop, Diversify, and Remediate Pilot Areas (ICMM or Member + Partner + Investor + GO)

Undertake the economic development and remediation of ASGM deposits by engaging and employing the local mining community to continue mining but with better practices with the goal of developing or participating in developing best practice standards in ASGM. The aim should be to develop stand alone sustainable mining businesses. To begin, set an example with one easy site (low hanging fruit) and use it as a *"ground zero"* for the standards of ASGM reclamation and transition to a formal business.

The successful remediation and transition of an ASGM site to a sustainable business would directly address all of ICMM's 10 principles. Additionally, it would provide an invaluable two way exchange of information between LSGM and ASGM and build reputation.

This activity could be initiated by performing feasibility studies of potential cases. Case studies could be close or far from company concessions depending on the goals and risks. Central Kalimantan in Indonesia, for example may be a suitable site for such a feasibility study. One area is estimated to contain 5 million ozt of gold and other resources (Appendix 4); safety compliance is not complicated; it has sophisticated gold merchants ready and willing to upgrade their businesses; the local government is educated about and engaged with small scale mining; and there are several suitable NGOs on the ground to assist with the government, community relations, and a remediation strategy, including re-creating endangered orangutan habitat – a potentially great source of motivation at the national and international level.

Potential Partners: **(i) ASGM experts/consultants/geologists/mining engineers/business experts with appropriate technical and ASGM field experience working with miners that can perform site feasibility studies by working with a local mining communities and miners; (ii) regional and/or national environmental and resource agencies**

Partner activity: **perform feasibility studies of potential sites for remediation and upgrading to formal businesses. Seek out and hold discussions with the investment community and country institutions to assess the viability of formal investment and business development. Discuss potential synergies and leveraging with international programs in terms of ecological restoration, and economic and human development.**

Role of ICMM and or Members: **(i) Fund a feasibility study and provide institutional and network support where possible with investors and other economic development institutions – national, international, or private.**

2.5 Fill Knowledge Gaps about Mercury in ASGM (ICMM + Partner + Scientists)

Sponsor targeted research programs to investigate the knowledge gaps surrounding mercury in ASGM described in the introduction. The fate of mercury used and released from ASGM remains poorly understood (introduction, Appendix 2). For example, for how long occupational hazards from emissions in gold shops persist is unknown, and perhaps more importantly, very little is known about the behaviour of mercury when it is used in combination with cyanide (CN) leaching – a rapidly growing trend. Helping to build the facts about the hazards of mercury in ASGM accomplishes multiple goals:

- Manages the risks of misinformation (e.g. gold industry emissions),
- Improves reputation with local to international stakeholders
- Creates information upon which to base technological innovations
- Leverages the resources and networks of the scientific community to innovate and raise awareness

One efficient route to begin this action would be to sponsor a session at the 9th International Congress on Mercury as a Global Pollutant (ICMGP), China, 2009, the world's premier conference on mercury science. Research fund announcements or prizes could be used to stimulate interest and research programs. Considerable leveraging of funds may be possible through this approach. For example many industrial partnership grants quickly leverage more than 50% of research funding from government sources.

Potential Partners: **(i) ASGM experts and Mercury Scientists with appropriate technical and ASGM field experience; (ii) the ICMGP management board**

Partner activity: **Organize ASGM sessions at conferences; Develop and execute research fund competitions.**

Role of ICMM and or Members: **(i) Provide sufficient funds to sponsor a session at ICMGP which would include invited speakers, a contribution to the conference, and a cash prize.**

2.6 Lobby for Program Based Education and Awareness (ICMM + Partner + IGO + Program)

In order to both raise awareness about solutions and to increase industry reputation, the ICMM, through a partner, could lobby programs targeted to the rural poor to include ASGM awareness modules. The One Laptop per Child program (OLPC, http://laptop.org/), sponsored by AMD and Google and others, may offer deep penetration into the both the rural poor (particularly to children and mothers) but also, importantly, into the urban luxury goods market. For example, ASGM or mercury awareness module could be installed on these laptops. Minimally, this action (lobbying) would raise awareness in both the developing and developed world and it would create a positive and helpful *"buzz"* about gold. Other programs like Medicins sans Frontieres (Doctors Without Borders) or organisations like the Gates Foundation that have deep communication networks that reach many in the ASGM communities could also be considered.

Potential Partners: **(i) An ASGM expert or experts and technical assistants with appropriate experience that could commit time developing appropriate materials and to lobbying suitable programs; (ii) CASM & UNEP as supporting agencies; (iii) the World Gold Council.**

Partner activity: **Develop appropriate materials and hold discussions with suitable programs in an effort to educate and convince them of the importance and relevance of the ASGM and mercury issues and how they are synergistic with their own efforts (malaria and aids and fish conservation and ecological conservation, and human and economic development for example).**

Role of ICMM and or Members: **(i) Fund the development of suitable lobbying materials and assist in gaining access to existing programs through ICMM's professional network.**

2.7 Build Centres of Excellence (Training & Research) for ASGM (ICMM or Member + Partners + IGO + NGO)

Educate and train experts in aspects of ASGM such as product development, clean technology, processing, waste management, environment, health, exploration, economics, safety, policy, conflict resolution, reclamation, etc. Currently, there are very few people with such expertise and even fewer local experts. Due to cultural, technical and language differences as well as the great distances between ASGM clusters, it would be appropriate to locate a centre on each continent (Asia, South America, Africa), probably co-located with a some existing educational infrastructure such as geology, mining, resource, environmental science, geography and political science schools/ colleges/ universities. Twenty one (21) graduates/year (7 per continent) is an appropriate initial target considering that the current number of people with such training may be less than 20. These centres could be linked to committed partners in the developing world such as the proposed *Global Centre for Artisanal Mining (GCAM)*, at UBC, Canada, or other likeminded initiatives.

Potential Partners: **(i) An ASGM expert or experts with appropriate experience that could commit time to visiting potential institutions and discussing the development of these centres (ii) geology, mining, resource, environmental science, geography and political science schools/ colleges/ universities (iii) CASM & UNEP as supporting agencies and sources of curriculum ideas and materials.**

Partner activity: **Perform feasibility studies for potential sites / partners; Develop curriculum; Investigate market for graduates; Negotiate with institutions; Liaise with stakeholders about needs.**

Role of ICMM and or Members: **(i) Provide sufficient funds to sponsor a the required discussions and commission a report on the potential of developing these centres**

3 Global Market Based Solutions

The basis for these solutions is the idea that communicating with and influencing the ASGM community can be accomplished indirectly through the global gold and mercury markets.

3.1 Development of an Artisanal Gold (AG) Market (ICMM or Member + Partner + Bank + IGO) *appendix 3 is a more detailed version of this idea that was discussed with banks in NYC.

The basic premise of this action is to separate ASGM gold from LSGM gold on world markets. This can be done because, of the approximately 135,000 tonnes of gold in circulation, it can easily be argued that at least 5% or 6750 tonnes of it are ***artisanal gold (AG)*** (appendix 3)***.*** Accordingly, for example, 20 of the 400 tonnes of gold that the IMF has recently decided to sell could be considered ***AG***. Further, new production of ***AG***, estimated at 330 tonnes/a (appendix 2), is about 12% of annual global gold production. At 900 US$/ozt, the total ***AG*** gold stock is potentially worth 195 billion USD and is growing at around 10 billion USD/year.

Separating the LSGM and ASGM gold markets would provide a mechanism for communication with the world's ASGM miners and their governments and could be used to coordinate the improvement of practices and governance – *a market based system to unite the ASGM community, formalize it, and clean up ASGM gold production*. If done properly and with the support of the right partners (ICMM, UNEP, World Gold Council, others...) a positive message can be broadcast that buying ASGM gold will support poverty relief and green ASGM incrementally over time to drive standards towards those of LSGM.

- Branding would be Positive: to support poverty relief and green ASGM towards standards of LSGM – more formal (legal), more green, and more fair
- Acting through the global markets will quickly bring together governments and stakeholders and provide a feedback on how ASGM evolves
- The development of ***AG*** gold would additionally add value to LSGM by reducing risk, and strengthening social license to operate – growing challenges.
- LSGM are excellent partners in this effort for many reasons, for example, they are a robust field presence
- A 1% premium on the existing stock of ***AG*** gold could potentially generate almost 2 billion USD at $900/ozt. A premium of 1% would be consistent with other funding mechanisms used by the mining industry for social programs. These funds could be collected into a non-profit organisation and dedicated to addressing ASGM issues.
- Trading ***AG*** would likely have a "starbucks effect" on the gold market, growing and diversifying it

The time to begin this is now because the luxury goods market (gold jewellery), and the financial market (bank gold reserves) are becoming more politicized due to consumer advocacy efforts and the investment ethics of sovereign wealth funds (SWF) and sustainability indexing. Media reports such as "Don't tarnish the Oscars with dirty gold" (http://www.earthworksaction.org/PR_HarryWinston.cfm) are becoming more common but neither accurately express reality nor provide solutions. In other words, it is inevitable that increased gold branding will occur and will involve ASGM.

The publicity that trading ***AG*** could generate would have great value and deep stakeholder penetration regarding education and awareness about ASGM and mercury use and how best to intervene and improve it.

Potential Partners: **(i) An ASGM expert, A Non-Profit Organisation, Investment Bankers, Ethical Investment Funds, Sovereign Wealth Funds, World Gold Council, World Bank, IMF, UNEP, ARM**

Partner activity: **Hold discussions with banks, investors, economists, IGOs, World Gold Council, ICMM and its Members, Gold consumers, the Media at large. Develop the AG brand and sell AG gold collecting the premium into a non-profit organisation to fund future interventions into ASGM.**

Role of ICMM and or Members: **(i) Provide sufficient funds to sponsor the required discussions; (ii) provide institutional and network support where possible with investors and other economic development institutions – national, international, or private.**

3.2 Driving Up the Price of Mercury (ICMM or Member + Partner + IGO + GO)

The price of mercury is influenced by supply and demand. This was clearly demonstrated in 2004-2006 when the price of mercury peaked due to panic among buyers after the Almaden mine in Spain shut down and the Spanish trading company was being scrutinised about where it was selling mercury. It is also a fact that scarcity of mercury (higher price) causes mercury conservation and recycling in ASGM. This has been reported in many ASGM sites (Appendix 2).

Emission control measures (fume hoods and retorts) and re-activation of used mercury (recycling) have been embraced by ASGM communities because they are profitable as described in the introduction and Appendix 2. This will be amplified if mercury prices increase. Emission controls alone can reduce global mercury consumption in ASGM by around 50%, reduce emissions to the atmosphere by 90%, and can easily reduce mercury consumption by 90% in some individual operations.

The ICMM can therefore reduce the consumption of mercury in ASGM by taking action to increase the price of mercury. This can be done by (a) retiring by-product mercury that its members produce – perhaps through mercury solidification technology in jurisdictions where this is viable; (b) supporting export bans such as the proposed European and US bans; or (c) even through purchasing a significant amount of the annual mercury demand (it is around 2000 to 3000 tonnes/a at a market value of around 30 million US$/a – average for 2002 though 2006) and retiring that.

Not only does this directly reduce ASGM mercury consumption by forcing conservation, it also provides a publicity opportunity to educate stakeholders about mercury and ASGM and how its use can be sustainably reduced which could in turn, acting as a positive feedback, further reduce mercury use in ASGM and further improve company reputation.

However, unfortunately this is not a panacea for limiting mercury use in ASGM. This is because the average mercury usage represents less than 0.2% of revenues from gold. Even if the price of mercury were to increase 100 times to a seemingly impossible $3000/kg, it would only represent 3-10% of gold revenue for many operations. Also, an increased price could cause more smuggling and artisanal production of virgin mercury (the capacity of artisanal mercury production is poorly known). Nonetheless, because of cost structures in most ASGM camps where costs are typically passed down to the bottom of the labour pyramid, conservation of mercury is already being practiced for economic reasons and a price increase would certainly stimulate further conservation.

Potential Partners: **(i) ASGM experts, IGOs, NGOs, Mercury Suppliers and Retailers, Mercury Recyclers and Disposal Facilities, UNEP, CASM**

Partner activity: **Liaise with IGOs, ICMM and its Members, and mercury suppliers and retailers about this initiative; Educate stakeholders with facts about mercury use and reduction scenarios in ASGM.**

Role of ICMM and or Members: **(i) Commission a report on price increase scenarios and how best to achieve them. Modify the position statement on mercury to reflect the potential impacts of induced price increases on global ASGM emissions.**

Appendixes

List of Appendixes:

Appendix 1
Presentation: Artisanal Gold, the Mercury Problem, and Some Ideas on How to Fix it. Kevin Telmer, (2008) London.
This is the presentation given to the ICMM at the bi-annual meeting in May 2008 in London.

Appendix 2
World Emissions of Mercury from Artisanal and Small Scale Gold Mining.
Coordinating lead author: Kevin H. Telmer, Canada
Contributing author: Marcello M. Veiga, Canada
In: Mercury Fate and Transport in the Global Atmosphere: Measurements, models and policy implications, eds. Nicola Pirrone and Robert Mason; Interim Report of the UNEP Global Mercury Partnership on Mercury Air Transport and Fate Research.
This was written as a necessary background for the work commissioned by ICMM and was begun as part of the ICMM report but then grew beyond the scope of the ICMM report when the opportunity to contribute to the UNEP task force arose. It is currently the world's most recent and comprehensive estimate of the scale of ASGM gold production, mercury use, major knowledge gaps (including the combined use of cyanide and mercury in ASGM) and discussion of best potential reduction strategies and scenarios. It has been reviewed by industry (including mercury retailers and the chlorine industry), governmental, and academic experts. It contains more than 100 literature references. It is now published as part of the materials that will feed the UNEP governing council meeting in February 2009.

Appendix 3
Proposal: Development of an Artisanal Gold (AG) Market. Kevin Telmer (2008).
This is a four page document written for a discussion with Lehman Brothers Bank, NYC, about creating an ***AG*** gold brand. It was delivered in June, 2008 and has been reviewed by several economists.

Appendix 4
Evaluating and Monitoring Small Scale Gold Mining and Mercury Use: Building a Knowledge-base with Satellite Imagery and Field Work. Kevin Telmer and Daniel Stapper (2007), UNIDO Project EG/GLO/01/G34 Final Report.
This is a report written for UNIDO's Global Mercury Project phase I which ended in 2007. It provides a methodology for building a regional ASGM database, synopsis of ASGM in Kalimantan, and a description of one alluvial orebody in central Kalimantan that might be good site to conduct a remediation and sustainable business feasibility study.

Appendix 5
Case Studies, Classification, and Evaluation of Different ASGM Settings. Available upon request. Twelve case studies of ASM-LSM conflict are described, classified into physical types, varieties of LSM-ASM conflict, and also into categories of Ease of Mining, Safety Compliance, Ease of Formalisation, Environmental Sustainability, and Life Quality (health + wealth) in order to explore commonalities and unique characteristics.

NOTE: Appendix 6 through 8 are examples of simple proposals that might be requested by companies to increase their participation in “fixing the mercury problem”.

Appendix 6

Available upon request: Proposal to Install a Mercury Monitoring and Educational System to Reduce the Use of Mercury by Small Scale Miners.

This is a proposal for a project to install a mercury monitoring and educational system (near or far from a mining concession) with the aim of engaging local and regional stakeholders in creating a sustainable system to minimize the use of mercury by small scale miners. The project can include activities such as the development of economically sustainable emission control equipment, economically sustainable alterations to processing techniques, building capacity for local authorities to run the educational and monitoring system, amongst others.

Appendix 7

Available upon Request: Proposal to Quantify Mercury Emissions from a Mining Operation.

This is a proposal for a project designed to provide the information necessary for companies to evaluate the emissions of mercury from their operations in the context of environmental commitments, natural regional geochemical fluxes, and existing and coming international standards, including those recently set out by the ICMM. This information informs industry about their emissions, minimizes conjecture about emissions, and allows the evaluation of available strategies to minimize mercury emissions and transport.

Appendix 8

Available upon Request: Proposal to Research the Nature of Cyanide-Mercury Interactions in Small Scale Mining.

This is a proposal for a research project designed to provide the fundamental information required to understand the creation, control, and fate of cyanide-mercury complexes created when mercury and cyanide are combined in processing ores from small scale mining operations. This information is essential for prevention, control, and remediation activities.