Yayasan Tambuhak Sinta

UNIDO Project No. EG/GLO/01/G34
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Community Awareness on Hazards of Exposure to Mercury and Supply of Equipment for Mercury-cleaner Gold Processing Technologies in Galangan, Central Kalimantan, Indonesia

FINAL REPORT

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Executive Summary

1.1 Overview

Yayasan Tambuhak Sinta, based in Palangka Raya, Central Kalimantan was awarded the contract to implement the UNIDO Global Mercury Project in Kalimantan at the end of June 2006. Implementation began shortly thereafter, and the project finished in the middle of March 2007.

The project attained three major goals:

i. The first was to prevent the release into the atmosphere of approximately 600 kilograms of mercury annually, by introducing to gold shops and the gold fields simple, low-cost equipment to capture and recycle mercury.
ii. The second was to reach out and make people in the gold fields and the town aware of the dangers from exposure to mercury, especially for young children and expectant mothers. The project contacted directly approximately 2500 individuals, and the media messages reached countless others.
iii. The third achievement was to actively involve local people and local government in implementing the project. This level of local ownership means there is a very good chance that local people and local institutions will continue to carry forward the message and the learning.

The project focused on achieving two objectives:

i. To make people aware of the dangers of mercury exposure; and
ii. To change the behaviour of people who handled or were exposed to mercury.

These objectives were pursued using several techniques:

i. Continuous field visits and direct presentations, divided between the Galangan gold fields and Kereng Pangi town. These were immediately followed up in response to the issues and needs that people raised.
ii. A saturation style media campaign that made sure people were constantly reminded that mercury is health threatening.
iii. In addition, special events were arranged with schools and women's health groups to ensure the mercury message reached everyone in the community.

Several principles and strategies underpinned the overall approach:

i. The deep engagement and involvement of local government and the local community from the very beginning, in order to achieve some measure of local ownership and sustainability after project closure.
ii. Gain a deeper understanding of the local context – social, cultural, economic, and technical – before proceeding with final project design and implementation.
iii. A flexible and adaptive management approach to quickly adjust to findings from field activities and other sources.

To get a better understanding of the field reality and to create a baseline for monitoring and assessment, the project conducted a baseline survey in the gold fields and in the town in the very first month. This survey assessed and measured people's understanding and awareness about mercury exposure and use. The same questions

were asked and answers compared in a second survey at the end of the project, to get a picture of how attitudes and behaviour had changed as a result of the campaign.

Early on it became clear that some of the assumptions that project design was based upon were incorrect:

i. One was that miners were releasing a lot of elemental mercury into the environment, and that the volume of mercury used by miners could be reduced.
ii. The second was that the techniques used to mine and recover gold were inefficient, and that therefore miners would be interested in adopting improved technologies.
iii. Thirdly, that gold shops would be interested in using retorts to capture mercury.

As was discovered, more mercury was being released through the burning of the gold-mercury amalgam in gold shops; less was entering the environment in the mining fields; and very little could be done to influence to use of mercury in the gold fields. The impact of these findings was to shift the main target of project activities from miners to gold shop owners, and to implement measures that proved effective in reducing mercury emissions, namely the introduction of water filtration devices on fumehoods to capture and condense mercury vapour that normally was released into the atmosphere.

In summary, the project shifted from implementing what were believed to be 'proven' technologies in the field and in the gold shops, to a form of 'action research' that ended up focusing on developing effective fumehood mercury recovery technology. The project became a continuous 'action learning' process – field activities led to improved understanding of what actions were needed, which led to changes in existing or planned activities and technologies – in a reflective and responsive 'learning-begets-action' loop.

1.2 Project Delivery

As originally proposed by Yayasan Tambuhak Sinta (YTS), the UNIDO Global Mercury Project in Central Kalimantan was delivered in four phases over nine months (schedule in Appendix IV):

Phase One: Preparation

During this phase, a range of media materials was prepared for an awareness campaign that targeted seven audiences: the general public, schools and clinics, communities, miners and families, gold shops, rig owners, and the government. In addition to producing five booklets with the assistance of UNIDO, the project created a sophisticated media campaign that utilized billboards, posters, flyers, stickers and broadcast media to spread a health warning about mercury to the community. Two large billboards were sited and erected close to the major target audience, namely the urban gold shops. Several weeks were also devoted to editing, improving and translating the UNIDO campaign booklets to make them suitable for local field conditions. This was done as an iterative process, and the booklets were finalized at the end of the month of August.

In tandem with this activity, a variety of portable equipment was procured and manufactured to provide technical demonstrations directly to miners in the field, utilizing a mobile Transportable Demonstration Unit (TDU). Equipment was prepared to demonstrate all of the stages of gold production from gold capture through to

concentration, separation, amalgamation, retorting and refining. The project took the initiative to design and build a variety of mercury-recycling equipment in preparation for field activities. Having submitted designs to UNIDO for approval, two prototype fumehoods and a variety of different retorts were fabricated.

In July 2006, the project developed measurable success indicators and undertook a baseline study so that changes in the awareness and behavior of the community could be quantified at the end of the project. In addition, a detailed survey of gold shops in the town was conducted to estimate the total amount of mercury vapour emitted into the urban environment. These studies provided the basis for the comparison study done at the close of the program. Miners, their families, gold shop owners, town residents and other community members were interviewed directly to obtain first-hand information prior to commencing with the awareness-raising and training programs. The study area was also mapped physically, using GPS points to determine the distribution of mining communities in the field and to identify future sites for implementation. Fieldwork was also undertaken on the secondary southern road to establish if alternative access was possible.

YTS project staff also prepared the content and programming for a follow-up to the first Training-of-Trainers event held in February 2006. This second training event, held in September, provided local government officers with the skills necessary to conduct training in the field, as well as a working knowledge of the appropriate technology. In addition, trainers learned the necessary social marketing skills to effectively deliver messages to the target audiences. The content for this event, including detailed training plans, was compiled and organized in the YTS office by experienced participatory workshop facilitators.

Phase Two: Implementation

The awareness campaign began with a public launch, which provided an opportunity for key figures from the community and government to show leadership and support for the campaign. Radio and newspaper reporters covered the event, which was well attended by around 500 community members. Following the launch, fieldwork commenced in both Kereng Pangi town and the Galangan gold fields. The project established a knowledge and information data base to document and measure progress and success. Various media were used – reports, photography and video.

Advice, information and guidance on health matters related to mercury exposure and intoxication were provided to mining communities in the field, as well as demonstrations on the use of the technical equipment. Direct interventions with gold shops took place in the town: the project provided filter systems to reduce levels of mercury emissions into the urban atmosphere.

In addition to providing direct counseling, trainers also distributed flyers, stickers, posters and booklets to a wide cross-section of the community. Trainers provided clear explanations when distributing health and technical booklets. These booklets were targeted to different audiences. Miners showed some interest in how to recover more gold using an improved sluice-box design, as well as in how to operate retorts and get more gold from the amalgamation process. They also began to understand the serious nature of mercury exposure. Women and children living in the field also received booklets and explanations, and attended screenings of UNIDO's mercury-

awareness films. The project employed a 'top down' approach, together with participatory strategies, to win cooperation from gold shop owners. The project was able to adapt to meet the needs of this target group over time, and this adaptive management approach gradually allowed barriers to change to be overcome.

Phase Three: Monitoring, Documentation, and Reporting

Monitoring, documentation, and reporting continued throughout the nine months of the project from June 2006 to March 2007. The final report prepared at project conclusion, documented changes in the awareness and behavior of the community, and assessed the relative success of the activities and the technologies implemented.

A comparison study conducted in February 2007 used the same indicators as in the baseline study: the methods, materials and results are compiled in the "Baseline and Comparison Study". The comparison study demonstrates that although the awareness campaign was highly successful, behavior change is a gradual process that will require ongoing efforts to build upon the areas of success in the project.

Phase Four: Project Closure

Implementation ended with a multi-stakeholder workshop attended by representatives of the local and regional government and NGO's. All five of the government departments attending the workshop made strong commitments to continue to effect changes in attitudes and behaviour. The demonstration equipment was officially handed over to the departments of Mining and the Environment at the close of the project.

1.3 UNIDO Representation

After notification of the contract award on the 5th June 2006, the YTS project office began to mobilise staff and other resources immediately. On the 13th June, an introductory meeting was held between UNIDO representatives, Masayoshi Matsushita and Budi Susilorini, and YTS project staff, Bardolf Paul and Sumali Agrawal, in the UNIDO Jakarta office.

On the 3rd July 2006, the YTS staff met with the provincial head of the Department of Mining in Palangka Raya, and also with the regional heads of the Department of Mining, and the Department of the Environment in Kasongan. Additional meetings were held with the heads of several government departments between 10-14 July 2006, to inform government about the project and to seek their active support, cooperation and participation. The UNIDO Indonesia Country Coordinator, Rini Sulaiman, and the Assistant to Country Focal Point, Budi Susilorini, attended all of these sessions.

The UNIDO representatives worked closely with the project team, and also met with the Head of the Katingan District at government headquarters in Kasongan; and with the district heads of the Department of Mining and Department of the Environment.

In the regional capital of Palangka Raya, the team also met with the provincial head of the Department of Mining; and subsequently with the Vice Governor of the Province, who gave his endorsement to the campaign.

From 6–12 September, Budi Susilorini and Imelda Hutabarat, the Indonesia technical advisor, attended the project's second training-of-trainers event, the launch of the campaign that followed, and the start of campaign implementation. Twelve trainers, representing four government departments - Mining, Environment, Health and Education, and three NGOs - Friends of the National Park Foundation, Yayasan Usaha Mulia, and Lembaga Dayak Panarang, were selected for the two-day training workshop.

Between 20-26 November, Dr Kevin Telmer and Budi Susilorini observed the follow-up campaign in the field, and together with Lars Weitkaemper of the University of Aachen, assisted with technical recommendations for the program.

From 19-23 February, 2007, Rini Sulaiman, Budi Susilorini and Sam Spiegel visited the study area to evaluate project success, and to represent UNIDO at the project wrap-up workshop in the district headquarters on 21 February. The multi-stakeholder workshop was a successful forum that brought together local miners and gold shop owners, leaders of women's health cadres, village heads, NGO's, and the staff and heads from five district government departments, to seek a commitment to continue the campaign for mercury emissions-reduction and to promote intermediate technologies for recycling.

1. Introduction

1.1 The Study Area

In many areas of Central Kalimantan, gold-bearing alluvial soils attract small scale miners from Java and South Kalimantan. These communities extract gold and heavy minerals throughout the study area by digging deep excavation pits: thereby stripping the landscape of all superficial soils and vegetation, and creating a barren wasteland.

In contrast, small scale miners from indigenous Dayak communities usually conduct extraction along river systems. These communities extract gold using floating pumps: thereby disturbing channel beds and riverbanks, as well as increasing sediment loads.

Both communities use the same equipment to recover gold, and both use mercury to separate the gold by amalgamation. What varies considerably is how much mercury is utilized in the amalgamation process, as well as how the excess mercury is disposed of.

Immigrant miners tend to utilize large quantities of mercury for amalgamation, yet often reclaim the excess carefully and reprocess it. By contrast, indigenous miners tend to use less mercury in the process, but often discharge the excess directly into river systems.

The project site of Kereng Pangi in Central Kalimantan, was identified by UNIDO as a regional ‘hot-spot’ for the release of mercury (Hg) into the environment. The high level of contamination in the study area stems from the activities of both the gold shops in the township of Kereng Pangi and of the miners in the surrounding gold fields of Galangan.

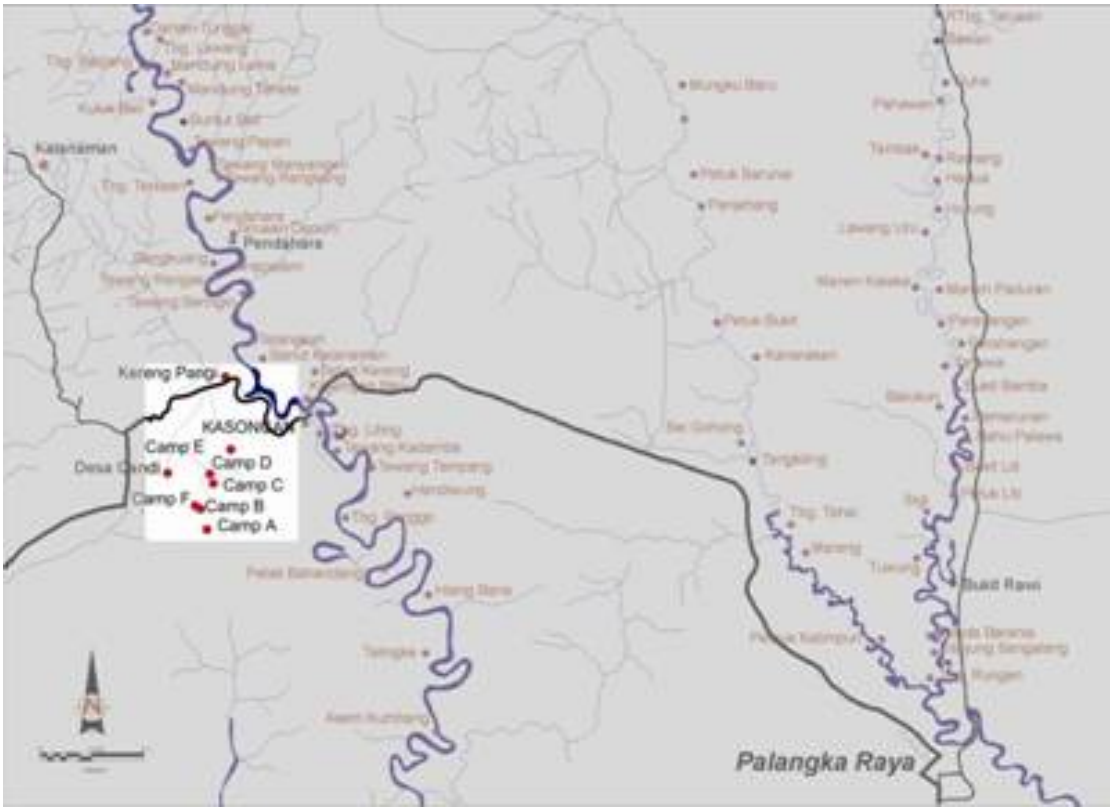
The miners lose some mercury to tailings when capturing gold through amalgamation, and the gold shops volatize mercury into the atmosphere when burning the amalgam.

There are thirty-five formal gold shops in the town of Kereng Pangi. Collectively, these shops emit over 1,500 kg of mercury per annum in vaporous form. As the gold shops are located in the centre of the town, all members of the urban community are affected by the pall of gaseous mercury that is emitted.

Furthermore, over 700 kg of mercury is combusted in the field as a result of the trade to these gold shops, as 40% of the amalgam received by gold shops is pre-burned. This increases the total quantity of mercury combusted annually to 2,225 kg.

In addition to the release of the mercury bonded in the amalgam, mercury is also released into the tailings wastes of the gold sluices during the amalgamation process. The amount of mercury lost in the tailings is somewhat less than the amount bonded in the amalgam. The total quantity is difficult to estimate, however it is in the order of 1,000 to 2,000 kg per annum. It is thus estimated that between 3,000 to 4,000 kg of Hg was released in the study area during 2006.

The Study Area



1.2 Demographics

Population

The Katingan District encompasses the entire catchment area of the Katingan River. The study area lies in the centre, in a sub-district known as Kecamatan Katingan Hilir. This sub-district has an area of 664 km/sq, 5 villages, and 14,669 permanent residents. The male population (7,319) and the female population (7,150) are equally divided.

The study area comprises the town of Kereng Pangi, with 9,500 permanent residents, and the surrounding gold fields, with 5,000 non-permanent residents.

Historical Context

The town of Kereng Pangi is also known as Hampalit as this was formerly the concession area of the gold company PT Hampalit Mas Perdahana. This Soeharto-owned company ceased operation after the financial crash of 1997. ASM activities that sprang up around the company's operations quickly overran the concession after the collapse.

Prior to 1990, local miners did not use mercury. Usage became widespread in the early 1990's when the Madurese population began to exercise control over the gold production. During the period of civil unrest in 2000, all Madurese immigrants were forcibly evicted from Kalimantan. Galangan is thus the geographic and historical centre of this land-based mining, however the area has now been overworked and yields are reduced.

Ethnicity

The mining population of Galangan is now from Java and South Kalimantan. Dayak miners do not mine on the plains, but lay claim to river and lake systems instead. Dayak river miners use Kereng Pangi as a base to service floating dredges and as a sales-point for their gold. They seldom associate with the itinerant miners; however they do trade gold and mercury with the Banjarese gold merchants from South Kalimantan.

Distribution

Long-term miners migrate seasonally, seeking new locations with greater yields. As a result, they rove about within the greater area, bounded by the satellite mining towns of Kalanaman to the north, Pundu to the west, and the gold fields of Galangan to the south.

The project area named Galangan, is that area of the gold fields which is accessible by road directly to the south of the town of Kereng Pangi. Baseline data confirmed over 1,000 miners remained in this area during 2006, even though many miners from Galangan moved further south to a new gold rush area known as Kelaruh Lake. At the peak of this gold rush, there were around 2,000 miners at this lake area, which is only accessible by motorcycle, then canoe, two hours travel to the south.

As new locations are opened up to the south, primary rainforest is removed using excavators. In new areas, such as the ‘Koperasi’ location, several camps may coexist within a few kilometers of each other. Miners usually congregate in one location in a group of 30 to 100 men. However, there is strong territorial behavior between camps, and miners do not readily share information with other miners in the vicinity.

Age

The majority of miners are in their twenties, and a substantial proportion are teenagers. Forty percent (40%) of the total of miners interviewed were bachelors without children.

Health

Although the majority of miners are young and healthy, there are a lot of untimely deaths in the field, often the result of rock-falls and the collapse of sheer work-faces. The majority of deaths in the field go unrecorded, and the actual number of accidental deaths is unknown. In addition, they are plagued by serious illnesses such as malaria, and by chronic infections exacerbated by fatigue. Miners work an eight-hour shift, six days a week; yet on the whole, they are inured to the hardships and dangers of their lifestyle.

Turnover

Ninety percent (90%) of the miners have been in the field for one year or less. As the population is almost entirely Muslim, the fast of Ramadan marks the end of the working year, and is a time when people endeavor to leave the area and return to their hometowns. Work-groups typically come from the same town or region, thus hometowns often serve as a labor pool and there is a high turnover of young miners as a result. Thus, only 10% of the field population are long-term residents.

Seventy percent of the younger miners interviewed had been in the field for less than six months. These itinerant labourers usually come to the field for 6 to 12 months and then return to their hometowns at the end of Ramadhan. Around one quarter of the population is unable to save enough money during the year to return home.

Some miners bring their wives to the field as well as babies, infants and young children. As a result, a substantial number of women and children reside permanently in the field.
Wives are usually occupied with cooking for their husbands, and often operate roadside food stalls. Women and children are never engaged in the physical labours of mining.

There is also a sub-economy based on prostitution, drugs and gambling in which some single women reside. Other female residents operate a range of businesses, such as fuel-depots, goods-stores and food-stalls, providing services to the community.

It is the unit bosses and location bosses that benefit most from this system of labour-hire and they usually commute to the field on a daily basis and keep a residence in the town.

1.3 Small Scale Gold Production

Income Level

Rig owners hire teams of five men to work as one unit. The owner has control over the top carpet of the sluice, where 90% of the gold is usually trapped. Although 12,000 kg of ore passes through a sluice-box per hour, the average yield is only 10 grams of gold. The operational costs are deducted, and half of the remainder belongs to the work-gang. If a location yields less than 10g of gold a day, exploratory miners will seek another location as 5g a day is only enough to cover the operational costs of fuel, food and transport. If five grams were split equally between five miners, individual miners would thus receive one gram of gold with a value of around Rp 165,000. However, as costs are deducted first, earnings for gold miners are half this amount, on average around Rp 90,000 a day (US$10).

New locations generally have higher recovery rates. For example, at the ‘Koperasi’ location, 17 units yield 25g to 30g of gold per day. This is because excavators are hired (at US$75 an hour) to remove the overburden and to dig through the clay layers. Miners at this location typically receive around Rp 3 million per month (US$330). As miner’s salaries depend upon yield, some feel gold is an unreliable source of income and switch to zirconium sands which provide a stable reward of around Rp 100,000 per day, with lower operating costs, allowing them to save around Rp 50,000 per day.

Access to Wage Opportunities

Thus, yields are shared 50:50 between the rig-owner (unit boss) and the five miners that comprise the work-gang. Returns are solely dependent on the yields of gold that can be obtained in that location. Without capital, the miners cannot obtain their own equipment and are completely reliant on local unit bosses for their income. Miners often go into debt on arrival, hoping to work that debt off during the initial months, and to realize some savings to take back to their hometown at the end of the Muslim calendar. Typically, miners borrow money at first from their boss and hope to repay it after two or three salary payments have been made. However, if yields are low, they

remain indebted and have no bargaining power with their employer. They remain stuck in a cycle of debt as they continue to borrow money for sustenance. This is often the case in locations where typical yields are low: for example, if less than 10g of gold is recovered per day. It can therefore be said that the miners have no bargaining power for the value of their labour due to the burden of their debts. Furthermore, the miners have no individual access to markets, as the gold produced is usually collectively traded to the unit or location boss.

Social Organization at Community Level

Thus, a well-established hierarchy exists in the field with Location Bosses in control of specific areas providing permissions to mine in that area to Unit Bosses. The Unit Bosses are in charge of work gangs comprising four or five miners. Local level institutions can hardly be said to exist, and local decision-making processes exist within the framework of this top-down hierarchy. The miners have very little access to public services or good information, and are extremely reliant upon the local bosses for their livelihood.

Land Tenure

Location bosses hold legal rights to the specific areas that they are licensed to operate in. The cheapest license issued by the Department of Mining allows for the extraction of zirconium sands. There are at least five permissions required from different government departments before entirely legal extraction can occur. These all require time and money to obtain, therefore most location bosses do not bother with all of them and often only hold a sand-mining license. Permission to mine is then illegally extended to unit bosses who may then enter the location and engage in gold mining. One location, the Koperasi, is owned and managed by a Dayak collective (a Koperasi) that established a traditional right to the land by clearing forest. However, this is an isolated case, as there are very few Dayak people in the field. There are hundreds of miners in this vicinity, but none of these are indigenous people.

Factors Affecting Incomes and Productivity

Fuel prices have risen hugely in recent years, since the government has stopped providing state-subsidized fuel. Thus, for small scale miners, the rising market price of gold has not automatically led to greater profits. Furthermore, as distance from established roads and towns increases, operational costs also increase, due to the cost of transporting people, equipment, supplies and fuel. For example, the cost of a liter of fuel rises from Rp 4900 in Palangka Raya, to Rp 5500 when sold in Galangan.

Gold Production

The average yield from one sluice-operation in Galangan is around 10 grams of gold per day. One unit may yield anywhere between 5 grams to 50 grams per day. The higher levels of gold are only obtained in newly opened areas with the assistance of excavators. In locations that are being reworked, 10 grams is considered acceptable, whereas 5 grams only covers the costs. It has been estimated that over 1,000 miners operate around 250 gold sluices in the Galangan area alone. If the average gold production from these units is taken to be 10 grams per day, it follows that the area yields 2.5 kilograms of gold a day. This is a low estimate, and it is more likely the Galangan area yields a total of around 1,000 kilograms of gold per year.

However, Galangan is only one area of the gold fields, and a greater number of miners operate in nearby Hampalit, Kelaruh and Pantai Harapan. Gold also comes to town from Dayak river miners working the Kalanaman river system to the north. The total number of sluices in the study area is therefore around 500 units, and total gold production is thus estimated at around 2,000 kilograms per year.

In an attempt to verify these estimates, data on incoming gold was collected from sixteen of the gold shops in Kereng Pangi. From this data, more reliable estimates could be made of both the total amount of gold produced in the study area, as well as the total amount of mercury vaporized to the atmosphere. From this data, the 35 gold shops in the town were estimated to trade over 2,000 kg of gold per year, in concurrence with the figures above.

1.4 Utilization and Release of Mercury

Mercury Release

Using equal values for Hg:Au in gold amalgam traded by the gold shops in the town, it is clear that over 2,000 kg of mercury is vaporized to the atmosphere in the study area each year. Two-thirds of this mercury is vaporized within the township of Kereng Pangi.

However, the total amount of mercury released into the environment each year is far greater, as this figure constitutes only that mercury which bonds with gold during the amalgamation process. To estimate the total amount of mercury release, we must combine this figure with the estimates of residual mercury in gold tailings.

By measuring losses during amalgamation, it was ascertained that the amount of mercury lost to tailings is probably less than the amount of mercury retained in the amalgam. Losses to tailings are therefore likely to be less than 10 grams per unit per day, based on the average yield of gold. However, this figure may vary, as it is dependent on how thoroughly the excess mercury is retrieved each day. However, it can be said that the quantity of mercury lost to tailings may be of less significance than the quantity of mercury that is traded annually as gold amalgam.

When we combine the estimated quantity of mercury in gold tailings with the mercury in amalgam, we see that between 3,000 to 4,000 kilograms of mercury is released into the environment of the study area in the average course of one year.

The Mercury Supply Chain

The supply of mercury is usually linked to the right to purchase the gold amalgam produced at that location. The supplier is usually a gold shop operator in Kereng Pangi, but these people do not come into the field. Instead, location bosses carry the gold amalgam to the town, together with old mercury. Tightly controlled syndicates service each location and it is obligatory for miners to use their services.

Mercury suppliers dictate the amount of mercury to be used, and oversee the amalgamation process to ensure that almost all of the excess mercury is returned to them at the end of the day. It is important to note that mercury is always supplied free of charge, and that individual miners have no control over the amount of mercury that is prescribed for use.

The Amalgamation Process

Mercury is typically distributed in a 150 ml 'Red Bull' bottle. A full bottle weighs around 2.5 kilograms and costs around Rp1.2 million. One full bottle cap weighs 100 grams. Miners report that they utilize between 2 to 4 caps per day per work group, or 200 – 400 grams of mercury. However, 500 – 1,000 grams was commonly observed being utilized, and it can be said that the amount prescribed varies greatly, depending on factors such as the availability of the mercury, the yield expected in that location, and the pressure exerted by the supplier.

It is important to note that the amount utilized is not the same as the amount released, as most of the mercury is retrieved at the end of the process. Whether 100 grams or 1,000 grams of mercury is utilized, it is likely that the same amount of mercury is lost in the process, for the rest is returned to the original supply bottle. Miners take care to return the excess to the supplier who generally oversees the process at the end of the day. There is a high degree of uniformity in both the amalgamation process and the ore type throughout the study area.

Appropriate Incentives for Change

Miners in the field know that the cost of mercury is around US$50 per kilo. However, in most locations, mercury is provided to the miners free of charge. The location boss has the right to collect the excess mercury, and it is understood that he profits from the fine gold that is trapped in the excess mercury. Reportedly, two grams of gold can be recovered from one kilogram of used mercury. Thus, the supplier benefits from retrieving the fine gold particles trapped in the excess mercury. As a result, suppliers of mercury view reduced use of mercury as detrimental to their interests.

The miners are shrewd enough to realize that the benefits of their labour may be lost to mercury suppliers if they squeeze too much mercury out of the amalgam ball, as the excess mercury carries off some gold. Thus, miners in Galangan usually try to maximize the amount of mercury that remains in the amalgam ball by not squeezing the ball too tightly.

Mercury in Waste Concentrates

Many gold miners have now built tarpaulin-lined amalgamation ponds to retain their concentrates beyond the amalgamation process. The secondary minerals are retained by the miners, as they contain heavy minerals such as zirconium, which are sold to overseas buyers. The recent increase in this business has important ramifications for both the issue of mercury lost to the environment, as well as the issue of the high level of mercury vaporized in the town. The importance of these concentrates lies in the fact that mercury is adsorbed into the mineral sands, which are often transported out of the field and sold for industrial uses. Waste concentrates from gold mining are often collected to be sold because, in addition to their value as zirconium sands, they typically retain one to two grams of gold per Tonne.

Zirconium sands are mostly derived from small operators who are not seeking gold, but a small percentage of the trade derives from the tailings of gold sluices. Increasingly, waste concentrates are sold and removed from the field to centralized collection points where they are reprocessed. These tailings are heavily contaminated by mercury, due to the prior amalgamation of the concentrate. This poses a problem

for buyers, as some Chinese ports have detected high levels of mercury in the zircon and now reject shipping consignments.
There are over twenty of these reprocessing points in the town, so this process is leading to increased urban contamination, as well as the export of mercury-contaminated zircon.

Small sluices are used to capture not only the gold, but also the waste mercury from the concentrate, and secondary concentrates are obtained. Although the incentive is the recovery of gold, a benefit is that residual mercury is also recovered in the process. However, further mercury is then added, to amalgamate with and separate the residual gold. Thus, a second waste concentrate is produced, containing both the original residual mercury plus the residual mercury from this second amalgamation. There is presently no policy to deal with these concentrates and they are frequently bagged and sold together with the clean product.

Amalgamation Processes of River Miners

Dayak river miners from several sluice operations were interviewed in the Gang Katingan river community. River miners differ from land-based miners in the following respects:

Less mercury is utilized during the amalgamation, and it is mixed more thoroughly. The mercury is mixed in a bucket for between 15 to 30 minutes. 100 grams of mercury is mixed with half a bucket of concentrate during one amalgamation. 100 grams of mercury is considered a sufficient quantity to be re-used for a second or even third amalgamation.

The excess mercury is retained and the amalgam ball is squeezed thoroughly to remove as much mercury as possible. As river miners have control over their use of mercury they minimize the amount of mercury retained in the amalgam. In contrast, land-based miners in Galangan maximize the amount of mercury in the ball for fear of losing gold.

Unfortunately, river miners dispose of mercury in waste-concentrates by throwing them directly into the river. This aspect, plus that of reduced water quality through the disturbance to river channels, bed-loads and riverbanks, makes the activities of river miners far more detrimental to aquatic systems than the activities of land-based miners.

2. Preparation

2.1 Awareness Campaign

A great deal of care was taken to prepare media materials of a high standard in advance of the campaign launch. A reliable creative design agency in Jakarta was entrusted with the conceptual work, based on their substantial advertising campaign experience. They rapidly developed a culturally-appropriate media campaign that sought to extend the reach of the message beyond the urban community and to reinforce the field activities.
The media materials were created specifically to fulfill the social marketing requirements of the project in Central Kalimantan, however the materials are nonetheless appropriate for use throughout Indonesia.

The materials developed were billboards, posters, banners, flyers, stickers and logos, with separate materials and messages for separate target audiences (samples in Appendix VI). The strategy of the campaign was to address three targets: a primary target of mercury handlers (miners, suppliers, processors); a secondary target of people exposed to vapors; and a tertiary target of town residents who resided at a distance from emissions but whose health was nonetheless impacted upon.

A strong visual identity and message was created for the campaign, incorporating the following elements:

- a house image logo for the TDU, describing it as a ‘gold clinic’
- a mercury droplet logo for general use with the slogan: “Use mercury wisely”
- two visual themes: one showing the face of a worried child with the accompanying message: “Mercury – a danger for his future”; the other with an illustration showing how mercury vapour causes brain damage, and with the heading: “Do you know mercury is dangerous?”

These elements were incorporated in all of the media materials, thereby creating a strong and unified media campaign that enhanced and supported all of the field activities.

In accordance with the media strategy, media materials were of two types:

(a) General Awareness Media

The general awareness media remained present throughout the term of the project and aimed to elevate the level of awareness and concern in the general community about the dangers from mercury.

The following quantities were produced and distributed to target audiences:

- Two hundred posters (of two different kinds)
- Two thousand flyers (of two different kinds)
- Five hundred stickers (depicting hazards in a cartoon)

Additional general awareness material produced and displayed:

- Two large billboards (in prominent locations)
- Six banners for the TDU (of three different kinds)
- Logos (two different kinds)

The posters aimed to encourage normative behavior and to prompt behavior change. Posters were distributed to government, and also affixed in strategic locations in the field, such as inside gold shops, at food-stalls, inside classrooms, and at local health centers.

(b) Health and Technical Booklets

Only distributed by trainers in conjunction with guidance and advice, these encouraged mercury users to: minimize use; handle mercury safely; use retorts; recycle and re-use.

- "Mercury and Family Health" 600 Copies
- "How to Use and Re-use Mercury" 600 Copies
- "Mercury in Gold Shops" 600 Copies
- "How to Protect Your Water" 400 Copies
- "How to Get More Gold" 800 Copies

2.2 Additional Media

Further media work included designing and editing the first project newsletter which was produced bi-monthly in an effort to inform the local community, government and other stakeholders about the progress of the project. The newsletter was made available in both Indonesian and English. The Indonesian language version was printed as four colour pages, and 500 copies of each of the four issues were distributed by mail to village networks, local government, schools, non-governmental organizations, gold shops, the mining community, and other local stakeholders.

In addition both language versions were distributed through email networks to reach a wider audience inside and outside of Indonesia, to government, non-government, and private sector contacts. The bi-monthly newsletter was first produced in August 2006, and subsequent editions were produced in October 2006, December 2006 and February 2007.

Video consisted of three mercury-awareness films provided by UNIDO. These videos were screened in the mining camps by the TDU operators at outdoor venues in the town, and in the auditoriums of the town's junior and senior high school.

A few weeks prior to the launch, two large billboards were erected in the town, one along the main highway, and one directly facing a row of gold shops. The billboards signaled the start of the awareness campaign and served as a constant reminder to the community over the course of the campaign. The billboards warned the general public of an upcoming "Mercury Hazard" and asked them to consider the future, for the benefit of their children. The local media possibilities were also investigated and a local radio station provided continual broadcast support during the last three campaign months.

2.3 Transportable Demonstration Unit (TDU)

Procurement

With regard to the technical component: the procurement and fabrication of the tools and equipment necessary for supply to the Transportable Demonstration Unit (TDU) was to the greatest extent possible, done with locally-available materials, so that miners in the field might also be able to source the same equipment. However, in some instances, specialist items were unavailable for purchase and had to be manufactured locally. YTS collaborated with a local technical school, the Palangka Raya Technical School, in making all of the gold shop prototypes and some of the field equipment.

Fabrication

The project pursued action research from the outset to find a fumehood solution for gold shops. Prior to the launch, a prototype was manufactured based on rudimentary sketches provided by UNIDO. Based on field trials and the feedback from gold shop owners, this fumehood underwent several modifications during the course of the project. In December 2006, it was installed in a busy gold shop and proved satisfactory to the owner. A second fumehood was then manufactured, incorporating the substantial learning from these trials.

This second prototype, made from stainless steel, incorporated a water trap, an air filter of glass marbles and an industrial blower in a simple design. This unit, included in the list of TDU components, represents the culmination of our experimentation, coupled with feedback obtained directly from gold shop owners and incorporated into the new design.

It was fortunate that a factory-made stainless-steel retort was found to be locally available for purchase for only US$35. This ‘Fauzi’ retort was tested on several occasions and was found to meet the needs of miners and gold traders, and its use was promoted heavily.

So as to offer alternatives to the ‘Fauzi’ retort, three other types of retort were fabricated: pipe-retorts, in both iron and stainless steel; kitchen-bowl retorts, using glass, stainless steel and enamel bowls; and finally, a ‘fish-tin’ retort, manufactured in steel.

The project also manufactured two sluice-boxes for demonstration purposes. Initially, a portable sluice-box was constructed from plans provided by UNIDO. This zigzag sluice was constructed directly from the plan in the training workshop manual. It was used to demonstrate features such as slope, carpet types, riffles and grizzly screen. Although it was valuable for dry-demonstrations, it proved unworkable for practical applications, and a second portable sluice was later built for this purpose, to different specifications.

An ‘Ecologics step pump and concentrator’ was donated to YTS by the manufacturer. This separation technology was field-tested and found useful as a demonstration tool that can quickly reduce concentrate to obtain a final concentrate, but not as an extraction tool.

Additionally, a portable 'CleanGold' sluice was provided by UNIDO to test the potential of adopting this mercury-free technology. Unfortunately, due to the non-magnetic nature of the ore, this technology proved unsuitable for use at this location. For a complete list of TDU components refer to Appendix I.

2.4 Baseline Data

Atmospheric Mercury Levels in Gold Shops in Kereng Pangi

Testing of the air quality in gold shops was designed to raise concern among operators about the dangerous levels they live with. Readings inside shops were taken when there was no burning activity taking place. The street-frontage results were obtained on the sidewalk in front of the store entrances:

Lumex Testing	Range of Readings ng/m^3	
	Street-frontage	Workbench In Shop
Average Reading	10,300	20,750 – 30,250

This data demonstrates extremely high levels of atmospheric contamination emanate from the gold shops which surround the central fresh food marketplace of the town, and on public sidewalks frequented by women and children.

Total Hg-Emissions in the Town Resulting from the Burning of Amalgam

With the cooperation of operators, individual estimations were made of the average quantity of amalgam burned in each of sixteen gold shops in the town:

Hg Burned in Gold Shops	gm Hg per Day	Kg Hg per Year	Av. Annual Recovery	Annual Emissions
Average	143g	52 kg	5 kg	47 kg
TOTAL	2,283g	833 kg	77 kg	757 kg

Emissions in the Field from Pre-Burned Amalgam Traded to the Town

An estimation of the quantity of amalgam received by each gold shop in a pre-burned condition was also made. From this data, it was possible to calculate the total emissions in the field from this trade, in the same manner:

Hg Burned in the Field	gm Hg per Day	Kg Hg Per Year	Estimated Recovery	Annual Emissions
Average	61g	22 kg	0 kg	22 kg
TOTAL	976g	356 kg	0 kg	356 kg

The sixteen shops studied can be taken to be a representative sample of the total number of gold shops in the town (35 shops in 2006). As can be seen from the above data, the gold trade from these sixteen shops resulted in 1,113 kg of atmospheric emissions in the study area, two-thirds of which occurred in the town centre (details in Appendix II).

Training of Trainers Event

At the start of September 2006, ten trainers selected for the program were provided with a second training course prior to setting out to work in the field. This two-day event was conducted by YTS, with active participation by UNIDO representatives. This further training provided the government staff with the necessary skills to broadcast our message to the local community and to demonstrate alternative technology, and thus assisted to build capacity within the local government.

Health and technical teams were trained separately to communicate specific content, and in the communication and facilitation techniques required for effective interaction with each audience. Trainers also had the opportunity to practice use of the TDU equipment and all the media materials. Trainers practiced handing-out booklets; using booklets to present information to candidates; giving the right booklets to the right audiences; approaching miners; introducing, validating and consolidating messages; and inviting people to demonstration events, videos, and to view the TDU components.

Health Trainers

Health trainers learned to discuss the effects of mercury contamination and deliver guidelines for handling mercury, such as the use of gloves and rotating drums during amalgamation. They learned to determine the level of awareness of the audience and to follow-through with a proper understanding of concepts. They learned how to deal with different audiences including women, children, miners, and gold shop operators. Furthermore, they learned to work with groups and encourage discussion of concepts so that the group itself would seek clarifications of ideas and asks questions.

Key Messages for Health Trainers

The following messages were communicated to gold miners in the field when provided with the brochure “How to use and re-use mercury”:

- Mercury is dangerous to your health and your family’s health.
- Use gloves. Never touch mercury with your bare hands.
- Use retorts. Make a simple retort and reuse the mercury.
- Burn outside. Never burn mercury inside your house.

The following messages were communicated to the general community in both the town and the field when provided with the brochure “Mercury and Family Health”:

- Mercury is most dangerous to pregnant women and young children.
- Mercury can be in the air you breathe and the water you drink.
- Avoid using water in places where people mix mercury in gold pans to get gold.
- Avoid eating fish that are grown in ponds in the gold-mining area.
- Avoid places where people burn mercury to get gold such as gold shops.
- Never touch mercury with your bare hands.

Technical Trainers

Trainers learned to present simple messages, using appropriate equipment to serve the twin outcomes of getting more gold and using less mercury. They were encouraged to

demonstrate the technology through a hands-on approach that would allow miners to experiment with equipment including retorts. Trainers were trained in the theory of gold capture and separation, and the relationship between the theory and the technology was demonstrated.

Key Messages for Technical Trainers

The following messages were communicated to gold miners when provided with the booklets “How to Use and Reuse Mercury” and “How to Get More Gold”:

- Pure gold has more value than gold mixed with mercury
- Mercury bonds with gold and gold is lost when you burn mercury
- Separate to make a final concentrate before you mix with mercury
- Mercury is unnecessary; you can use a gold pan or elutriation column instead
- Use a magnetic strip to capture fine gold and process it with mercury separately
- Use amalgamation drums to mix mercury with gold
- Mix inside a sealed drum with a ratio of 10g Mercury: 1kg Concentrate
- Turn for at least half an hour to bond all the gold with mercury
- Save excess mercury and reuse it and recycle it, don’t throw it away
- Never throw mercury into ponds, or streams, or rivers
- Never touch mercury with your bare hands – use gloves
- Never burn mercury inside your house - use a retort outdoors and far from others
- Use the features demonstrated on the sample sluice to increase gold capture
- Use proper sluice design: consider width, slope, zigzags, and rock screens
- Spend more time on amalgamation to get more gold
- Separate the pure gold first using a gold pan or an elutriation column

The following messages were communicated to the gold shop operators in the town and the field when provided with the brochure “Mercury in Gold Shops”:

- Mercury fumes are dangerous to your health and your family’s health
  Keep children and pregnant women away from burning area – out of the shop
- Mercury is an invisible metal in the air that you inhale into your body
  Dust masks do not protect you from mercury fumes
- Mercury is invisible, has no smell, and sticks to everything
  Wear one protective coat when burning; keep it separate from other clothes
- The existing chimney design is dangerous, as mercury escapes into the air
  Use a blower and a water filter to capture the Hg gas permanently
  Use retorts or make a fumehood for use when burning amalgam
- It is better to burn Mercury in a place outside town, away from people
  Save excess mercury and reuse it and recycle it, don’t throw it away

3. Implementation

3.1 Urban Campaign

Implementation began with a public launch in Kereng Pangi on September 9, 2006.

Staged entertainment attracted approximately 500 spectators, the majority of whom were women and children. The community listened to several speeches stating the aims and purposes of the campaign, and elaborating the health and environmental concerns raised.

This public event was well attended by the local community, broadcast live by local radio and reported on by the major provincial newspaper, the Kalteng Post.

An excellent speech delivered by the Head of Katingan District emphasized how the mining community could benefit from the activities of the project. He deliberated on the health impacts for children, and this caught the attention of the women, especially.

The entire event, including the speeches and the entertainment, was broadcast live by 'Radio Zona', a local radio station servicing listeners living within a 50 km radius.

During the launch, the Transportable Demonstration Unit (TDU) was presented to the community, with various pieces of equipment on display such as a zigzag model sluice-box, different kinds of retorts, and a prototype fumehood for gold shops.

The launch was an entertaining and educational event that provided the opportunity to transmit key messages to a wide cross-section of the community. Over 300 booklets were distributed to ensure these messages could be further digested over time.

Five trainers, with diverse skills, were selected to work with the community in town:

Dr Robert:	medical doctor, head of the local health clinic; runs a busy practice in the centre of the town
Irwanto:	an officer in the District Department of the Environment
Adam:	a school-teacher at the local junior high school
Ambu:	the regional deputy head of WALHI, a prominent environmental NGO
Fauzi:	local miner, gold shop owner, and designer of the Fauzi retort; an expert on mercury recycling

This team of trainers was led by the local doctor, and much individual attention was paid to gold shop operators and their families. Their daily activities were closely monitored by the Project Manager throughout.

In the town, the primary target for behavior change was the thirty-five gold shops. From the outset, all these established businesses were invited to participate in our program. An awareness-raising film night was attended by representatives of fifteen of these gold shops, and was followed by a participatory discussion on fumehood technology, during which the operators clearly outlined their needs with regard to adopting cleaner technology, and debated the pros and cons of the prototype fumehood we had specially constructed for this purpose. Much useful technical feedback was gained as a result.

Urban trainers made individual approaches to gold shops and sought to promote the use of a locally-made stainless steel retort. Trainers from the departments of Environment and Health consulted with gold-shop operators individually in an effort to raise their level of concern for their own health and safety. These approaches to gold shops led to a trial installation of the prototype fumehood in one gold shop, and trials by seven further gold shops of the locally-made 'Fauzi' retort.

As speed of operation was found to be the primary concern of these operators, the project manufactured another type of retort which promised to provide a faster processing time. As a result, a 'fish-tin retort' was built and tested in the field, however the turnaround time of this particular retort proved to be no more economical than the other types.

Additionally, Lumex testing of air quality was conducted with a view to raising the concern of gold shop operators about their own health and public health, and to inform them clearly about the existing levels of Mercury contamination in their workplaces. Trainers were able to demonstrate that high levels of contamination existed by conducting Lumex testing inside the gold shops and on the street.

In addition to working directly with gold shops, a public awareness campaign was successfully implemented in the town. One of the primary targets for this campaign was the younger generation. All of the three schools in the town - comprising elementary, junior high and senior high school levels - were addressed. Trainers from the departments of Health and Education held lectures, screened films, and distributed booklets, to raise awareness on Mercury issues as well as on AIDS. Three mercury-awareness films were screened to 200 junior high and 200 senior high school students, together with question-and-answer sessions to improve understanding.

Film and education evenings were also held at four other public locations for the benefit of approximately 300 adults from the town community. In the course of the campaign, a total of 650 booklets on mercury-related issues were distributed in the town.

Information was also provided to women through the regular health clinic for mothers, and booklets on 'Mercury and Family Health' were provided, together with advice. Further informational booklets were produced by the local health clinic and distributed to women living near gold-shops, together with advice from trainers from the clinic. The brochure on mercury produced by the clinic is now part of the district health media set.

<u>Summary of Initial Urban Campaign</u>

- The Urban Campaign started with a Public Launch on September 9th which was attended by **500 local people**: miners, gold shop owners, teachers, community leaders, representatives from relevant government offices, women and children.
- **Over 100 mothers** informed through the local Public Health Center (Puskesmas). The local medical clinic then produced its own brochure on 'How to Avoid Mercury Contamination', and the 10 staff continue to distribute it to the public through clinic.
- The project engaged in a participatory dialogue with the operators of **20 of the 35 gold shops** in the town. This began with an invitation to an awareness film and an

open forum to discuss the technology of fumehoods and retorts. Prototypes were available, and the pros and cons of each were discussed openly. This was followed by individual visits to shops by trainers who provided health counseling and technical advice. A Lumex spectrometer was used to demonstrate the high levels of contamination in their workplace. The project then provided some retorts free of charge for operators to trial. The project focused on promoting the locally-produced Fauzi retort to gold shop operators, as well as other varieties.

- **100 Students (aged 8-10), 100 Parents and 2**0 Staff at the local Elementary School were given stickers and flyers and education sessions by trainers from the Department of Education. The awareness of these children will be further raised through an art workshop focusing on mercury contamination in the follow up program.
- 340 Students (aged 12-16) watched three mercury awareness film screenings at the Junior High School. This was followed by a lecture on health issues on both Mercury issues and AIDS. 100 Booklets, 100 stickers, 200 flyers and several posters were provided on mercury contamination, plus 200 booklets, 200 booklets and 200 stickers on AIDS prevention. A week later, all the students were provided further counseling through 9 individual class sessions.
- 300 Students (aged 17 – 18) were provided an hour lecture on AIDS, and an hour lecture on mercury issues. 200 AIDS booklets, booklets and stickers were given during the first lecture. 100 mercury booklets, 200 flyers, 100 stickers, and several posters during the second lecture. Dr Robert supported questions and answers with medical advice. A week later the students were provided three screenings of the mercury awareness film.
- 500 flyers were distributed in a door-knock campaign in areas of the town where miners reside, and the community was invited to film screenings at four locations. **A total of 270 Adults and 140 children** attended and were provided with brochure information. **A total of 650 booklets** on mercury-related issues were distributed in the town during the campaign.

3.2 Field Campaign

In parallel with the urban activities, the Transportable Demonstration Unit commenced operations in the field starting in September. Five weeks of fieldwork were completed at five camp locations in the Galangan gold fields, until severe smoke and drought conditions terminated mining activities in the field. Teams were in direct contact with miners at each location, providing health information and technical advice. Equipment demonstrated to miners included the sluice-box, amalgamation drum, and retorts. Booklets outlining the technical alternatives were distributed to miners in the field, and awareness films were screened in the camp each evening.

Locations for camps were selected along the roadside - based upon the density of operators in the area - to maximize the exposure of miners to the TDU. In addition, trainers set out to distribute booklets and meet miners in more isolated areas.

Six locations were chosen for the field campaign because of their proximity to mining camps and availability of access roads. Each camp was established in one location for one working week. The sixth camp location was finally established at the end of the follow-up campaign.

Summary of Initial Field Campaign

- The Field Campaign was conducted throughout the survey area, but focused on five specific camp locations, with one fixed camp location per week.
- The Transportable Demonstration Unit traveled to provide consultation to distant settlements and operational units throughout the field, in addition to meeting the miners, women, and other workers in the five fixed camp locations.
- An approximate total of 445 people were thus contacted and provided with brochure information during the course of the five-week campaign.
- A total of 650 booklets were distributed by trainers, together with explanation of the contents of each. Brochure contents had five different varieties of theme.
- Around 370 Miners were provided with direct technical and health consultations both in the campsite and through worksite visits by the trainers.
- Around 75 Women were provided with direct consultation on the dangers of mercury for family health, and how best to avoid mercury contamination.
- An investigation was made into the trade in waste concentrates from gold tailings. Many location bosses were found to be collecting and selling waste concentrates. These contaminated tailings were found to be transported to 22 processing points in the township, and these sites were found to be contaminated by Lumex testing.

3.3 Urban Follow-up Campaign

General awareness-raising in the urban community continued through the venue of the health clinic, the monthly mother and baby sessions, through education seminars at schools, and through regular radio broadcasts. Trainees also devoted much of their time and energy to providing direct counseling to gold shop operators and their families.

Posyandu

A *posyandu* is an informal, women's community-based health group that gets together usually once a month. The project used the monthly *posyandu* check up for mothers and babies, to advise young mothers to avoid contaminated areas such as gold shops, and to keep mercury away from children. The mothers expressed a strong interest in the message, because many of them were in everyday contact with mercury, and did not understand that mercury was hazardous. These group meetings provided an opportunity to provide booklets and counsel to mothers on a regular basis.

School-to-School Presentations and Art Contest

To leave a lasting impression on a wide audience, and to encourage a high level of community participation, the project held an art competition, providing art materials and prizes to the elementary, junior high, and senior high schools in the town. Prior to the competition, presentations were provided at a peer-to-peer level by other students from another high school outside the district. Ten students from this high school created poster presentations on the issue and delivered them directly to students in the town.

There were approximately 150 entries from students, all of which carried mercury reduction messages to the community in poster artworks. Thirty of the best entries were sent to the local UNIDO headquarters in Jakarta for display. As most children

discussed and displayed their artwork with their families at home, a multiplier effect of four can be applied to the 150 children that took part in the art competition – so in the process, it is likely that around 600 people thus got the message that mercury is a health hazard.

Radio Broadcasts

Continual radio broadcasts were held during the months of December 2006 and January and February 2007, to the entire mining community living within a 50 km radius of the town. Two kinds of programming were recorded, one as a short, two-minute health advisory warning on the dangers of handling mercury, and another as a long interview segment delivered by project trainer Dr. Robert, and mixed with music into an entertaining 30 minute format. Miners in the field reported listening to the broadcasts by Dr Robert, which made them aware of the hazards of using mercury on a daily basis. The 2-minute monologue was broadcast five times a day, making a total of 150 broadcasts per month, and the longer interview was broadcast 12 times a month. Thus, there was a total of 450 advisories, plus a total of 36 half-hour interviews, broadcast over three months.

Approaches and Modifications to Gold Shops

Following recommendations by UNIDO, the project focused heavily on promoting the use of retorts to gold shops at the start of the follow-up campaign. Several different types of retorts were demonstrated to gold shop operators; including kitchen bowls, fish-tin retorts, pipe retorts and Fauzi retorts. The second issue of the newsletter contained a technical focus on the various types of retort technologies available for burning amalgam, and promoted safer burning practices.

However by the end of this campaign, only one gold shop reported owning and using a retort. The retort was only used once or twice a month to burn large amounts of gold (several hundred grams), which gradually accumulated in the shop. The usual gold shop trade involves burning much smaller amounts, as customers usually bring in 1g – 10g balls for immediate sale. It became evident that most gold shop operators would not consider using such closed retorts for a variety of reasons, and that what was required was an effective solution using ‘fumehood technology’ that would not significantly alter the manner in which the gold is usually processed.

Furthermore, between November 20-24, the project hosted field investigations by Dr Kevin Telmer from the University of Victoria. An important finding was made regarding the relative amounts of mercury lost to the soil and to the atmosphere, respectively. This finding shifted the burden of emissions towards the vaporization of mercury that occurs when amalgam is burned by gold shops. As a result, the project also shifted the onus of the remaining fieldwork to the town, where the majority of this burning takes place.

The project then redesigned the prototype fumehood using a new concept employing glass marbles as filters instead of water. Unfortunately, the marble filter system was ineffective, so the water system was reinstated using a blower placed after the water barrier. This system was then reinstalled in a busy gold shop and proved effective.

In December, the project obtained detailed data on the gold trade from a survey of sixteen gold shops, and made a close estimate of the total amount of mercury that is

combusted annually in the town (see Appendix III). This amount was found to be over 1,500 kg per annum. Although a few of the gold shops had rudimentary collection systems such as exit pipes that ended in a water tank, most of the operators did not attempt to collect any mercury whatsoever.

It was then decided to devote additional time to working closely with the 35 existing gold shops in the town to try to effect a reduction in vapor emissions by direct intervention at the point-sources by modifying the existing gold shop fumehoods with simple filtration-systems. The project thus began working with those gold shops in the town that wished to modify their existing chimneys. Two types of filter were tested in seven gold shops. By the end of 2006, modifications had been made to the chimneys of seven gold shops, providing simple filtration systems in an attempt to reduce these vapor emissions by direct intervention at the point-sources.

One such system used a water barrier and worked well, whereas the other type that used glass marbles as a filter did not perform as expected. Due to the successful installation of the first type in several shops, many other shops expressed interest in fitting the same system. Thus, it proved necessary to extend these activities in the town until February 18, to maximize the number of interventions. By the end of the project, modifications had been made to 16 gold shops in the town by the addition of a water condenser circuit between the existing chimney and the outlet pipe. As cost proved to be a significant barrier, operators were only charged for the replacement cost of the equipment. This proved acceptable, as the total cost of the equipment was only US$55. Once paid, these funds were used to purchase more equipment for further gold shops. Thus, the program finally achieved success through providing adaptations to the existing fumehoods, rather than through outright replacement of the technology.
The project also developed a second generation prototype fumehood - representing the culmination of all the research and experimentation, and incorporating the body of knowledge gained during discussions with several gold shops regarding their technological requirements. A significant amount of research and experimentation was invested in this new design, and all of the resulting information was provided as feedback to UNIDO. This fumehood, manufactured in stainless steel, was provided to the Department of the Environment at the end of the program.

It is difficult to estimate the efficacy of these filter systems at this early stage. Limited early data suggests that capture rates of around 50% have been achieved, however these capture rates may well be as high as 80%. The actual amounts can only be verified by monitoring individual gold shops over the course of time, and through careful continuous measurements of rates of burning, capture, and recycling.

Data is available for eight shops in which filtration systems were installed (see table below). Using a low capture rate of 50% it can be estimated that these shops are likely to capture and recycle over 258 kg of mercury during 2007. As 16 gold shops in the town have been fitted with recovery systems, this figure can likely be doubled to 516 kg.

These systems only represent an intermediate stage of intervention and should be considered temporary. As better technology is tested, and better capture rates are demonstrated, it is anticipated that, over time, more and more operators will become more willing to install better systems. The incentive to do so will arise spontaneously

as gold shops realize the monetary value of recycling mercury. Additionally, it is likely that operators will be willing to expend greater sums to realize better capture rates.

Sample of Eight Gold Shops with Systems Installed

	Annual Hg Combustion	Gold Shop Name	Recycling Projection for 2007 (Estimated Hg Capture = 45%)
1	120 kg	Jonito	60.0 kg
2	14 kg	Huda	7.0 kg
3	30 kg	Central	15.0 kg
4	33 kg	Nooryahya	16.5 kg
5	178 kg	Delta	89.0 kg
6	12 kg	Sahabat Baru	6.0 kg
7	52 kg	Karya Baru	26.0 kg
8	75 kg	Karya Family	37.5 kg

Total: 258 kg of Hg captured per annum

3.4 Field Follow-up Campaign

During the follow-up campaign, trainers revisited the five former camp locations, as well as the other mining camps in the surrounding area. Thus, the TDU was not restricted to one location but roved about to visit mining camps as they re-established themselves.

The follow-up work was an opportunity to build upon the understanding gained by the mining groups already encountered, and to build new relationships with new arrivals. Due to the high turnover in the workforce, field activities were extended so that more of the newly arrived miners could have contact with the TDU. Follow-up work continued until January 20, ending with a final full encampment at a sixth location.

As many new miners entered the gold fields and established new sites, mining communities that had no prior contact with the TDU were exposed to the media, technology, and training provided by the program from the new camp locations. Trainers provided health and technical advice in the form of equipment demonstrations and the delivery of mercury awareness booklets and films to all accessible mining camps.

Special efforts were made to reach all of the following mining locations:

Location	Location Bosses	No. of Rigs
A	Anum	17
	Anjir	5
	Pangat	6
	Yono	2
B	Samuji	10
	Misran	14
	Ibam	8
C	Huda	5
	Wah	3
	Yudi	5
D	Ijum	15
E	Usai	5
	Tris	10
	Fadlan	10
	Jam'an	15
	Agam	15
F	Syahrani	8
	Amir	6
	Su	3

As demonstrated above, the TDU approached 162 working rigs during the course of the follow-up campaign, and thus contacted over 800 miners. In addition, approximately 200 women had close contact with the TDU in the field, making a total of 1,000 individuals.
During this period, 1,000 booklets were distributed during consultations with trainers.

Recycling of Mercury in the Field

Most miners have little use for retorts. This is because they only retain very small amounts of amalgam (often less than 1 gram) and because their amalgam is usually burned at a trading post by a gold trader. There are, however, specific individuals in the field who accumulate gold and burn large quantities of amalgam. The unit bosses are one such group of individuals, and the other such group is the location bosses.

The first retort provided in the field was to unit boss, Pak Huda. He expressed interest in keeping the retort after a successful demonstration was performed using his amalgam. As the owner of five rigs, Huda accumulates around 30 grams of gold per day, which is an optimal amount to burn in a Fauzi retort at one sitting. The unit boss saw the benefits of using the retort and was pleased with its operation. With consistent use, he is now in a position to recycle around 600g of Hg per month.

Three other Fauzi retorts were provided in the field, all of them to location bosses who accumulate even greater quantities of gold, and combust large quantities of mercury.

When trainers explained its use, Pak Syahrani purchased a retort immediately. With eight rigs working at his location, he purchases around 100g of gold per day. Use of the retort thus allows him to recycle as much as 3 kg of mercury per month.

Another location boss, Pak Jam'an, was provided a retort for free – as he was in a position to recycle about 6 kg of mercury a month through its use.

By far the greatest success however, was with the manager of the Koperasi location. Camp location A operates a centralized management system that purchases and processes all of the gold produced by the 17 rigs operating at the camp headquarters. The camp produces around half a kilo of gold per day on average, aided by excavator machinery. The manager of the location first purchased a retort for use, and then also modified the fumehood at the headquarters with a water box condenser and blower. These interventions are likely to reduce the release of Hg to the atmosphere by 10 kg a month, as well as to reduce subsequent demand for Hg by the same amount, as the captured Hg is now recycled. It is therefore anticipated that over 100 kg of Hg emissions will be prevented during 2007 at this location alone.

4. Evaluation

4.1 Indicators of Successful Implementation

Numbers of People Consulted and Advised

- Through the combined activities of the launch; information sessions at mothers' groups; community education by trainers; film nights; seminars, films, and an art competition at the three local schools; and the continual consultations with gold shops, the project delivered its message to well **over 1,500 members** of the town community.
- Additionally, through the platform of the TDU, trainers provided consultation and advice on both health issues and technical issues to **over 1,000 members** of the mining community during the initial field campaign and the follow-up campaign.
- Thus, over **2,500 people** received information and advice by direct consultation.

Number of Booklets Printed and Distributed

A total of 3,000 booklets were printed and distributed to target audiences during the course of the project. Approximately 300 remaining booklets were provided to the departments of Mining, Environment and Health at the close of the project.

In addition to the above, 500 booklets on AIDS awareness were distributed to teenagers in the junior and senior high schools during an AIDS awareness seminar held by the health trainers; as well as 500 diaries and other AIDS awareness media, which was provided to the Department of Health at the close of the campaign.

Women's Participation in the Awareness Campaign

Cadres working with women's health groups received a high level of information from trainers from the local health clinic, which they were then able to pass on to members of their groups. Delivery of booklets was always accompanied by explanations by trainers, who simultaneously provided health advice. Women were a specific audience for the family health brochure, and women trained in the field included the wives of miners, and other women working in informal shops such as eating places and fuel shops.

Number of Radio Broadcasts

A two minute health advisory, warning people to avoid mercury exposure, was broadcast 150 times per month, and a half-hour interview segment with the local doctor and trainer was broadcast 12 times a month. Thus, a total of 450 advisories, plus a total of 36 half-hour interviews, were broadcast through December 2006 until the end of February 2007.

Degree of Change Effected in Amalgam Burning

The campaign was most effective at addressing the issue of amalgam burning in the urban environment. There is a concentration of amalgam burners in the town that can be addressed collectively, and consequently a greater degree of change can be effected. However, such change requires that leadership and initiative be taken by key

individuals, as the community of gold shops exhibits strong conformism and reluctance to change.

It was gradual shift to an intermediate level of technology that ultimately proved successful. It is likely that this paradigm shift towards recognizing the value of mercury recycling, coupled with the marked increase in concern for human health, will sustain the process of technological change and create new normative values at the top of the hierarchy of mercury suppliers. As the technology has been effectively demonstrated and proven to work, it is likely to undergo further development by operators themselves.

Mining Technology Improvement

A significant change observed during the course of the project was the widespread adoption of purpose-built amalgamation ponds, a concept that was heavily promoted by trainers from the Department of Mining. The community often stated that the purpose of building these separate ponds was to contain mercury and stop it from spreading into the bathing ponds. However, the main incentive for their construction was probably to retain the secondary minerals for resale to the zircon industry.

This practice contains the contaminated concentrates for collection, and reduces the level of mercury released on site - shifting the burden to the processing points of the zirconium buyers. This creates a new opportunity for intervention at these points, most of which are located within the town and which can more easily be addressed by local government departments wishing to have better standards within the zircon industry.

Community Members Involved

The project interacted closely with the mining community during the course of the project. Participation by gold shops grew quickly towards the end of the campaign, and likewise, many rig bosses and location bosses were very familiar with the trainers and the objectives of the campaign by the end of the program. These people are permanent residents of the town community and are the primary users and distributors of mercury in the gold fields.

Through the course of the program, trainers established a friendly rapport with this audience that overcame the barriers of hostility and suspicion through non-confrontational support for their activities, while suggesting alternative approaches to mercury use. Additionally, many members of the mining community had opportunities for close interaction with the project staff through the establishment of the six field camps.

The project also worked closely with staff from three schools, and over 600 students participated in learning exchanges and in the making of poster-art presentations.

Health workers distributed community health information to the general community of the town, specifically to mothers with infants, but also to shopkeepers, market-sellers, labourers, and the riverside community.

Peripheral Benefits

The health and technical booklets attracted a high level of interest from the outset and some samples were requested for local networks outside of the study area. As a result, 100 booklets were distributed 200 km to the north in the upper Kahayan river region, 180 km to the south east in the lower Kapuas river region, and a further 100 booklets along the road to Desa Kalanaman.

All of these areas have high levels of small scale gold mining activity. The Department of Mining took the initiative to promote the use of retorts in the field in the lake area named Kelaruh, as well as in Kalanaman. The project supported this local initiative with follow-up work along the road to Tumbang Samba in the area of Kalanaman, and one gold shop received equipment to modify its fumehood as a result.

Indications that Awareness will be Sustained

Due to the high turnover of miners towards the end of 2006, much of the mining community had been replaced by new immigrants by January 2007. Interestingly, the comparison study found that new arrivals were now often aware of mercury hazards, despite having had no contact with the TDU. Apparently, word-of-mouth is perpetuating the message within the community despite the high labour replacement rate. However, without a continuation of awareness-raising activities and the active promotion of retort and fumehood technology, the heightened level of awareness will be subject to entropy.

Fortunately, strong commitments to further the aims of the project were obtained from five government department during the wrap-up workshop. The focus of discussion was on promoting the use of mercury recycling technology. The departments of Mining, Industry, and Environment discussed how to promote the recycling technology of fumehoods and retorts, and the departments of Health and Education discussed how to educate the mining community to handle mercury as a toxic substance.

Government Commitments to Maintain and Extend the Activities

The wrap-up workshop sought to develop partnerships and a coalition among stakeholders through an open forum that encouraged contributions that promoted the concept of recycling and the use of intermediate technology. This multi-stakeholder event was attended by representatives of the district government, village heads, NGOs, women's health groups, location bosses, miners, and gold shop operators. It provided a forum to disseminate the findings of the project and gather wider feedback through participation by stakeholders. The support of the district government was evidenced by the presence of the District Head and heads of the five departments, as well as the in-kind contribution of the meeting chamber and other facilities for the workshop.

The commitments made by five government departments are meaningful statements that will translate into local action plans and new government regulations. The workshop deliberately focused on a narrow agenda to promote the concept of emissions reduction through recycling. This narrowed focus provided attainable goals that each department felt capable of committing to make a contribution towards.

The positive outcomes of the multi-stakeholder workshop are strong indicators that the heightened awareness will not only be sustained, but will also spread more widely at district level. This is likely to take place as a result of the following specific resolutions made by the government:

The Department of Mining committed to:

- Compel mine-operators and gold-shop-operators to use retorts and fumehoods through enforcement of regulations;
- Support and encourage law enforcement of the regulations concerning mercury trade and distribution;
- Conduct regular monitoring and evaluation regarding the use of mercury recycling technology; and
- Support and encourage the mining community to register their mining businesses with the relevant government departments.

The Department of the Environment committed to:

- Promote use of standardized fumehood equipment to gold shops, through enforcement of health and environmental regulations;
- Apply sanctions to businesses that do not conform to these regulations;
- Conduct socialization activities regarding mercury-recycling technology;
- Conduct regular, long-term public campaigns;
- Optimize the use of the media in providing public information;
- Seek a supplier for the intermediate technology;
- Conduct relevant training for civil servants and the community;
- Coordinate with other relevant departments and service-providers; and
- Work on a long-term plan to create a dedicated amalgam-burning centre.

The Department of Industry and Trade committed to:

- Formulate a new district level decree regarding the use of toxic substances;
- Form a coordination team to follow-up the campaign; and
- Formulate and forward a letter to the provincial government requesting follow-up be performed on existing provincial level regulations.

The Department of Health committed to:

- Formulate an integrated campaign for public awareness of mercury as a health hazard, and apply prevention measures targeting miners, gold shops, women and children – using various forms of media, including radio, TV, booklets, posters and leaflets;
- Encourage public participation in the above campaign;
- Work together with other relevant departments and services; and
- Conduct ongoing monitoring of the concentration of mercury in the public body.

The Department of Education committed to:

- Hold regular training for students on the dangers of mercury exposure;
- Include material about mercury hazards in the local syllabus;
- Provide training to students on safer, more effective gold processing technology; and
- Hold a seminar involving relevant officers on the dangers of mercury exposure.

All of the TDU equipment was officially handed-over to the Department of Mining so that it could continue to pursue this agenda, with the exception of the audio-visual equipment and the second prototype fumehood, which were provided to the Department of Environment, to promote further urban awareness raising and urban emissions reduction.

By focusing on the recycling technology of retorts and fumehoods, it seems possible to change the present constitution of the mercury supply chain and to reduce purchasing levels. Buyers will be in a stronger position, as they will be able to supply some of their own needs. As the technology becomes increasingly sophisticated and the number of users grows, capture rates are likely to increase. Hence, if a point is reached whereby all gold shops achieve capture rates of 90% or more, the market for mercury would be reduced to 50% of its current level. This would effectively reduce demand by around 2,000 kg per annum in the study area alone.

It is therefore important that the development of an industrial fumehood be continued beyond the two prototypes manufactured by YTS. As many gold shops have already embraced the idea of recycling mercury it should be relatively easy to make a further transition towards more sophisticated systems. As far as possible, these should be designed to be in keeping with existing systems.

Another successful campaign activity that needs to be furthered is the distribution of retorts to location bosses. This could be a subsidized activity, but in most cases bosses can afford to purchase retorts. It would be a mistake to expect miners to buy retorts, as they have little use for them. However, location bosses and unit bosses should be compelled to use them, and the Department of Mining has made a commitment to do so.

During 2006, government run activities planned by the Mining Department ran concurrent with program activities. These activities involved awareness raising and the promotion of retorts directly to miners in the field. In future, these activities are likely to spread beyond the study area, and use of the technology is likely to spread throughout the district.

4.2 Indicators of Change in Community Awareness

Prior to the campaign, a baseline study[1] was undertaken to focus on both the attitudes and the behavior of specific sectors of the community regarding their use of mercury. This baseline data was compared with the data obtained at the end of the campaign, using the same methods. As a result, it was possible to assess the changes that have taken place in the community regarding their level of awareness and their behavior regarding mercury.

[1] Baseline and Comparison Study, March 2007, YTS

Before the program, there was very little awareness in the Galangan community about the health hazards of mercury. Many men reacted with surprise and some concern when informed about these hazards, after baseline data had been gathered.

Women were more responsive on the issue, whereas men were more defensive. However, generally speaking, neither group took serious precautions to avoid contact with mercury in the local environment. Some people did claim to have separate places for bathing and obtaining drinking water and some tents apparently collected rainfall for drinking water. There were also small purpose-built amalgamation ponds made of plastic sheeting behind some tents.

By contrast, in the town of Kereng Pangi, many members of the community were well aware of the hazard that mercury poses. This was more apparent among long standing members of the community; however their knowledge was not communicated to those who had arrived more recently. Much of the community remained completely unaware of the dangers posed by the high concentration of gold shops in the middle of town.

In the town, the second survey measured the primary target group and the secondary target group independently. The primary target group was clearly identified as the operators of the 35 gold shops in Kereng Pangi. The secondary target group, sampled at random, was the community most affected by the activities of the gold shops.

In the gold fields, the second survey made a random sampling of the community to determine the efficacy of the awareness raising and training activities.

After the campaign, awareness levels that mercury is a health hazard had increased substantially throughout the mining community. Among gold shop owners, 100% in a sample of 20 gold shops took the view that mercury can damage one's health.

In the field, among the primary target group of gold miners, this awareness increased from 21% prior to the campaign to 93% at the close of the campaign. The secondary target group of women - not direct users of mercury - rose to a similar level, from 15% to 91% over the course of the six-month campaign.

Among the general community in the town of Kereng Pangi, there was a moderate increase in awareness: by the close of the project, 51% from a representative sample agreed that mercury was a health hazard.

4.3 Indicators of Change in Community Behavior

Capture and Recycling of 50% of Mercury Emissions

The project's prototype fumehood remained installed and functioning in the gold shop 'Toko Jonito' at the completion of the project, and the operator reported obtaining and recycling around 5 kilograms of mercury from the water trap per month. Due to the very high burning rates in the shop, this figure represents a recapture rate of around 50%, as 2.3 kilograms of mercury is estimated to be combusted each week in this particular shop. As this fumehood uses the same blower and water trap technology as the water-box condensers used to modify the existing fumehoods of the other gold shops, it is likely that the other gold shops are achieving a similar level of recovery.

Number of Modification Units Installed

The campaign had a lasting impact on the level of awareness of the community in the town and in the gold fields. This is most strongly reflected in the behavioral changes made by the gold shop operators, who expressed a strong desire to work together with trainers to improve the existing fumehoods in their shops and make their work places safer. This involved some capital expenditure on their behalf, albeit a small sum of money, it signified a genuine wish for ownership of the technology, reinforced by a wish to capture and recycle mercury using the equipment. The adoption of this recycling technology by 16 gold shops in the urban area (plus two outside the urban area) is a significant step forward towards a massive reduction of mercury emissions in the town of Kereng Pangi.

Forecasted Reduction in Mercury Emissions

At this early stage this figure is difficult to quantify, however it can be conservatively estimated that the condenser boxes may capture around 50% of the mercury fumes that would previously have been emitted. This will be equivalent to a reduction in emissions of over 500 kg per year in the urban area, and with the addition of the Koperasi location, perhaps as much as 600 kg per year will be recycled, as a result of existing modifications.

Number of Retorts Distributed

At least five 'Fauzi' retorts were in use in the field by the end of 2006. The users of these retorts were all rig owners who accumulate substantial quantities of gold on a regular basis from a number of rig operations. The vast majority of the gold produced in Galangan is traded by such rig bosses. These people are therefore the most appropriate users of retorts. By contrast, miners usually handle small balls of only one or two grams of amalgam. The willingness of several location and unit bosses to purchase and use these locally made retorts is a positive indicator of changing habits in the field.

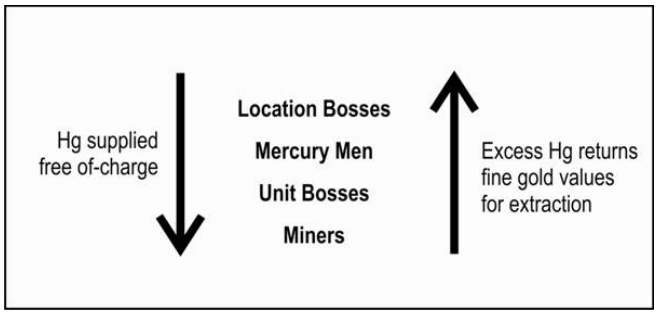
4.4 Barriers to Mercury Reduction

The initial campaign attempted to introduce use of an amalgamation drum as a model of efficient processing. However, miners showed very little interest in this concept and maintained that the process was too slow. They also considered their existing process to be more efficient at capturing the gold. It is true that their current process is more time-efficient, and it is also true that it is quite efficient at capturing the fine gold in the ore.
It could be said that attempts to promote the use of an amalgamation barrel failed due to the successful nature of the existing processes, but this would be an oversimplification, as the main obstacle to promoting this method is a systemic problem regarding the supply of mercury.

To clarify: it is necessary to study the reward mechanism to the location bosses from the miners. This is based on the miner returning excessive quantities of mercury to the location boss, which is one mechanism for paying for the use of the location. One gram of gold is obtained from each kilo of mercury returned to the supplier. Therefore, the existing hierarchy benefits from oversupply of mercury during the amalgamation process as illustrated below.

As can be seen, the existing hierarchy makes it very difficult for miners to change the existing amalgamation process, as the mercury is supplied free by the location bosses, because they can recover the fine gold from the excess mercury that the miners return to them.

Mercury Supply Mechanism



In this *pinjam* system, the miners only 'borrow' the mercury from the suppliers and do not pay for it. Most of the borrowed mercury is returned immediately after the amalgam process.

The miners are aware that the mercury still carries their fine gold values, and that this provides the economic return required by the mercury suppliers. The suppliers cool the excess mercury with ice, and then squeeze it further to obtain further amalgam.

This is the accepted modus operandi throughout the gold fields of Galangan. As a result, it was evident in all field locations that none of the miners were willing to consider any changes to the present process of amalgamation. All miners maintained that they are compelled to use mercury in the quantities it is provided at the site.

Furthermore, it is evident that promoting the use of 'less mercury' is completely contrary to the interests of the mercury suppliers at the top of the hierarchy, as they derive their benefits directly from the fine gold entrapped in the excess mercury and returned to them.

Location bosses intimidate miners into compliance with this system, and the mercury suppliers at each location are armed with weapons which they can use for this purpose.

Miners are thus obligated to use excessive quantities of mercury by the 'Mercury Men' who operate the local syndicates as protection rackets. If miners do not comply with their demands, their equipment will be damaged and they may be forced out of the location.

For these reasons, it is necessary to consider how to intervene after the process of amalgamation has taken place; namely, to promote the on-site reprocessing of the mercury bearing waste concentrates. If these can be efficiently reprocessed by the miners, the greater monetary rewards may mean the processes are likely to be adopted.

Cultural Barriers

Due to prevailing superstitions and the practice of 'black magic' by local shamans there is a common misconception that the application of mercury to the skin, or drinking doses of it while reciting a mantra, can make a man stronger. Reportedly, some miners do rub mercury directly onto their skin in a ritual practice, in the belief that this will protect them, make them stronger, and perhaps even invulnerable to attacks by knives and bullets. Most community members are aware of this practice and can cite examples of people who have done it. Several individuals were encountered who had themselves drunk regular doses of mercury. This cultural anomaly is the cause of a widespread disbelief in the community that mercury is dangerous to human health, because these individuals are evidently healthy.

Barriers to Change in Gold Shops

From early November, the urban trainers, the TDU operator, and the project manager, visited many of the gold shops in Kereng Pangi in an effort to promote the use of retorts, and also to consider how to improve the design of existing chimneys. The gold shops maintained their resistance to the idea of using closed retorts because they required too much time to operate. Other major reasons stated were:

- They believe the retorts are impractical to operate;
- They believe the sellers will feel cheated and they will lose business;
- They want to see the maturity of the gold as the amalgam burns; and
- They fear that if the gold is burned too hot for too long, they will lose a percentage.

4.5 Barriers to Enhanced Gold Production

The TDU concept has a lot to offer miners, as it takes the activity directly to the field and allows for direct interaction. Unfortunately though, without prior field-testing of the equipment, implementation easily devolves to experimentation. Thus trainers often found it difficult to prove that the new principles and features could actually produce more gold.

Sluice Demonstrations

The TDU constructed a portable zigzag sluice from the plan in the workshop manual. It proved valuable for dry demonstrations, and erected by the side of the road, caused a lot of passing miners to stop and take a look. It allowed miners to study the materials and the adjustable slope angles, and the features could be quickly understood.

Unfortunately, all attempts made to install it at a mine site and field test it failed, as the design did not match field conditions. For example, during the second week of the campaign, a site was chosen for its proximity to an operating sluice, which was easily accessible. Although the zigzag sluice was small, it required four men to carry and install it. With prior permission from the miners, it was placed below the outfall of their sluice. This was the most practical way to obtain the feed, but the slurry entered far too fast, and in much too great a volume. It was evident from this trial that it was not possible to simply process the tailings from another sluice directly, as the demonstration sluice box was designed to operate at a far lower capacity.

Later, an attempt was made to remedy this by splitting the flow and feeding half of the slurry to the zigzag sluice, and half to the ordinary sluice. It was hoped that a direct comparison could thus be made between the effectiveness of the two sluices. Over the course of two days, a splitter was fitted to the head with a down pipe that fed into the zigzag sluice. Although this pipe sloped downwards, it nonetheless quickly filled with sand, ending the experiment after only a half hour of operation. Due to the relative heights of the sluices and the topography, it was impossible to remedy.

A successful demonstration would require the installation of a larger sluice rated to the capacity of the existing pumps (12 Tonnes per hour). This would not be 'transportable' in the ordinary sense, and would be a substantial undertaking given the technical challenges that must be overcome to get the sluice operating smoothly at an active mine site.

Later, a 1.4m wide sluice with a rock screen was built and used to try to capture losses from the miner's sluices and thus prove to the miners that their processes are inefficient.

This mini-sluice was used to demonstrate how to improve gold capture, and was erected at each camp location in tandem with a working sluice. The mini-sluice had the appropriate slope angle and width to demonstrate how to reduce flow velocity, and also featured a rock screen and a nomad carpet that retained more concentrate.

However, after several attempts in several locations, it was not possible to demonstrate any significant losses. The mini-sluice was installed in tandem with existing sluices at four locations, and processed tailings for 5 to 6 hours at each location. At the end of each day, the concentrate from the tailings-sluice was processed together with the work gang, who always showed a high level of interest in the proceedings. However, daily results from this process were minimal, and no more than half a gram of amalgam was obtained from any one of these trials. The conclusion is that, given the limited means available, the miners in the field do a reasonable job of recovering the larger gold particles from the ore (which constitutes the bulk of the gold in the ore).

Much of the gold in this location has precipitated from solution, and consequently there is a large percentage of fine gold in the ore. However, both the results of the above trials and technical input from the University of Aachen, confirmed that a focus on improved recovery of fine gold is essentially beyond the miners' present economic means.

5. Recommendations

5.1 SWOT Analysis

Strengths

By moving freely between the field and the town, trainers could interact with all of the actors in the mercury supply chain. As key individuals utilized most of the mercury, it was important to be able to provide close consultation and technical assistance to location bosses and unit bosses in the field at an inter-personal level.

Likewise, by taking a targeted approach to mercury users in the urban area, gold shop operators became personally interested in improving their equipment.

The project developed positive working relationships with these individuals by taking a careful and collaborative approach to build trust and to gradually overcome the natural suspicion that the project was trying to interfere with the activities of these key actors.

This so-called 'top down approach' was effective because the supply of mercury is dictated from the top down by syndicated trading networks. The project was successful in achieving an understanding with those at the top of the network because of the inclusive and participatory approach taken in searching for technical solutions.

By employing local trainers with local understanding, important ideas were communicated effectively. This was supported by the widespread media campaign that reinforced general awareness, while also providing specific information. As government staff served as trainers throughout the implementation, these officers are now able to institutionalize their experience and learning within their organizations. This level of direct involvement in the project has brought reality-based understanding into government, and has helped to reinforce the commitment of government to the goals of the project, as well as strengthening public perception that government is leading the initiative.

Weaknesses

The attempts to reduce levels of mercury use during the amalgamation stage failed because the technological approaches were made based on assumptions that the miners could themselves determine the amount of mercury they used in the process.

After observing the reality in the field, it became evident that the miners had no control over the amount used, as it was governed entirely by local syndicates. Therefore, it was not possible to intervene in the amalgamation stage, and the trainers were limited to promoting the use of purpose-built amalgamation ponds.

The attempts to improve incomes through enhancing gold capture were also based on weak premises. Miners have arrived at their present methods through long experience. They strike a balance between capital and labour costs and the expected yields. Methods to maximize the recovery rate from the ore will therefore be rejected if they are more capital-intensive or labour-intensive, if they reduce the overall level of return.

For example, using an expensive type of carpet and a reduced slope angle will capture more heavy sand and increase the amount of concentrate at the end of the day. From the miner's point of view this is not desirable, as this requires more time to process. It also requires the use of greater amounts of mercury. As a result, miners prefer to use steeper slope angles, because they do not wish to accumulate too much bulk of sand in the sluice.

For future projects, UNIDO should provide on-the-ground technical experts during preparation phase to work with trainers in finding the best technology solutions that are accepted by the miners and gold shop owners. The project trainers were not trained to experiment with technology, and a lot of time was taken away from reaching the target population by having to experiment with technology

Due to the low level of investment in equipment that exists presently, methods that are more capital-intensive are generally viewed as unattainable. There is a danger that demonstrating expensive equipment in the field is merely interpreted as showing-off.

Similarly, methods that are more labour-intensive will be rejected, as miners balance labour inputs against returns. They will not invest extra time and energy in an activity unless it can be proven to provide extra benefits to the current opportunity-cost.

To prove the effectiveness of alternative processes, a working mine would have to be established, and the theoretical ideas tested, optimized, and proven to be of greater benefit than existing processes, before being demonstrated to miners.

Opportunities

Intervention with fumehood technology in gold shops has proven to be a direct method of substantially reducing emissions. Gold shop operators appreciate technical assistance and want to make their work environments safer. Therefore, fumehood technology that is appropriate to their needs is likely to be adopted, as long as it is reasonably affordable.

Retorts are not an acceptable solution for gold shops in the competitive gold market of Kereng Pangi, as operators will not accept the increased workload and turnaround time.

The opportunity is strong to achieve full adoption of the technology by all gold shops in town and in the surrounding areas, driven by the example set by the eighteen gold shops that have successfully adopted the technology. Because of the strong economic incentive, other gold shops are likely to follow this example, especially if local government or a local NGO continues to promote the technology.

Gold shops may also be willing to operate as distribution points for retorts: for instance, if provided at a subsidized cost to the operators, they could be promoted directly to miners and even sold at a profit.

Lastly, there is an opportunity to reduce the release of mercury to the environment from gold tailings containing residual mercury that are brought into the town for further processing.

Contaminated gold tailings are presently bought by Puya processors for their zirconium values. Residual gold and mercury are extracted during cleaning and sorting the tailings, and this final concentrate is amalgamated with additional mercury. Unfortunately, this final concentrate is usually bagged and included with uncontaminated shipments to be sold overseas. However, this is a point where collecting these small amounts of concentrate from 22 locations in the town plus others in the field, would recover much of the residual mercury that is contained in the gold tailings.

Threats

The widespread adoption of intermediate technology to recycle mercury could easily be compromised by inappropriate government regulations regarding mercury storage and resale. If the technology of water-box condensers that recover mercury is to be promoted, the government must endorse the concept of recycling mercury for resale. If policies limit the capture and storage of mercury, it will limit the ability of gold shops to recycle it.

Recycling mercury is a sustainable activity that directly reduces levels of mercury emissions and reduces demand for mercury as a consumable. It prevents further purchases and is a self-perpetuating activity. Policies that prevent miners and gold shops using and storing mercury will have an adverse impact on implementing recycling technologies. As a result of project activities, it is likely that 600kg of mercury will be recycled in 2007 that otherwise would have been emitted into the atmosphere. This is a promising outcome that can easily be enhanced through promoting recycling technologies such as retorts and fumehoods.

It is important that there is good understanding in government circles about the nature of the campaign successes, so that future action and intervention will build on these successes, preferably through a continuation of the most effective campaign activities: namely, distributing equipment and providing advice to install condensers in gold shops; distributing retorts to bosses; and improving management of the zircon trade through separating contaminated gold tailings from clean stock. Without follow-up on these activities, some of the important findings from the project may not be addressed.

5.2 Strategies for Successful Interventions

- Focus only on mercury-recycling technology: rather than attempting to change a wide range of existing processes, it is more profitable to focus on adapting existing amalgam-burning processes to make them more sustainable.
- Employ a top down approach: seek key individuals in centralized locations, such as gold shop owners and gold traders. It is far simpler to address the large scale burning activities of these key individuals than the small scale burning activities of individual miners. It is also far more productive in terms of reducing high level mercury emissions.
- Build cooperative relationships with mercury users: behavior change in gold shops is likely to generate additional behavior change in the supply network. For example, gold shop operators can be encouraged to promote the use of retorts to miners, and can serve as distribution points for retorts to miners. Baseline studies show that gold shop owners endorse the use of retorts in the field because pre-burning in the field reduces their workload and simplifies their trade.

- Focus on centralized targets: gold dealers, location bosses, and unit bosses accumulate large amounts of gold and are especially good targets for retort use. These key individuals control the mercury supply and specify how it is used. Although they control most of the gold trade in the field, they usually own houses in town and spend much of their time in town. Future programs therefore can meet with them in town, and not bother seeking them out in the field.
- Extend the scope of intervention: river villages are good locations to effect education and training with miners. Programs aimed at this audience need not travel to mining sites on the river, as these miners frequent river villages to purchase goods and equipment, and reside there. River miners are serviced by gold dealers and gold shops at these locations. They do not use mercury in the same way as miners in Galangan. Instead, gold dealers perform the amalgamation and provide the mercury for it. The alluvium is first weighed, and once the waste that does not bond with the mercury is separated, it is weighed again. The miner is paid for the balance which is presumed to be the gold value. In this system of sale, it is in the interest of these gold dealers to use a retort, as it will maximize their returns.
- UNIDO follow up needed: to completely evaluate the medium term impact of the project and to ensure sustainability of results, UNIDO needs to follow up and accurately measure the amount of Hg being captured in the gold shops. This will provide a clear measure of how effective and sustainable the inputs from the project have been.

Appendices

Appendix I: TDU Components

1. Transportable Demo Unit (TDU)

Trailer- Mounted Aluminum Cargo Box with TDU Signage

2. TDU Components

Sluice Box Model
Elutriation Column
Retorts: Fauzi Retorts / Salad Bowl Retorts / RHYP Retorts
Portable Stove (Kerosene)
Portable Propane Torch
Amalgamation Drum 10-20 Kg
Amalgam
Gold Pans
Fumehood
Activated Carbon Filters
Scales: Gold Scale (20 Gram) / Sample Scale (200 Kg)
Slurry & Water Pump
Sieves (25mm, 2mm, 1mm, 0.5mm, 0.3mm, 0.15mm, 0.75mm)
Grizzley Screen (1 x 1 x 2.5 Cm)
Buckets
Tubs
Wheelbarrow
Shovels
Magnetic Sheet
Various Carpets
Mercury Reactivation Cell
Protective Equipment (Gloves, dust masks, boots, safety glasses)
Tent (6m x 6m)
Small Tools (Hammer, Screwdrivers, etc)

3. TDU Operational Supply

Tables
Mat
Tarp
Portable Power Generator
Tent Lighting
VCD Player
Voltage Regulator
Computer Projector and Screen
Cabinet
Cutlery, Glasses and Dishes
Camping Stoves & Cooking Material
Bedding Set
200 L Water Tank

Appendix II: Estimates of Unburned and Pre-Burned Amalgam Supply

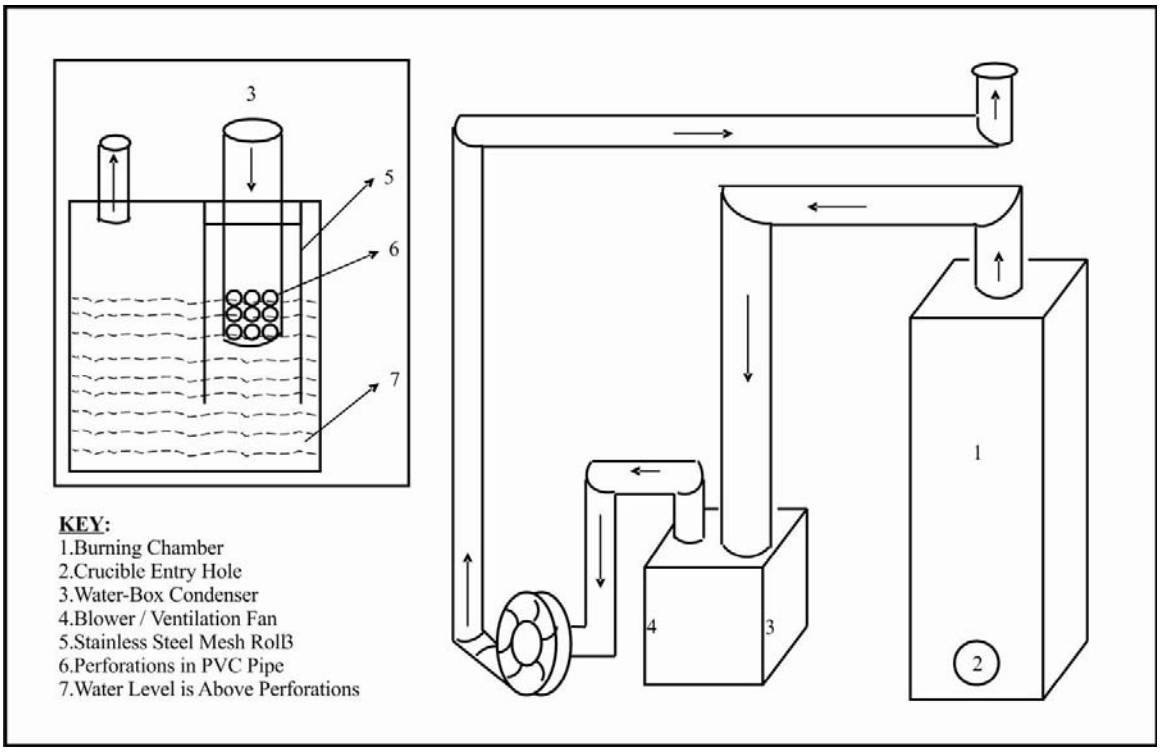
QUANTIFICATION OF UNBURNED AND PRE-BURNED AMALGAM SUPPLY: THESE ESTIMATIONS BY GOLD SHOPS INCLUDE 2006 RECOVERY LEVELS

	Cut-off is 20g Au													50% Cut-off	
SUPPLIED TO GOLDSHOP	Estimated # Balls/Day	Estimated Min Weight Au	Estimated Max Weight Au	Estimated Avg Weight Au	Annual Trade in Kilos of GOLD	**QUANTITY OF UNBURNED AMALGAM** Hg x factor	Avg Hg Weight	% is Unburned	Daily gm/Hg in Unburned Balls	**QUANTITY OF PRE-BURNED AMALGAM** Hg x factor	Avg Hg Weight	% is Pre-Burned	TOTAL gm/Hg Vaporised Daily	ANNUAL Kg/Hg Vaporised	Estimated RECOVERY	**ANNUAL EMISSIONS**
Huda	10	1	20	10.5	38,325	100%	10.5	30%	31.5	10%	1.1	70%	38.9	14,180	7,090	**7,090**
Delta	60	1	20	10.5	229,950	100%	10.5	75%	472.5	10%	1.1	25%	488.3	178,211	7,200	**171,011**
Jonito	50	1	15	8	146,000	100%	8.0	80%	320.0	10%	0.8	20%	328.0	119,720	36,000	**83,720**
Aulia Indah	12	1	15	8	35,040	100%	8.0	75%	72.0	10%	0.8	25%	74.4	27,156	3,000	**24,156**
Dua Saudara	4	1	15	8	11,680	100%	8.0	80%	25.6	10%	0.8	20%	26.2	9,578	0	**9,578**
Karya Famili	40	1	15	8	116,800	100%	8.0	60%	192.0	10%	0.8	40%	204.8	74,752	8,000	**66,752**
Al Karomah	20	1	8	4.5	32,850	100%	4.5	40%	36.0	10%	0.5	60%	41.4	15,111	3,600	**11,511**
Sahabat Baru	16	1	8	4.5	26,280	100%	4.5	40%	28.8	10%	0.5	60%	33.1	12,089	0	**12,089**
Maskanah	12	1	5	3	13,140	100%	3.0	40%	14.4	10%	0.3	60%	16.6	6,044	0	**6,044**
Kenangan Baru	25	1	10	5.5	50,188	100%	5.5	50%	68.8	10%	0.6	50%	75.6	27,603	400	**27,203**
Sumber Kayu	30	1	15	8	87,600	100%	8.0	50%	120.0	10%	0.8	50%	132.0	48,180	500	**47,680**
Noor Yahya	30	1	10	5.5	60,225	100%	5.5	50%	82.5	10%	0.6	50%	90.8	33,124	4,000	**29,124**
Pancar Indah	50	1	20	10.5	191,625	100%	10.5	85%	446.3	10%	1.1	15%	454.1	165,756	4,000	**161,756**
Sentral	30	3	7	5	54,750	100%	5.0	50%	75.0	10%	0.5	50%	82.5	30,113	0	**30,113**
Karya Baru	30	5	8	6.5	71,175	100%	6.5	70%	136.5	10%	0.7	30%	142.4	51,958	3,000	**48,958**
Swarga	12	1	10	5.5	24,090	100%	5.5	80%	52.8	10%	0.6	20%	54.1	19,754	0	**19,754**
Shop Average	26.9	1.4	12.6	7.0	74,357	100%	7.0	60%		10%	0.7	40%	142.7	52,083	4,799	47,284
TOTALS	431				1,189,718				2174.6				2,283	833,328	76,790	756,538

BURNED FOR GOLD SHOP	**QUANTITY OF Hg PRE-BURNED IN FIELD** # Balls/Day	Avg Hg Weight	% is Pre-Burned	TOTAL gm/Hg Vaporised Daily	ANNUAL Kg Vaporised Hg	Estimated RECOVERY	**ANNUAL**
Huda	10	9.5	70%	66.2	24,145	0	**24,145**
Delta	60	9.5	25%	141.8	51,739	0	**51,739**
Jonito	50	7.2	20%	72.0	26,280	0	**26,280**
Aulia Indah	12	7.2	25%	21.6	7,884	0	**7,884**
Dua Saudara	4	7.2	20%	5.8	2,102	0	**2,102**
Karya Famili	40	7.2	40%	115.2	42,048	0	**42,048**
Al Karomah	20	4.1	60%	48.6	17,739	0	**17,739**
Sahabat Baru	16	4.1	60%	38.9	14,191	0	**14,191**
Maskanah	12	2.7	60%	19.4	7,096	0	**7,096**
Kenangan Baru	25	5.0	50%	61.9	22,584	0	**22,584**
Sumber Kayu	30	7.2	50%	108.0	39,420	0	**39,420**
Noor Yahya	30	5.0	50%	74.3	27,101	0	**27,101**
Pancar Indah	50	9.5	15%	70.9	25,869	0	**25,869**
Sentral	30	4.5	50%	67.5	24,638	0	**24,638**
Karya Baru	30	5.9	30%	52.7	19,217	0	**19,217**
Swarga	12	5.0	20%	11.9	4,336	0	**4,336**
Shop Average		6.3	40%	61.0	22,274	0	22,274
TOTALS				976	356,390	0	356,390

Grand Total of kg/Hg released by trade:	1,112,928

Appendix III: Water Box Condenser System



Appendix IV: Working Schedule for Mercury Campaign Program

Working Schedule for Mercury Campaign Program

Galangan-Central Kalimantan, Indonesian
June 2006 - March 2007

Activities	June				July				Aug				Sept				Oct				Nov				Dec				Jan				Feb				March			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
A. Preparation																																								
1. Relationships and Patnerships		x	x	x	x	x	x	x																																
2. Field Survey					x																																			
3. Preparing Transportable Demonstration Unit					x	x	x	x	x	x	x	x																												
4. Creating and Producing Media Campaign					x	x	x	x	x	x	x	x																												
5. Organizing and Implementing TOT													x																											
B. Implementation																																								
1. Public Launching Program													x																											
2. Building Awareness & Demonstrating Technologies																																								
Group Galangan A/Targel Area 1													x																											
Group Galangan B/Target Area 2														x																										
Group Galangan C/Target Area 3															x																									
Group Galangan A/Targel Area 4																	x																							
Group Galangan B/Target Area 5																		x																						
Group Galangan C/Target Area 6																			x																					
Group Kereng Pangi D													x				x																							
3. Follow Up																																								
Group Galangan A/Targel Area 1, 4																					x				x				x											
Group Galangan B/Target Area 2, 5																						x				x				x										
Group Galangan C/Target Area 3, 6																							x				x				x									
Group Kereng Pangi D																					x				x				x					x	x					
C. Monitoring, Documentation, Reporting																																								
1. On Going Monitoring					x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x								
2. Monthly Reporting				x				x				x				x				x				x				x				x				x				
3. a. Radio Interaktif													x												x	x	x	x	x	x	x	x	x	x	x	x				
b. Newsletter									x								x									x							x							
c. Newspaper													x								x								x								x			
D. Program Closure																																								
1. Assesment and Analysis																																x	x	x	x					
2. Wrap up Event																																			x					
3. Final Reporting																																			x	x	x	x		
4. Closing Office and Project																																					x	x		

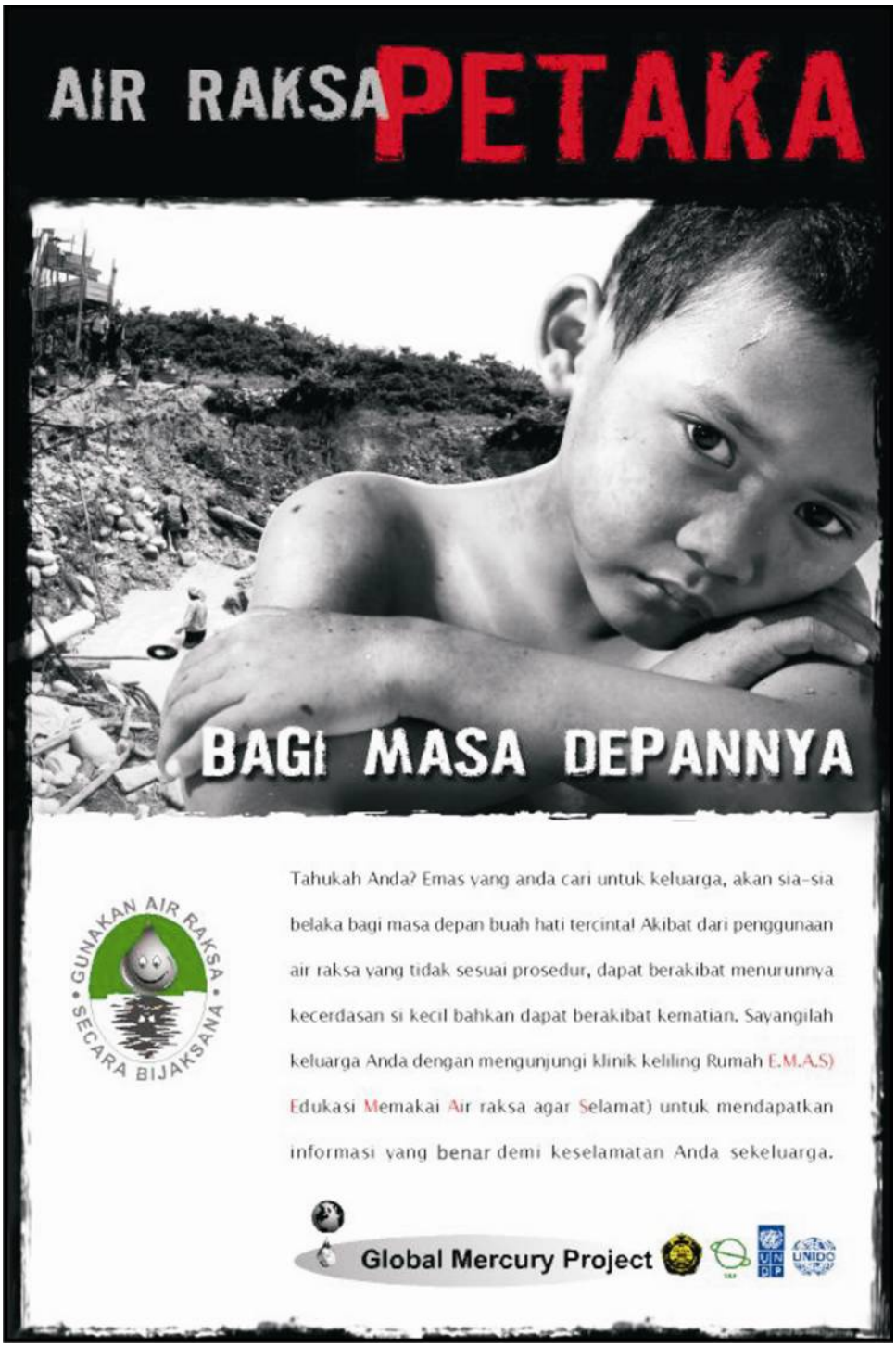
Appendix V: Contractor's Personnel

Trainer Name	Project Function	Project Area Contracted	Project Area Completed	Home Office Contracted	Home Office Completed
YTS CONTRACT STAFF		(Work-Months)	DAYS	(Work-Months)	DAYS
Bardolf Paul	Team Leader	0.4	10	2.4	54
Mayang Meilantina, M.P.	Project Assistant	1.2	28	3.1	69
Sumali Agrawal	Project Manager	4.8	108	2.7	82
Dzul Fikri, ST	TDU Operator	8.5	190	0.0	0
Kartie Vitamerry, ST	Communication Assistant	0.0	0	4.3	96
Yuliana, SE	Accountant	0.0	0	1.0	23
SUB-TOTAL			**336**		**324**
CONTRACT-LISTED TRAINERS		(Work-Months)	DAYS		
Ambu Naptamis, SE	Training Facilitator	1.1	24		
Rosita	Interpreter / Translator	2.1	0	Field translation not required	
G.T. Wirabella, S.Hut	Technical Facilitator	0.7	0	Trainer replaced	
Muchran	Technical Facilitator	0.7	17		
Irwanto D.Thomas, S. Si	Technical Facilitator	0.7	19		
Ari	Technical Facilitator	0.7	0	Trainer replaced	
Dr.Frinsevae Anggen	Health Facilitator	0.7	0	Trainer replaced	
Dedy Rusady	Health Facilitator	0.7	18		
Dr Robert Pamuryanto	Health Facilitator	0.7	17		
M. Hafid	Health Facilitator	0.7	29		
SUB-TOTAL			**124**		
REPLACEMENT TRAINERS					
Linde Diong	Technical Facilitator	0.7	19	Replacement trainer	
Fauzi	Technical Facilitator	0.7	18	Replacement trainer	
Adam	Education Facilitator	0.7	16	Replacement trainer	
TOTAL DAYS			**513**		**324**

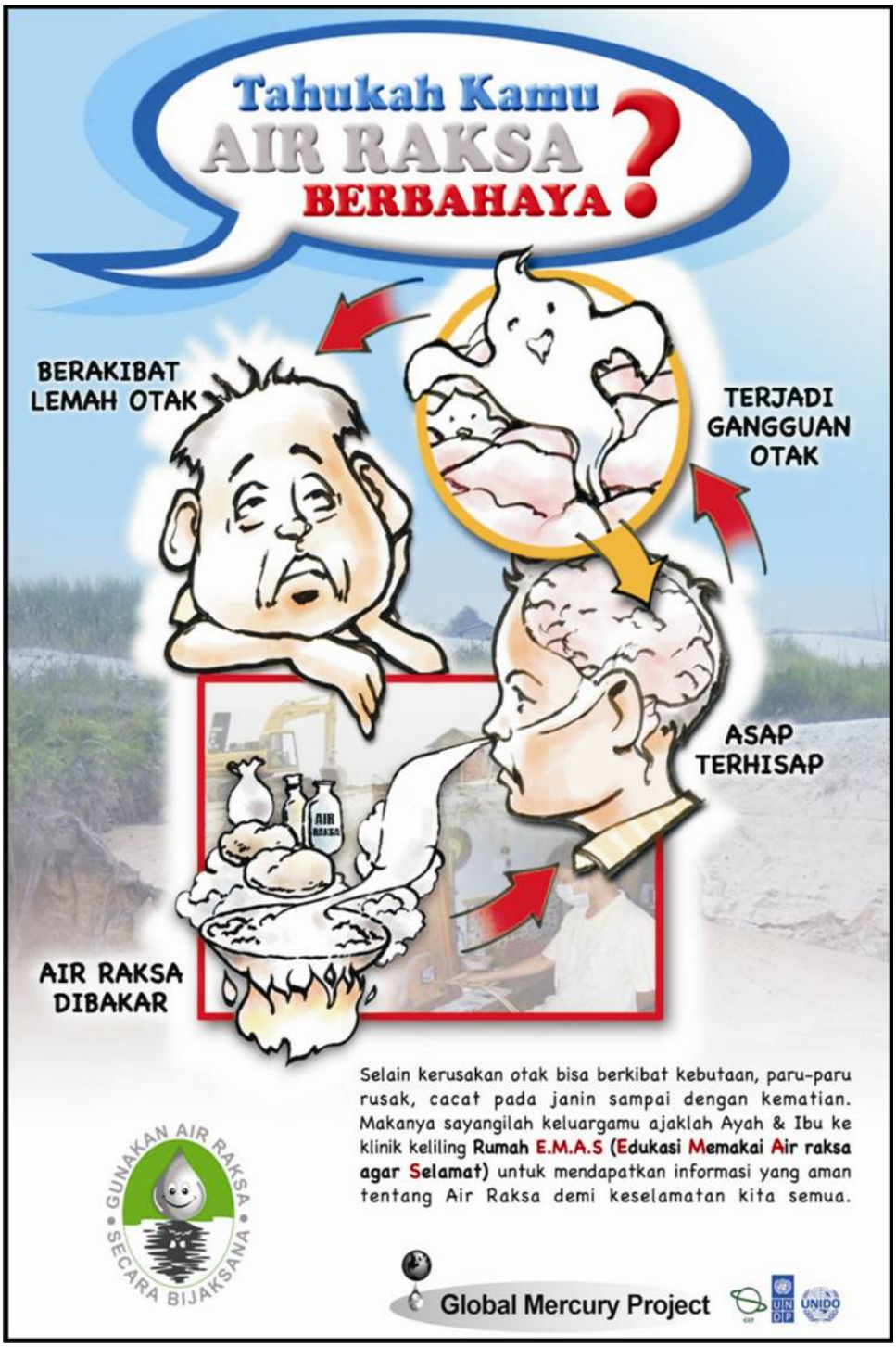
Appendix VI: Samples of Media – Billboard and Banners

Appendix VI: Samples of Media – Sticker and Flyers

Appendix VI: Samples of Media – Poster



Appendix VI: Samples of Media – Poster



Appendix VI: Samples of Media – Newsletters