SMALL AND MEDIUM SCALE
GOLD MINING DEMONSTRATION PROJECT

NORTHWEST DISTRICT

ARAKAKA

Prepared for

Guyana Geology and Mines Commission

Guyana Gold and Diamond Miners Association

Canadian International Development Agency

Natural Resources Canada

Environmental Protection Agency

and

University of Guyana

by

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EXECUTIVE SUMMARY

The objectives of this field program were to demonstrate small-scale exploration methods, gold recovery, and mining practices with an emphasis on worker safety and environmental mitigation.

The site of the demonstrations was in and near Arakaka in the Northwest Mining District (1) of Guyana, South America (figure 1). Similar demonstrations were conducted in Mahdia in September, 1999.

Technical seminars were held in Arakaka for four evenings (April 3rd, 4th, 5th and 7th). GGMC (Unata Boston, Mickle Bertuen and Ronald Glasgow) presented information to inform local miners and workers in all aspects of alluvial mining including exploration, mine planning, gold recovery, safe mercury amalgamation, water management and environmental restoration. Outlines of the seminar topics are appended (Appendix A).

Three sluiceboxes were refitted with riffle systems at small lode/vein and alluvial mines near Arakaka. Comparative radiotracer testing was conducted at Moen Insanalli's operation on his original and refitted sluiceboxes to prove the efficiency of the refitted sluicebox to miners. In this demonstration 25 gold particles (150 microns) were recovered within the first 4 ft of the sluicebox (pictures 12 and 13).

Conventional testing with the small testing sluice was conducted on the tailings from John Phillips' secondary (hammer mill product) sluice. The small testing sluice was also used to demonstrate how to upgrade sluicebox concentrates prior to amalgamation at Moen Insanalli's (picture 9) and John Phillips' operations (picture 14).

Safe mercury handling and retorting methods were demonstrated at the seminars and at Moen Insanalli's, John Phillips' and Bryan Phillips' mine sites (pictures 10 and 18). Six retorts were left at Arakaka to reduce the occupational and environmental hazards associated with "burning" mercury.

This program is part of the Guyana Environmental Capacity Development Project (GENCAPD) which is being sponsored by the Canadian International Development Agency (CIDA), and delivered by Natural Resources Canada (CANMET).

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INTRODUCTION

The site of the demonstrations was in and near Arakaka in the Northwest Mining District (1) of Guyana, South America (figure 1). Similar demonstrations were conducted in Mahdia in September, 1999. Access to Arakaka is by rough dirt roads from airstrips at either Port Kaituma or Mathews Ridge (figure 1). Port Kaituma is also a river port and home to a large timber harvesting operation.

Arakaka lies in the Barama-Mazaruni greenstone belt, greenstone belts are common hosts of gold deposits. The area is a historic mining area with many small-scale lode/vein and residual/alluvial gold mines. The deposits are generally the weathered surface exposure of steeply dipping, gold-bearing quartz veins in red or red/brown saprolite clays. Generally, the only remaining non-weathered mineral is quartz from the veins. The open pit at Richard Rodriguez' operation indicates that the host rocks have been weathered to a depth of at least 100 ft (30 m, picture 1). Generally the soils at the mining sites near Arakaka were fairly solid and supported heavy equipment relatively well.

The veins are mined using hand-held water jets to erode the weathered veins (picture 2). The miners all used Brazilian gravel pumps to pump the gravels to a raised wooden sluicebox (land dredging). At most mines, all of the soils, including barren overburden and clays were moved with the gravel pumps and processed by the sluiceboxes (pictures 3 and 4). This resulted in excessive dilution of the ore with barren overburden, which could otherwise be stripped (if heavy equipment is available and used) and moved prior to mining. Heavy equipment including bulldozers and excavators were used at Mr. Insanalli's and Mr. Rodrigues' mines to break up the vein or cemented gravels (catch cow) and increase the throughput to the sluiceboxes. Heavy equipment was used at Insanalli's operation to move low grade and waste materials from the pit area (picture 2). A lack of exploration and delineation of the deposits by drilling, trenching or pitting, meant that the deposits were advanced on a day-to-day basis.

John Phillips and Richard Rodrigues used hammer mills to grind the oversize quartz and then sluiced them once more (picture 5). John Phillips reported that he recovered more gold from the pay gravels after they were ground in a hammer mill. Moen Insanalli was conducting test work to determine the values of locked gold in his oversize gravels. Several of the sluiceboxes were already using Nomad matting and expanded metal riffles due to recommendations from an earlier visit in February of 1997.

1.1 Mine Site Descriptions

a) *Moen Insanalli*

At Moen Insanalli's operation, the gold was located in a steeply dipping (30 degrees) quartz vein/shear zone that ranged in width from 8 to 15 ft (2.5 to 4.5 m). The vein was aligned roughly parallel with the valley floor (strike of 259 degrees magnetic). Movement along the zone must have occurred after the quartz and gold were deposited in the vein. The center of the vein consisted of ground quartz and yellow clay (fault gouge). This was sandwiched on both sides by relatively solid white quartz. The quartz was surrounded by red or red/brown saprolite clay. One area of the vein was too hard to dig with excavators and the operator had moved downstream where the vein was softer and more sheared.

The miners were using four hand-held water jets to wash down a 20 ft (6 m) tall benched face and direct the gold bearing quartz vein and surrounding clay into a clay/bedrock sump. Diluted gravel slurry was pumped from this sump to either of two twin wooden sluiceboxes using six-inch (150 mm) Brazilian gravel pumps powered by a six-cylinder diesel engine. The miners had a total of seven jets and two gravel pumps but the operator intended on enlarging the bottom of the pit before operating all of the jets and both gravel pumps at the same time. Two bulldozers and/or excavators were used to break up the vein and push the material to the jets. The bulldozers were also used to push barren or low-grade soils away from the pit (picture 2).

The two sluiceboxes were originally fitted with bare Nomad matting in the inverted top of the sluicebox (picture 3). This was followed by a deep wooden boil box and then by coarse expanded metal riffles over ribbed Brazilian carpet. Bare ribbed Brazilian carpet was used in the lower part of the sluicebox. The general manager indicated that the bare Nomad matting wore out very quickly. The sluiceboxes were too wide at 8 ft (2.5 m) and had to be raked by hand to keep rocks from building up on the deck.

The sluicebox slurry was discharged into a dammed tailings pond (picture 6). Clear water was recirculated via a ditch to a 6 by 8 inch centrifugal water supply pump (picture 7). No effluent was discharged to the environment. The general manager wished he could drill near and under the tailings pond in case he was covering up good gold grades. The manager had completed some testing with a small hammer mill to determine if there were economic values of gold in the oversize quartz rocks.

One of the twin sluiceboxes was modified to 4 ft wide for the top sluice (picture 8) and 6 ft wide for the main sluice (picture 4). The cracks in the floor of the sluice were filled. The top sluice was fitted with a short steel slick plate and a 4 ft section of one-inch angle iron riffles fitted tightly over unbacked Nomad matting. The wooden boil box in the main sluice was reduced in height from 9 to 3.5 inches to reduce the build of gravels. This was followed by an 8 ft length of coarse expanded metal riffles fitted tightly over unbacked Nomad matting, a 4 ft section of steel slick plate, and another 4 ft long section of coarse expanded metal riffles fitted tightly over unbacked Nomad matting. The remaining bottom 10 ft of the main sluice was fitted with bare Nomad and ribbed Brazilian carpet. Radiotracer tests were conducted on the original box while the other was being refitted. The sluicebox ran for several hours before the tracers were added and for several hours after the tracers were added. Two radiotracers were detected in the tailings shortly after their addition. Then the slurry was switched to the refitted sluicebox and it was salted the next day with radiotracers.

Both sluiceboxes were washed down separately and their concentrates were upgraded on the author’s testing sluicebox (picture 9). This demonstrated the advantages of upgrading sluicebox concentrates prior to amalgamation. These concentrates were dried and sieved into several size fractions. The radiotracers were removed and counted. Each size fraction was weighed, split, and the purity was estimated by hand picking or panning. The concentrate was returned to a bucket and amalgamated with mercury. The mercury was filtered in a cloth and then recovered while demonstrating the use of a mercury retort (picture 10). The calculated gold size distribution was reconciled with the weight of the gold buttons.

The results indicated that the original sluicebox was relatively efficient and had a gold recovery efficiency of 78%, due to the more steady gravel pump output and the use of Nomad mats and coarse expanded metal riffles. However, this was increased by 17% to 95% after narrowing and refitting the sluicebox. The refitted sluicebox was more efficient at fine (100 mesh, 150 micron) and for chip size (14 mesh, 1.2 mm) gold recovery.

The radiotracers also indicated that shallow (3.5 inch, 90 mm deep) boil boxes work at least as good as the deeper boxes. Boil boxes are probably not necessary for gold recovery. The radiotracer gold was more concentrated at the top of the angle iron riffles and the top of the expanded metal riffles in the refitted sluicebox. The radiotracers traveled further down the original sluicebox (34 versus 24 ft, 10 versus 7 meters). The standard error for the test work ranged from +-4% for the original sluicebox to +- 1% for the refitted sluicebox.

Most of the gold recovered by both sluiceboxes was between 200 and 28 mesh (74 and 600 microns) and the most common size was 100 mesh (150 microns). The wide size distribution of the gold particles is typical of residual or vein deposits. The gold was very irregular in shape and porous, this indicates that it is near or at the lode source.

The production from these land dredges (with one six-inch pump and six-cylinder motor) is about 16 to 22 loose cubic yards per hour (12 to 17 cubic meters per hour). The pumps also pump from 600 to 1,000 Ig/m or about 50 to 75 liters per second of water. The pumps only operate at full output for about 75% of the time. The daily production is about 122 cubic yards (93 cubic meters) per day. All of the soils surrounding the vein are commonly processed through the pump and this creates some dilution of the gold grades. The authors only observed the area for an eleven day period, however, the results of the test work also indicate that undiluted gold grades in this area are higher than those commonly mined in North American alluvial gold mines.

b) *John Phillips*

At John Phillips' operation, the gold was located in a steeply dipping zone (30 degrees) of several erratic quartz stringers. The quartz was surrounded by red or red/brown saprolite silty/clay that appeared to originally have been gneiss (metamorphosed granite). The stones were irregular fragments of quartz. All other rock types appear to have been completely decomposed to clay.

The miners were using three hand-held water monitors to wash down a 50 ft (15 m) tall face and direct the gold bearing quartz stringers and surrounding clay into a clay/bedrock sump (picture 11). Diluted gravel slurry was pumped from this sump to a wooden sluicebox using a six-inch (150 mm) Brazilian gravel pump powered by a six-cylinder diesel engine. The owner had a bulldozer but did not use it to bench the face, push the material to the jets, or to push barren or low-grade soils away from the pit.

The single sluicebox was fitted with a deep wooden boil box, a short section of dredge riffles (2.5 inches deep), and a section with fine warped expanded metal over Brazilian carpet. Bare ribbed Brazilian carpet was used in the lower part of the sluicebox. The sluicebox appeared to be too narrow at 4 ft (1.2 m) for the gravel pump output.

The sluicebox slurry was discharged into Arakaka Creek on the downstream side of a water supply dam. Clear water from Arakaka Creek on the other side of the dam was pumped with a 4 by 6 inch centrifugal water supply pump.

Another wider sluicebox (5 ft, 1.5 m) was built beside the original sluicebox (pictures 12 and 13). The cracks in the floor of the sluice were filled. The top sluice was fitted with a short (4 ft, 1.5 m) section of coarse expanded metal riffles fitted tightly over unbacked Nomad matting and a short section of slick plate covered with Brazilian carpet. This was followed by an eight-foot length of coarse expanded metal riffles fitted tightly over unbacked Nomad matting. The sluicebox was then narrowed to 2 ft (0.6 m) wide and fitted with one-inch angle iron riffles fitted tightly over unbacked Nomad matting.

The production from the land dredge was about 11 to 17 loose cubic yards per hour (8 to 13 cubic meters per hour). The gravel pump also pumped from 600 to 900 Ig/m or about 50 to 70 liters per second of water. The pump only operated at full output for about 75% of the time. The daily production is about 87 cubic yards (67 cubic meters) per day. All of the soils are processed through the pump and this dilutes the gold grades significantly.

The authors used radiotracers to prove the efficiency of the refitted sluicebox to workers. In this demonstration, 25 gold particles (150 microns) were recovered within the first 4 ft of the sluicebox (pictures 12 and 13).

The small testing sluice was used to demonstrate how to upgrade sluicebox concentrates prior to amalgamation. The workers tested each section of the refitted sluicebox separately and tested the tailings from the small testing sluice with a battel to satisfy themselves that the refitted sluicebox was efficient (picture 14). The sluicebox concentrate was amalgamated with mercury and the use of a retort was demonstrated to Mr. Phillips and his workers. They were amazed at the amount of mercury recovered by the retort from the gold/mercury amalgam.

The tailings gravels from the primary sluiceboxes were fed with a small excavator to a hammer mill and small sluicebox. The quartz was ground to a top size of 0.25 inches (6 mm) and a consistency of coarse sand/fine gravel. The hammer mill had high wear and its hammers had to be replaced every three hours. The hammer mill produced about 2 loose cubic yards (1.5 m^3) per hour or about 12 cubic yards (9 m^3) per day. The gravel was discharged from the hammer mill with only 34 Ig/m (3 liters/second) of water resulting in a very high density of 17% (by volume).

The hammer mill sluicebox was 1.2 ft (360 mm) wide and 35 ft (10.6 m) long. It was fitted with a short section of packed dredge riffles, some bare unbacked Nomad matting and ribbed Brazilian matting (at the end). The testing sluice processed some of the tailings from the hammer mill sluicebox and recovered some coarse (3 to 4 mm) gold particles. The water flow to the sluicebox should be increased to at least double its present volume and a section of this sluicebox should be narrowed to about 10 inches (250 mm) in width and fitted with coarse expanded metal riffles over Nomad matting to improve coarse gold recovery.

c) *Bryan Phillips*

At Bryan Phillips' operation, the alluvial/residual gold deposit was located in a small gulch about 500 meters from the village of Arakaka. The gold particles were irregularly shaped fragments that ranged in size from 200 mesh (74 microns) to chips (1 mm) and larger nuggets. The gravel was almost entirely composed of irregular white quartz gravels with minor spherical ironstone (illmentite) balls. All other rock types appear to have been completely decomposed to clay. The gravels were overlain by a red/brown silty/clay overburden and underlain by white clay/bedrock (picture 15).

The miners were using hand-held water monitors to wash down a 20 ft (6 m) tall face and direct the gold bearing gravels and overburden into a clay/bedrock sump.

Diluted gravel slurry was pumped from this sump to a wooden sluicebox using a six-inch (150 mm) Brazilian gravel pump. The owner did not use any heavy equipment to assist in the mining operation except for clearing brush.

The single sluicebox was fitted with a deep wooden boil box, a short section of dredge riffles (2.5 inches deep by 2.5 ft long), a short 5 ft (1.5 m) section of bare Nomad matting and a long 19 ft (5.8 m) section of ribbed Brazilian carpet. Bare ribbed Brazilian carpet was used in the lower part of the sluicebox. Several people appeared to be making a living by hand panning the tailings from the sluicebox.

The sluicebox floor was sealed and it was refitted with an 8 ft (2.4 m) long section of coarse expanded metal riffles over unbacked Nomad matting, a 4 ft (1.2 m) slick plate covered by bare Nomad matting and then another 4 ft (1.2 m) long section of coarse expanded metal riffles (picture 16). The last 8 ft (2.4 m) of the sluicebox was narrowed to 2 ft (0.6 m) and refitted with one-inch (25 mm) angle iron riffles over Nomad matting (picture 17). Bryan Phillips installed 7 ft (2.1 m) of ribbed Brazilian carpet in front of the angle iron riffles (to reduce wear to the wooden sluicebox floor).

The production from the land dredge was about 14 to 19 loose cubic yards per hour (11 to 15 cubic meters per hour). The gravel pump also pumped from about 770 Ig/m or about 60 liters per second of water. The pump only operated at full output for about 75% of the time. The daily production is about 108 cubic yards (82 cubic meters) per day. All of the soils are processed through the pump and this dilutes the gold grades significantly.

The operation of a mercury retort was also demonstrated to Bryan Phillips and his workers and family (pictures 18 and 19).

d) *Richard Rodrigues*

At Mr. Rodrigues’ operation, the gold was located in a steeply dipping zone of several erratic quartz stringers. The quartz was surrounded by red or red/brown silt. The stones were fine irregular fragments of quartz. All other rock types appear to have been completely decomposed to clay.

The miners were using hand-held water monitors to wash down an 80 ft (15 m) tall face and direct the gold bearing quartz stringers and surrounding clay into a clay/bedrock sump. Diluted gravel slurry was pumped from this sump to a wooden sluicebox using an eight-inch (200 mm) Brazilian gravel pump powered by an eight-cylinder diesel engine. The owner used bulldozers to bench the face and to push the material to the jets (picture 19).

The single sluicebox was fitted with a deep wooden boil box, a 7 ft (2 m) section of dredge riffles (2.5 inches deep), a 16 ft (4.8 m) section with fine warped expanded metal over Nomad mat, and 17 ft (5.3 m) section of bare ribbed Brazilian carpet. The sluicebox appeared to be too narrow at 6 ft (1.8 m) for the gravel pump output. Richard Rodrigues' mining operation was shut down due to heavy equipment repairs for most of the period and therefore his sluicebox could not be widened and refitted in time.

The sluicebox slurry was discharged into Arakaka Creek on the downstream side of a water supply dam. Clear water was pumped from Arakaka Creek on the other side of the dam.

The production from the land dredge was measured at about 6 to 8 loose cubic yards per hour (5 to 6 cubic meters per hour) but this was at a very low density of solids (2%). The actual mining production should be in the range of 18 to 30 loose cubic yards per hour (13 to 23 loose cubic meters per hour). The gravel pump also pumped from 1200 Ig/m or about 90 liters per second of water. All of the soils are processed through the pump and this dilutes the gold grades significantly.

The tailings gravels from the primary sluicebox were pushed up to a small excavator, which fed them to a hammer mill and small sluicebox (picture 5). The quartz was ground to a top size of 0.25 inches (6 mm) to a consistency of coarse sand/fine gravel. The hammer mill produced about 9 to 12 loose cubic yards (7 to 9 m^3) per hour or about 65 cubic yards (50 m^3) per day. The gravel was discharged from the hammer mill with only 360 Ig/m (30 liters/second) of water.

The hammer mill sluicebox was 4 ft (1.2 m) wide and 44 ft (13 m) long. It was fitted with a short section of packed dredge riffles, a short section of coarse expanded metal over Nomad and Astro Turf carpet, and a long length (20 ft, 6.2 m) of bare Astro Turf carpet. This sluicebox should be narrowed to ½ of its width.

e) *Timothy Adams*

At Timothy Adams' operation, the alluvial/residual gold deposit was located in a small valley about a 40-minute walk along jungle trails from John Phillips' operation. There were several small land dredges operating in this area and several were reworking older tailings. The gold-bearing material was mainly washed angular quartz-rich gravels that were pumped up to elevated wooden sluiceboxes. All other rock types appear to have been completely decomposed to clay. The gravels were underlain by white clay/bedrock.

There was virtually no heavy mobile equipment working in this area due to the poor access. The miners were using hand-held water monitors to wash down a 7 ft (2 m) tall face and direct the gold bearing gravels and overburden into a clay/bedrock sump. Diluted gravel slurry was pumped from this sump to a wooden sluicebox using a six-inch (150 mm) Brazilian gravel pump.

The main sluicebox was 6 ft (1.8 m) wide and was fitted with a deep wooden boil box, a section of dredge riffles (2.5 inches deep by 6.5 ft long), and a 14 ft (4.2 m) long section of fine warped expanded metal over Brazilian carpet. The lower (blood eye) section was narrower at 3 ft (0.9 m) wide and was fitted with a 4 ft (1.2 m) long section of dredge riffles followed by a 7.5 ft (2.3 m) length of bare ribbed Brazilian carpet.

The production from the land dredge was about 6 to 8 loose cubic yards per hour (5 to 6 cubic meters per hour). The gravel pumps also pumped from about 480 Ig/m or about 36 liters per second of water. The pump only operated at full output for about 75% of the time. The daily production is about 43 cubic yards (33 cubic meters) per day.

This sluicebox was not refitted or tested with radiotracers due to the poor access.

CONCLUSIONS

Water and gravel flows were measured at gold mines near Arakaka. The slurry flows were measured with the float method and separate samples were collected from the sluice runs at various times with a small sample cutter to estimate the mass flows. The flows produced by the gravel pumps were highly variable. The appended data and calculations indicate that the mining rate from the five mines measured varied from about 43 cubic yards (33 cubic meters) per day at Mr. Adams' operation to about 122 cubic yards (94 cubic meters) per day at Mr. Insanalli's operation.

All of the mines used 6 by 6 inch Brazilian gravel pumps but the production varied depending on the power and speed of the motor driving the pump, and on the density of the slurry. Soils which were relatively loose (Bryan Phillips' operation) or where heavy equipment was used to break up the working face (Moen Insanalli's operation) had the greatest slurry density and greatest throughputs. These production rates are very low compared to similarly equipped North American mines.

A second wooden sluicebox was constructed at both Moen Insanalli's and at John Phillips' operations (pictures 8, 4, 12 and 13). These two sluiceboxes and Bryan Phillips' wooden sluicebox were refitted with riffle systems including coarse expanded metal, one-inch angle iron riffles and unbacked Nomad matting. Alluvial gold grades can vary dramatically from day to day, however, the operation of the refitted versus original sluiceboxes should demonstrate the increased gold recovery efficiency over a period of time. Mr. Richard Rodrigues' mining operation was shut down due to heavy equipment repairs for most of the period and therefore his sluicebox could not be widened and refitted in time.

Comparative radiotracer testing was conducted at Moen Insanalli's operations (pictures 8 and 4). Mr. Insanalli's original sluicebox was already equipped with Nomad matting and coarse expanded metal riffles but his gold recovery was improved with the refitting from 78% to 95% free gold recovery. Most of the gold was recovered in the first 16 ft (5 m) of the two sluiceboxes. The other two refitted sluiceboxes (Phillips) should provide greater increases in gold recovery (15 to 25%) because their original sluiceboxes were not fitted as well as Mr. Insanalli's.

Conventional testing with the small testing sluice was conducted on the tailings from John Phillips' secondary (hammer mill product) sluice. The small testing sluice was also used to demonstrate how to upgrade sluicebox concentrates prior to amalgamation at Moen Insanalli's (picture 9) and John Phillips' operations (picture 14). At John Phillips' operation, the workers tested each section of the refitted sluicebox separately and tested the tailings from the small testing sluice to satisfy themselves that the refitted sluicebox was efficient. Both operators indicated that they intended to build their own Long Toms for this purpose.

Safe mercury handling and retorting methods were demonstrated at the seminars and at Moen Insanalli's, John Phillips' and Bryan Phillips' mine sites (pictures 10 and 18). All the miners were amazed at the amount of mercury recovered with the retorts and conversely with the amount of mercury that they previously inhaled. Six retorts were left at Arakaka. The use of retorts will also reduce the occupational and environmental hazards associated with "burning" mercury.

Feed rate estimates are based on sampler cuts and timed flow measurements as indicated. Variations could result from surging or varying feed rates. Water and slurry flow rates are estimated by measuring the speed of the slurry in the sluice runs and their cross sectional areas.

The previous conclusions are based on the pay material processed during the sampling period. Pay gravels, which are significantly different in character, gold content and particle size distribution, may require different processing considerations.

RECOMMENDATIONS

It is recommended that other sluiceboxes in various mining districts of Guyana be refitted and tested to verify and increase the gold recovery improvements. This should be done in conjunction with evening seminars to inform local small-scale miners and to train government officials in efficient methods of alluvial exploration, mine planning, gold recovery, safe mercury usage and environmental mitigation.

STANDARD RECOMMENDATIONS

Field and laboratory test work has indicated that sluicebox runs should be designed to the following specifications for optimum recovery levels:

a) Every sluice run should have a section of expanded metal riffles and a section of angle iron riffles in series;

b) the expanded metal section should be sized to handle 8 loose cubic yards per foot of width and consist of coarse expanded metal mesh (4 to 6 lbs/ft^2) fitted tightly on top of Nomad matting;

c) optimum slurry velocities for the expanded metal riffles section will range from 5 to 6 ft per second (1.5 to 1.8 m/s);

d) the expanded metal section of the sluicebox should preferably be at least 16 ft long and followed or preceded by an 8 ft long section of angle iron riffles;

e) the angle iron riffle section should be approximately one half the width of the expanded metal riffle section and may have to be set at a steeper gradient of up to 3 inches/foot to achieve a slurry velocity of 6 to 8 ft per second (1.8 to 2.4 m/s), care must be taken to reduce rooster tails where runs are narrowed;

f) the one-inch angle iron riffles should be aligned at 15 degrees from the sluicebox's vertical towards the top of the box and they should be located with a clear distance of 2 to 2.5 inches (50 to 65 mm) between each riffle;

g) the angle iron riffles should be fitted tightly on top of Nomad matting (light expanded metal may be inserted between the riffles and the matting to prolong the life of the matting); and

h) nuclear tracers indicated that the gold particles can migrate down the sluice run (especially during start up periods) therefore sluice runs that are easily washed down will allow more frequent clean ups (preferably every 24 hours) to further reduce gold losses.

Randy Clarkson P.Eng.

NORTHWEST DISTRICT MINES DATA
SLUICEBOX DATA AND CALCULATIONS

Table 1

Moen Insanalli's operations in Arakaka			
Location:	07 – 34.20 N 837,904 N	60-02.70 W 826,166 E	WGS 84 SAM 69
Deposit:	Quarts vein bounded shear zone in clay. Striking 259 degrees magnetic, dipping 29 degrees, 8 to 15' thick. Yellow clay-rich, crushed rock sandwiched between solid quartz. Gold bearing material is a clayey fine angular quartz fragment.		
Mining:	Open pit, hydraulic jetting assisted with bulldozers and excavators.		

NORTHWEST DISTRICT MINES DATA
SLUICEBOX DATA AND CALCULATIONS

Table 1a

Moen Insanalli's operations in Arakaka (continued)						
Original sluicebox dimensions (imperial)					1 m = 3.2808 ft	
Description	**Length ft**	**Width ft**	**Depth inch**	**Area ft^2**	**Volume yd^3**	**Note**
Top sluice	7.0	3.0 5.0 widened	0.5	21	0.04	Bare unback Nomad
Boil box	3.4	8.0	9.0	27	0.76	Wood box 9" deep
Upper sluice	8.0	8.0	0.8	64	0.15	Coarse exp/carpet
Bottom run	18.0	8.0	0.3	144	0.11	Bare ribbed carpet
Combined	36.4	7.0		256	1.06	Total (yd^3)
Gravel pump	6 by 6	Dambrose gravel pump powered by 6 cylinder diesel				
Pipeline	6' PVC	140 ft length			30 ft lift	
Water supply pump	Berkley 6x8" centrifugal powered by 120 hp, 6 cylinder Ford					
Number of jets	4	Normally 7 jets and 2 gravel pumps operating. Water recycled from enclosed tailings pond.				
Feed rate	22 yd^3/hr @ 75% operation				16 yd^3/hour	
Daily feed	10 hours @ 75% operation				122 yd^3/day	

NORTHWEST DISTRICT MINES DATA
SLUICEBOX DATA AND CALCULATIONS

Table 1b

Moen Insanalli's operations in Arakaka (continued)

Refitted sluicebox dimensions (imperial)

Description	**Length ft**	**Width ft**	**Depth inch**	**Area ft^2**	**Volume yd^3**	**Note**
Top sluice	4.0	4.0	1.5	16	0.07	One-inch angle / Nomad
Boil box	3.4	6.0	3.5	21	0.22	Wood box 3,5" deep
Upper sluice	8.0	6.0	1.0	48	0.15	Coarse exp/Nomad
Middle sluice	4.0	6.0	1.0	24	0.07	Coarse exp/Nomad
Bottom run	4.0	6.0	0.5	24	0.04	Bare Nomad mat
Bottom run	6.0	6.0	0.3	36	0.04	Ribbed carpet
Combined	23.4	5.7		133	0.55	Total (yd^3)

Gravel pump	6 by 6	Dambrose gravel pump powered by 6 cylinder diesel	
Pipeline	6' PVC	140 ft length	30 ft lift
Water supply pump	Berkley 6x8" centrifugal powered by 120 hp, 6 cylinder Ford		
Number of jets	4	Normally 7 jets and 2 gravel pumps operating. Water recycled from enclosed tailings pond.	
Feed rate	22 yd3/hr @ 75% operation		16 yd^3/hour
Daily feed	10 hours @ 75% operation		122 yd^3/day

Notes: The original sluicebox uses Nomad matting and coarse expanded metal riffles for gold recovery. However, it has only the boil box for coarse gold recovery. This is not adequate for the recovery of chip size gold particles.

The sluicebox was refitted with one-inch angle iron riffles over Nomad matting in the top section of the sluicebox to improve coarse (chip size) gold recovery. The lower section of the sluicebox was narrowed to 6 ft wide to improve water flow. Unbacked Nomad matting was installed under the coarse expanded metal riffles to improve gold retention.

NORTHWEST DISTRICT MINES DATA
SLUICEBOX DATA AND CALCULATIONS

Table 2

John Phillips' operation in Arakaka			
Location:	07-33.84 N 837,256 N	60-02.72 W 826,094 E	WGS 84 SAM 69
Deposit:	Numerous quartz stringers bounded by red clay/silt, formerly gneiss. Various strikes and dips, zone is dipping approximately 30 degrees. Gold bearing material is silty with fine angular quartz fragments		
Mining:	Open pit, hydraulic jetting assisted with bulldozers and excavators.		

NORTHWEST DISTRICT MINES DATA
SLUICEBOX DATA AND CALCULATIONS

Table 2a

John Phillips' operation in Arakaka (continued)

Original sluicebox for processing pit-run material dimensions (imperial)

Description	**Length ft**	**Width ft**	**Depth inch**	**Area ft^2**	**Volume yd^3**	**Note**
Top sluice	11.6	4.3	2.75	49	0.42	Hungarian 2.5X1X4.5 o/c, full/packed
Boil box	4.4	4.3	6.00	19	0.35	Wood box 6" deep full/packed
Middle run	14.5	4.3	0.5	62	0.10	Lt warp exp/carpet Raised off carpet
Bottom run	16.5	4.3	0.25	70	0.05	Bare ribbed carpet
Combined	47.0	4.3		200	0.91	Total (yd^3)

Gravel pump	6 by 6	Dambrose gravel pump powered by 6 cylinder Perkins	
Pipeline	6' PVC	18 ft length	6 ft lift
Water supply pump	6 by 4 centrifugal powered by 4 cylinder Perkins		
Number of jets	3	Fresh water ditched from Arakaka Creek.	
Feed rate	14 d3/hr @ 75% operation		10 yd^3/hour
Daily feed	11 hours @ 75% operation		87 yd^3/day

About 40% of total gold is recovered in the original pit-run fed sluicebox.

NORTHWEST DISTRICT MINES DATA
SLUICEBOX DATA AND CALCULATIONS

Table 2b

John Phillips' operation in Arakaka (continued)						
Sluicebox for processing hammer mill product dimensions (imperial)						
Description	**Length ft**	**Width ft**	**Depth inch**	**Area ft^2**	**Volume yd^3**	**Note**
Top sluice	5.5	1.8	0.5	10	0.01	Bare Nomad mat
	2.5	1.8	3.0	4	0.04	Hungarian 2.5X1X4.5 o/c
Middle run	8.0	1.8	0.5	14	0.02	Bare Nomad mat
Bottom run	19.1	1.8	0.3	33	0.03	Bare ribbed carpet
Combined	35.1	1.8		61	0.10	Total (yd^3)
Feed rate	2 yd^3/hr @ 100% operation				2 yd^3/hour	
Daily feed	10 hours @ 60% operation				12 yd^3/day	
About 40% of total gold is recovered in the original pit-run fed sluicebox.						

NORTHWEST DISTRICT MINES DATA
SLUICEBOX DATA AND CALCULATIONS

Table 2c

John Phillips' operation in Arakaka (continued)

Refitted sluicebox for processing pit-run material dimensions (imperial)

Description	**Length ft**	**Width ft**	**Depth inch**	**Area ft^2**	**Volume yd^3**	**Note**
Top sluice	4.0	4.8	1.0	19	0.06	Coarse exp/Nomad
Boil box	4.0	5.1	6.0	20	0.38	Wood box 6" deep
Upper middle	3.5	4.8	0.3	17	0.01	Bare Brazilian carpet
Lower middle	8.0	4.8	1.0	38	0.12	Coarse exp/Nomad
Bottom run	8.0	2.0	1.5	16	0.07	One-inch angle / Nomad
Combined	27.5	4.0		110	0.64	Total (yd^3)
Gravel pump	6 by 6	Dambrose gravel pump powered by 120 hp, 6 cylinder diesel				
Pipeline	6' PVC	180 ft length		60 ft lift		
Water supply pump	6 by 4 centrifugal powered by 4 cylinder Perkins.					
Number of jets	3	Fresh water ditched from Arakaka Creek.				
Feed rate	14 yd3/hr @ 75% operation				10 yd^3/hour	
Daily feed	11 hours @ 75% operation				87 yd^3/day	

Notes: There was one original sluicebox for processing the pit run material and another smaller sluicebox for processing the (hammer mill) ground quartz fragments. Another slightly wider sluicebox was constructed and refitted to process the pit run material. The refitting with sections of coarse expanded metal and one-inch angle iron riffles over unbacked Nomad matting should increase gross gold recovery by about 15 to 25%.

The miners normally washed the overburden soils and concentrated the sands and gold on the bottom of the pit. The sands and gold and pumped up to the sluicebox at the end of the mining period.

NORTHWEST DISTRICT MINES DATA
SLUICEBOX DATA AND CALCULATIONS

Table 3

Bryan Phillips' operation in Arakaka			
Location:	07 – 34.74 N 839,258 N	60-01.40 W 828,680 E	WGS 84 SAM 56
Deposit:	Shallow alluvial / residual deposit, tailings being reworked by operator. Washed angular gravels rich in quartz fragments and spherical ironstone.		
Mining:	Shallow (20 ft) open pit, mined with hydraulic jetting only.		

NORTHWEST DISTRICT MINES DATA
SLUICEBOX DATA AND CALCULATIONS

Table 3a

Bryan Phillips' operation in Arakaka (continued)						
Original sluicebox for processing pit-run material dimensions (imperial)						
Description	**Length ft**	**Width ft**	**Depth inch**	**Area ft^2**	**Volume yd^3**	**Note**
Head box	4.7	4.6	9.0	22	0.60	Wood box 9" deep full/packed
Drop box	1.5	4.6	7.0	7	0.15	Wood box 7" deep
Top sluice	2.5	4.6	3.0	12	0.11	Hungarian 2.5X1X4" o/c, full/packed
Middle sluice	5.0	4.6	0.5	23	0.04	Bare Nomad carpet
Bottom run	19.0	4.6	0.3	88	0.07	Rib Brazilian carpet
Combined	32.7	4.6		151	0.96	Total (yd^3)
Gravel pump	6 by 6	Dambrose gravel pump				
Pipeline	6' PVC	120 ft length		30 ft lift		
Feed rate	19 yd^3/hr @ 75% operation				14 yd^3/hour	
Daily feed	10 hours @ 75% operation				108 yd^3/day	

NORTHWEST DISTRICT MINES DATA
SLUICEBOX DATA AND CALCULATIONS

Table 3b

Bryan Phillips' operation in Arakaka

Refitted sluicebox for processing pit-run material dimensions (imperial)

Description	Length ft	Width ft	Depth inch	Area ft^2	Volume yd^3	Note
Head box	4.7	4.6	9.0	22	0.60	Wood box 9" deep full/packed
Drop box	1.5	4.6	7.0	7	0.15	Wood box 7" deep
Top sluice	8.0	4.4	1.0	35	0.11	Coarse exp/Nomad
	6.0	4.4	0.5	26	0.04	Bare Nomad carpet
Middle sluice	4.0	4.4	1.0	18	0.05	Coarse exp/Nomad
	7.0	4.8	0.3	33	0.03	Rib Brazilian carpet
Bottom run	8	1.9	1.5	15	0.07	One-inch angle / Nomad
Combined	31.2	4.5		141	0.98	Total (yd^3)

Notes: The original sluicebox has only the wooden box and a short packed section of dredge riffles for coarse gold recovery.

This sluicebox was refitted with coarse expanded metal riffles and one-inch angle iron riffles over unbacked Nomad matting to improve gold recovery and gold retention. Gross gold recovery should improve by 15% to 25 %.

NORTHWEST DISTRICT MINES DATA
SLUICEBOX DATA AND CALCULATIONS

Table 4

Richard Rodrigues' operations in Arakaka			
Location:	07 – 34.13 N 837,103 N	60-02.39 W 826,860 E	WGS 84 SAM 56
Deposit:	Numerous quartz stingers bounded by red clay/silt. Various strikes and dips. Gold bearing material is silty with fine angular quartz fragments.		
Mining:	Deep open pit, hydraulic jetting assisted with owner's bulldozers.		

NORTHWEST DISTRICT MINES DATA
SLUICEBOX DATA AND CALCULATIONS

Table 4a

Richard Rodrigues' operations in Arakaka (continued)

Original sluicebox for processing pit-run material dimensions (imperial)

Description	**Length ft**	**Width ft**	**Depth inch**	**Area ft^2**	**Volume yd^3**	**Note**
Boil box	3.8	6.2	7.5	23	0.54	Wood box 7.5" deep
Top sluice	6.7	6.2	2.5	41	0.32	Hungarian 2.5X1X4.5 No carpet, packd
Center run	15.8	6.2	0.8	97	0.22	Lt exp/Nomad warped above mats
Bottom run	17.3	6.2	0.3	107	0.08	Bare rib carpet
Combined	43.5	6.2		268	1.16	Total (yd^3)

Gravel pump	8 by 8	Dambrose gravel pump powered by 8 cylinder diesel 180 hp diesel	
Pipeline	8' PVC	180 ft length	50 ft lift
Water supply pump	N/A Fresh water pumped from Arakaka Creek.		
Number of jets	N/A	High pressure jets tied down with ropes to stakes.	
Feed rate	8 yd^3/hr @ 75% operation		6 yd^3/hour
Daily feed	10 hours @ 75% operation		48 yd^3/day

Note: The gravel pump was pumping mostly water; therefore its normal throughput should be higher than shown.

NORTHWEST DISTRICT MINES DATA
SLUICEBOX DATA AND CALCULATIONS

Table 4b

Richard Rodrigues' operations in Arakaka (continued)						
Sluicebox for processing hammer mill product dimensions (imperial)						
Description	**Length ft**	**Width ft**	**Depth inch**	**Area ft^2**	**Volume yd^3**	**Note**
Top sluice	8.5	4.0	2.5	34	0.26	Hungarian 2.5X1X4.5. No carpet, full
Upper middle	4.0	4.0	1.0	16	0.05	Coarse ex/Nomad Warped above mat
Lower middle	11.0	4.0	0.8	44	0.10	Coarse exp/astroturf
Bottom run	20.4	4.0	0.5	82	0.13	Bare Astro turf carpet
Combined	43.9	4.0		176	0.54	Total (yd^3)
Feed rate	12 yd^3/hr @ 75% operation				9 yd^3/hour	
Daily feed	10 hours @ 75% operation				65 yd^3/day	

Notes: There was one sluicebox for processing pit run material, another for reprocessing tailings, and a smaller sluicebox for processing (hammer mill) ground product. The operator reported that the hammer mill was required to liberate gold in the catchcow (iron-rich cemented layer). The hammer mill product was coarse sand/fine gravel with mostly 1/8 to 1/4 inch diameter.

These sluiceboxes were not refitted due to break-downs with the heavy equipment. The operator should widen his pit run sluicebox to 8 ft and install a 16 ft section of coarse expanded metal and narrow a section to 4 ft wide 8 ft long for one-inch angle iron riffles. This should increase his gold recovery so that he does not need to sluice it a second time prior to grinding in the hammer mill.

NORTHWEST DISTRICT MINES DATA
SLUICEBOX DATA AND CALCULATIONS

Table 5

Timothy Adams' operations in Annie Creek			
Location:	07 – 43.50 N 838,787 N	60-03.27 W 825,186 E	WGS 84 SAM 56
Deposit:	Shallow alluvial/residual deposit, tailings being reworked by operator. Washed angular gravels rich in quartz fragments.		
Mining:	Shallow (7 ft) open pit, mined with hydraulic jetting only.		

NORTHWEST DISTRICT MINES DATA
SLUICEBOX DATA AND CALCULATIONS

Table 5a

Timothy Adams' operations in Annie Creek (continued)

Original sluicebox for processing pit-run material dimensions (imperial)

Description	Length ft	Width ft	Depth inch	Area ft^2	Volume yd^3	Note
Boil box	3.0	6.0	8.0	18	0.44	Wood box 8" deep
Top sluice	6.5	6.0	2.8	39	0.33	Hungarian 2.5X1X4.5 o/c
Middle sluice	14.0	6.0	0.5	84	0.13	Fine exp/carpet
Bottom riffles	4.0	3.0	2.8	12	0.10	Hungarian 2.5X1X4.5 o/c
Bottom carpet	7.5	3.0	0.3	23	0.02	Bare rib carpet
Combined	35.0	5.0		176	1.03	Total (yd^3)

Gravel pump	6 by 6	Dambrose gravel pump powered by 4 cylinder diesel	
Pipeline	6' PVC	100 ft length	20 ft lift
Water supply pump	8 by 6" centrifugal pump powered by 6 cylinder diesel.		
Number of jets	2	Ground water and local surface water.	
Feed rate	8 yd^3/hr @ 75% operation		6 yd^3/hour
Daily feed	10 hours @ 75% operation		43 yd^3/day

Notes: This sluicebox and many others around it were not refitted due to their distance from Arakaka and the lack of access by truck and/or tractor.

This sluicebox needs to be reduced to a 4 ft wide by 16 ft long section fitted with coarse expanded metal riffles and a 2 ft wide by 8 ft long section fitted with one-inch angle iron riffles over unbacked Nomad matting. This should improve his gross gold recovery by 15%to 25%.

NORTHWEST DISTRICT MINES DATA
SLUICEBOX DATA AND CALCULATIONS

Table 6

SLUICE SLOPES - RESUME			
Descriptions	Percent	Degrees	in/ ft
Table 1a: M. Insanalli's original	17	9	2.0
Table 1b: M. Insanalli's refitted	19	11	2.3
Table 2a: J. Phillips' Original	0	0	
Table 2b: J. Phillips' Hammer Mill	15	8	1.8
Table 2c: J. Phillips' Refitted	11	6	1.3
Table 3a: B. Phillips' original	15	9	1.8
Table 3b: B. Phillips' refitted	13	8	1.6
Table 4a: R. Rodriguez's original	8	5	1.0
Table 4b: R. Rodriguez's Hammer Mill	8	5	1.0
Table 5a: T. Adams' original	15	9	1.8

NORTHWEST DISTRICT MINES DATA
SLUICEBOX DATA AND CALCULATIONS

Table 7

MASS FLOWS – WATER FLOW RATES

The water and pay gravel feed rates were derived from sampler data and time studies. These were compared to recommended values for expanded metal riffles derived from previous research: feed rate at 8 loose cubic yards/hr and water rate of 160 Ig/m of water per foot of sluice width. (One-inch angle iron riffles require 320 Ig/m and can be loaded at up to 16 loose cubic yards/hr per foot of sluice width).

Description	Slurry velocity		Depth of water		Width of sluice run		Slurry flowrate			Recommended by width	Iron riffles
	m/s	ft/s	cm	in	m	ft	cm/s 0.800 factor	Ig/m	USg/m	%	∝
Original M. Insanalli	1.7	5.6	2.2	0.9	2.4	8.0	0.074	983	1180	77	38
Refitted M. Insanalli	1.5	5.1	2.1	0.8	1.9	6.1	0.047	624	749	64	32
Over angle iron M. Insanalli				1.4							
Original J. Phillips	1.8	6.0	4.8	1.9	1.0	3.2	0.068	894	1073	176	88
Original J. Phillips Apr. 3rd.	1.4	4.5	3.3	1.3	1.3	4.3	0.047	621	746	91	46
Refitted angle iron J. Phillips	1.7	5.7	6.4	2.5	0.6	2.0	0.053	705	847		110
Refitted, expanded J. Phillips	1.4	4.6	3.3	1.3	1.5	5.0	0.057	750	901	94	
Hammer mill J. Phillips	1.3	4.1	0.5	0.2	0.5	1.8	0.003	34	40	12	6
Original B. Phillips	1.9	6.2	2.8	1.1	1.4	4.6	0.058	770	225	104	52
Pit run Low output R. Rodrigues	1.8	5.8	3.4	1.3	1.9	6.1	0.090	1184	1421	55	27
Hammer mill R. Rodrigues	1.2	4.0	2.1	0.8	1.8	6.0	0.036	480	576	50	25
T. Adams	1.2	4.0	2.1	0.8	1.8	6.0	0.036	480	576	50	25
Average	1.5	5.1	3.0	1.2	1.4	4.6	0.051	673	808	84	49

NORTHWEST DISTRICT MINES DATA
SLUICEBOX DATA AND CALCULATIONS

Table 7

MASS FLOWS – WATER FLOW RATES (continued)
Note: Water flow rates less than 100% or greater than 150% of recommended values usually provides lower gold recoveries. The width of a sluicebox can be widened if the flow is too high or narrowed if the flow is too low. Bryan Phillips' sluicebox was a suitable width for expanded metal riffles. Richard Rodrigues' sluicebox needed to be widened to 8 ft and John Phillips' needed to be widened to 5 ft. All of the other sluiceboxes would have to be narrowed to between 2/3 and 1/2 of their present width if they were refitted with coarse expanded metal riffles. Some of the slurry velocities would also have to be increased to between 5 and 7 ft per second.

NORTHWEST DISTRICT MINES DATA
SLUICEBOX DATA AND CALCULATIONS

Table 8

PAY GRAVEL FEED RATES					
Description	Solids %	Solids cm/s 1.00 factor	Sluice solids Lyd^3/hr	Recommended by ft %	Iron riffles $\propto$
Original M. Insanalli	6	0.0046	22	34	17
Refitted M. Insanalli	7 surging density	0.0034	16	33	17
Original J. Phillips	4	0.0024	11	44	22
Original J. Phillips Apr. 3rd.	5	0.0024	11	33	16
Refitted angle iron J. Phillips	7	0.0035	16		51
Refitted, expanded J. Phillips	7	0.0035	16		51
Hammer mill J. Phillips	17	0.0004	2	14	7
Original B. Phillips	7	0.0041	19	52	26
Pit run low output R. Rodrigues	2	0.0018	8	17	9
Hammer mill R. Rodrigues	9	0.0025	12	35	18
T. Adams	5	0.0016	8	16	8
Average	7	0.0027	13	32	15

Notes: Pay gravel feed rates, which exceed 100% of recommended values, are one of the greatest factors contributing to gold losses. Pay gravel feed rates below 100% of recommended values may improve gold recovery slightly.

All of the sluiceboxes tested, except John Phillips hammer mill sluicebox, had solids volume densities of less than 12% and were operating below their capacity due to the inability of the water jets to quickly fluidize the compacted clays and gravels.

DISTRIBUTION OF RADIOTRACERS ALONG THE LENGTH OF THE SLUICE

Table 9

A COMPARISON OF THE ORIGINAL AND CONVERTED SLUICEBOXES						
Moen Insanalli's operations in Arakaka						
Original sluicebox				**Converted sluicebox**		
Distance from top ft	**Final reading CPS**	**Total %**	**Cumulative**	**Final reading CPS**	**Total %**	**Cumulative**
		73			94	
2	24,100	16.7	16.7% Bare Nomad	28,600	40.2	40.2% One-inch
4	10,200	7.1	23.8% Bare Nomad	11,200	15.8	56.0% Angle/Nomad
6	8,300	5.8	29.5% Bare Nomad		0.0	56.0% Wood box
8	-	0.0	29.5% Boil box		0.0	56.0% Wood box
10	3,000	2.1	31.6% Exp/carpet	17,700	24.9	80.9% Cexp/Nomad
12	12,000	8.3	39.9% Exp/carpet	2,700	3.8	84.7% Cexp/Nomad
14	12,150	8.4	48.3% Exp/carpet	3,750	5.3	89.9% Cexp/Nomad
16	24,600	17.0	65.4% Exp/carpet	1,740	2.4	92.4% Cexp/Nomad
18	2,250	1.6	67.0% Exp/carpet	450	0.6	93.0% Cexp/Nomad
20	1,000	0.7	67.6% Rib carpet		0.0	93.0% Cexp/Nomad
22	2,400	1.7	69.3% Rib carpet		0.0	93.0% Bare Nomad
224	-	0.0	69.3% Rib carpet	460	0.6	93.7 % Bare Nomad
26	4,000	2.8	72.1% Rib carpet		0.0	93.7% Rib carpet
28	-	0.0	72.1% Rib carpet		0.0	93.7% Rib carpet
30	-	0.0	72.1% Rib carpet		0.0	93.7% Rib carpet
32	-	0.0	72.1% Rib carpet			93.7% end
34	2,000	1.4	73.5% Rib carpet			
			end			
Total	106,000	73.5		66,600	93.7	

GOLD AND TRACERS RECOVERED BY ORIGINAL AND REFITTED SLUICE

Table 10

Moen Insanalli's operations in Arakaka

Original Sluicebox			**Refitted Sluicebox**		
Mesh size	**Recovered gold dist %**	**Recovered tracers**	**Recovered tracers**	**Recovered gold dist %**	**Diameter mm**
+8	0.8	48% estimated	90%	0.2	2.380
+14	1.3	80%	100%	2.2	1.190
+28	6.0	88%	96%	10.2	0.595
+48	27.3	84%	96%	34.6	0.297
+100	39.3	88%	100%	35.8	0.149
-100	25.3	53% estimated	80%	16.9	
Total	100.0	73%	94%	100.0%	
	Weighted recovery	78%	95%		

Notes: One radiotracer was spilled at wash down; this was recovered and included.

This sluice was not fitted for chip size gold recovery.

Notes: One radiotracer remained in the sluice; this was also included in calculations.

This sluice has one-inch angle iron riffles.

<u>Accuracy of these results:</u>

Binomial probability distribution.

The standard error = {(n*p*q)^0.5}/n, where n = 100, p = % recovery and, q = 1-p.

For the original sluicebox test, p = 85%. The standard error is 4%. The radiotracer test results will be within 4% of the true value 68% of the time.

For the refitted sluicebox test, p = 98%. The standard error is 1%. The radiotracer test results will be within 1% of the true value 68% of the time.

The previous calculations are based on the pay gravels and operating conditions encountered during the sampling period. Pay gravels, which are significantly different in character, gold content and particle size distribution, may require different processing considerations.

Figure 1

Scale: NTS	Drawn by: RRC – New Era Engineering Corporation
Date: March 15, 2000	Revision: 0

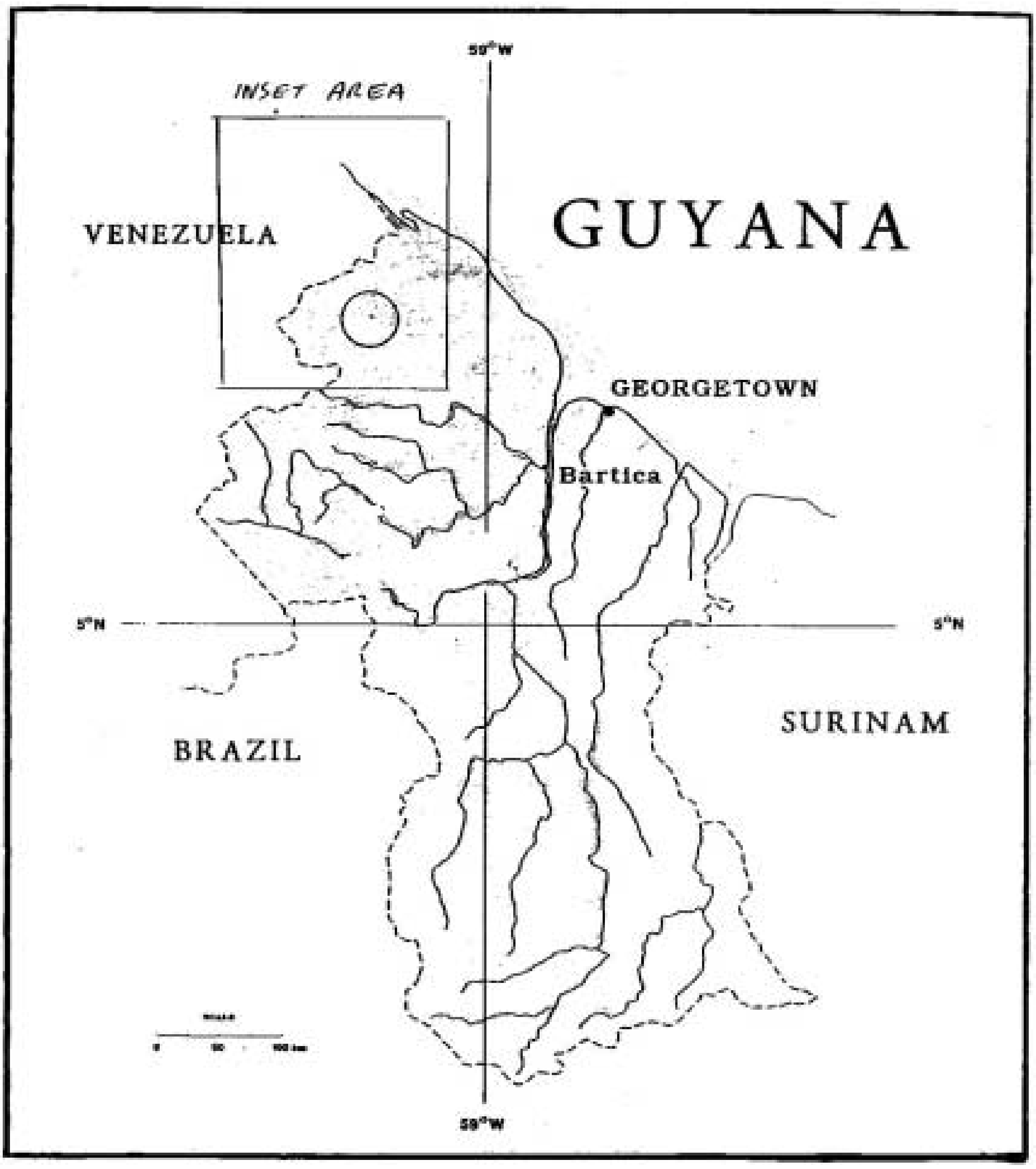


Figure 2

Scale: ¼ Drawn by: RRC – New Era Engineering Corporation
Date: May 12, 2000 Revision: 0

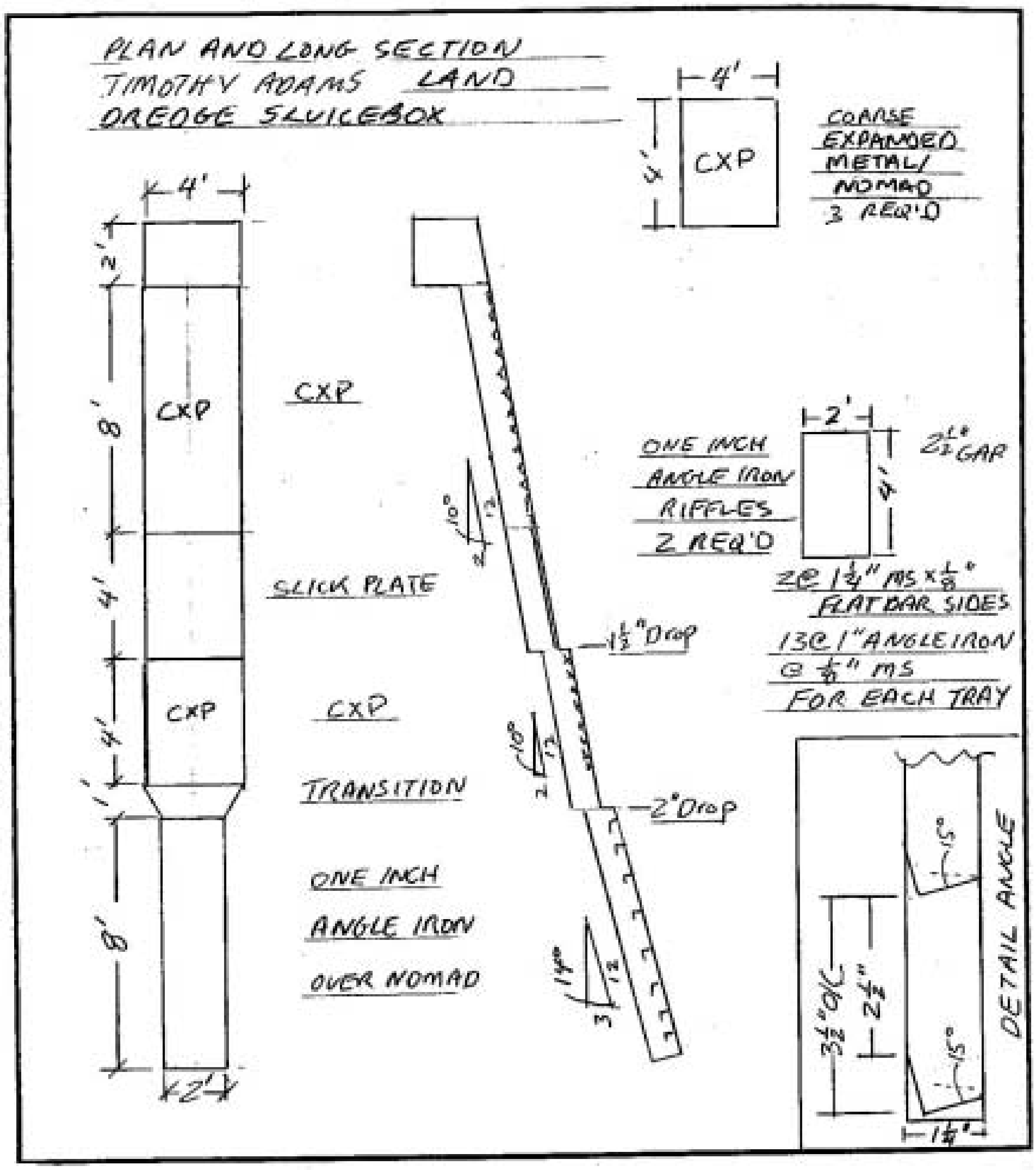
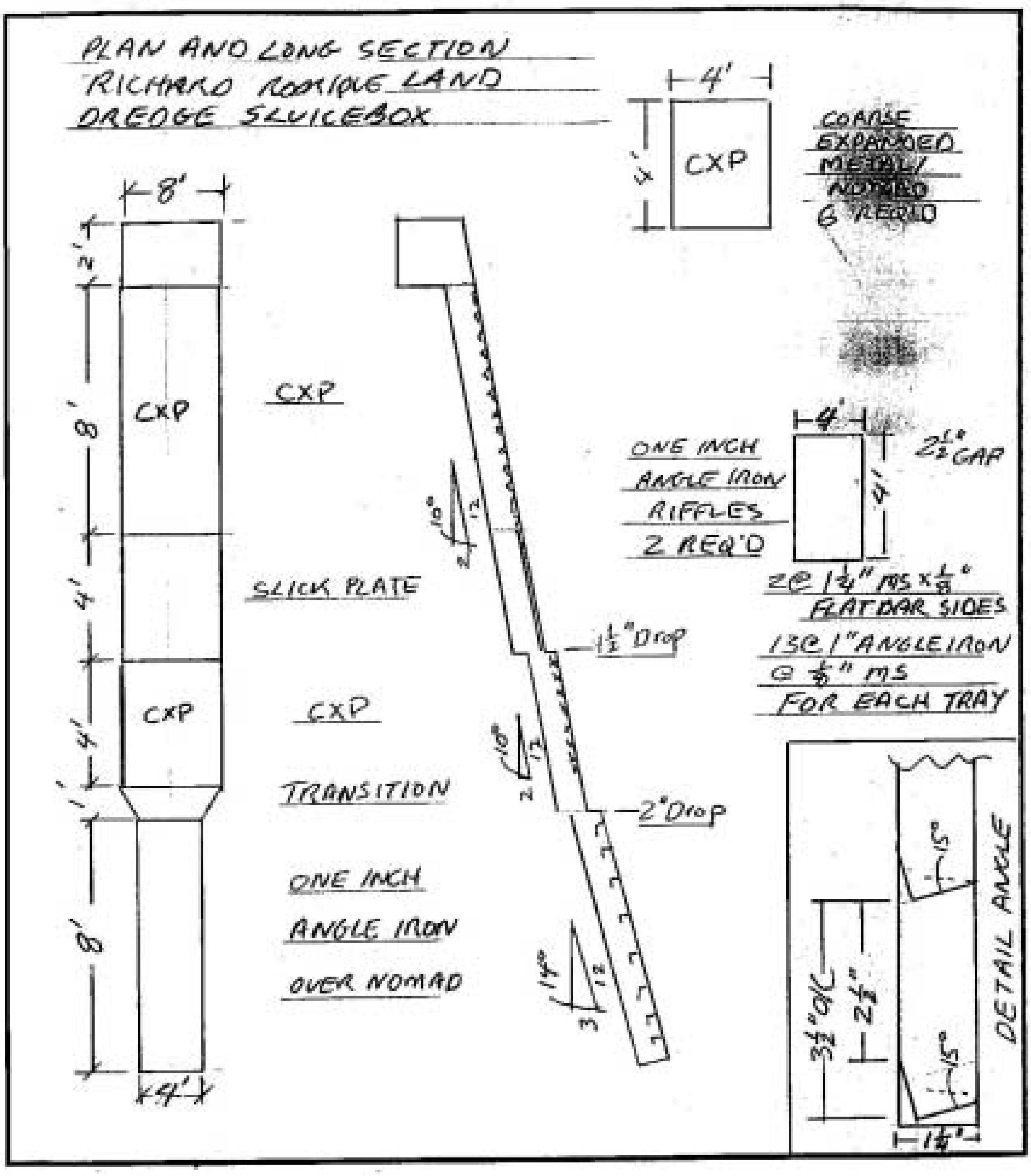


Figure 3

Scale: NTS — Drawn by: RRC – New Era Engineering Corporation
Date: May 12, 2000 — Revision: 0



Picture 1: Richard Rodriguez' deep open pit mine with quartz stringers in red clay.

Picture 2: Mr. Insanalli's Open Pit with quartz vein exposed on lower left, jetting on right assisted by excavator and bulldozer (top right), and gravel sump on lower center.

Picture 3: Mr. Insanalli's original 8 ft wide sluicebox fitted with bare Brazilian carpet on very bottom, expanded metal in the middle and bare Nomad mat on the very top.

Picture 4: Mr. Insanalli's lower sluice narrowed to 6 feet in width and fitted with coarse expanded metal riffles over unbacked Nomad matting, lowest section is carpet.

Picture 5: Mr. Rodriguez' hammer mill grinds quartz aggregate to liberate locked gold.

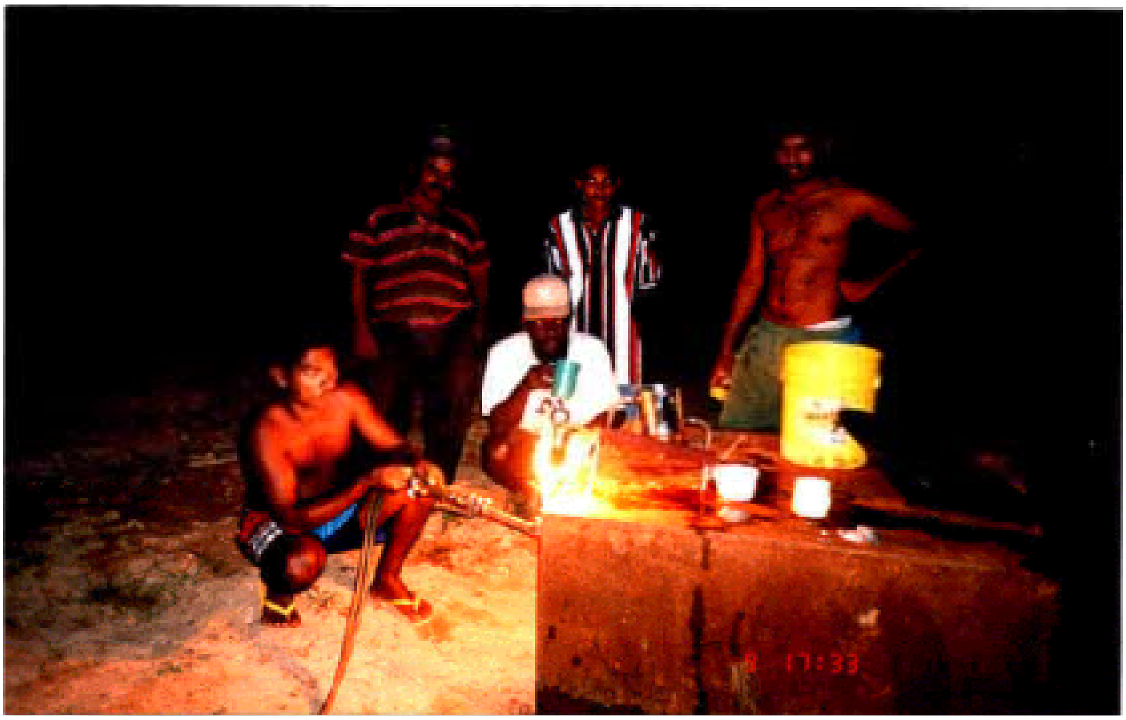
Picture 6: Water/tailings retention dam from process water recycling system.

Picture 7: Water supply pump and recycled process water return ditch at Mr. Insanalli's mine.

Picture 8: Mr. Insanalli's top section narrowed to 4 ft in width and refitted with one-inch angle iron riffles over unbacked Nomad matting, yellow ribbons indicated radiotracers.

Picture 9: Upgrading sluicebox concentrates with small sluicebox (Long Tom) prior to mercury amalgamation.

Picture 10: Demonstration of mercury retort at night at Mr. Insanalli's mine.



Picture 11: Open pit face with quartz stringers at John Phillips' mine.

Picture 12: Newly refitted sluicebox with one-inch angle iron riffles on the lower narrow section and coarse expanded metal riffles over Nomad matting on upper section.

Picture 13: Yellow flagging marks 100 mesh (150 micron) radiotracers recovered in top 4 ft of coarse expanded metal at John Phillips' mine.

Picture 14: Upgrading sluicebox concentrates and testing refitted sluicebox with a small sluicebox (Long Tom) at John Phillips' mine.

Picture 15: Bryan Phillips' water filled alluvial mine pit, note standing timbers from old underground tunnel in center of photo.

Picture 16: Refitting the upper section of Bryan Phillips' wooden sluicebox with coarse expanded metal riffles over Nomad matting.

Picture 17: Completed refit of Bryan Phillips' sluicebox, note narrow lower section is fitted with one-inch angle iron riffles.

Picture 18: Demonstration of mercury resort that is being heated with a small plumber's propane torch at Bryan Phillips' operation.

Picture 19: Alluvial gold "Cookie" after retorting.

Picture 20: Local Porknockers hand panning sluicebox tailings for a living.

APPENDIX A

ALLUVIAL GOLD MINING SEMINARS

Instructors: Randy Clarkson (NEW ERA Engineering) and

________________________________ (GGMC)
________________________________ (GGMC)

This demonstration and seminar series is part of an environmental capacity development program for the Guyanese mining industry (GENCAPD).

The project is funded by the Canadian International Development Agency and is operated by CANMET (a division of Natural Resources, Canada).

Alluvial mining provides a necessary occupation and wealth generator for many remote areas of Guyana (which are occupied by Amerindians) as well as a source of foreign exchange.

Alluvial mining and reasonable environmental mitigation are not mutually exclusive strategies.

Canadians have developed some alluvial mining, gold recovery and environmental mitigation technology that may be adapted for use in Guyana to help improve alluvial mining.

This portion of the GENCAPD project is the small-scale alluvial mining demonstration program, which also provides some evening seminars.

SEMINAR TOPICS

Introduction to Alluvial Gold Mining
- Canadian Dry Land Methods
- Canadian Hydraulicing Methods
- New Zealand Floater Methods
- Guyanese Methods

Exploration and Sampling of Alluvial Deposits
- Formation of Alluvial Deposits
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EXPLORATION AND EVALUATION

FORMATION OF ALLUVIAL DEPOSITS

- Alluvial deposits are formed by the weathering and erosion of hard-rock gold deposits over long periods of time.

- The hard rock gold may be just upstream, hundreds of miles away or may have been completely eroded away.

- Residual alluvial deposits are formed by the weathering of hard-rock sources and can result in an enrichment of the source but are generally low grade (figure 2).

- Slope alluvial deposits are usually found on hillsides forming a sheet-like mass below the hard-rock source. These deposits may slowly move downhill, allowing the lighter mineral particles (and possibly the finer gold) to be removed by rain-wash and wind.

- Alluvial (stream) alluvial deposits are found where gold has been concentrated as a result of the action of flowing streams.

- They are the most common and economically important type of alluvial deposit.

- Bedrock that forms natural riffles perpendicular to the watercourse or fractured and pitted bedrock are favorable for trapping gold particles.

- Other places for gold concentrations occur on the insides of turns in a meandering stream or where there is a decrease in the stream gradient. An example is skim bars on the upstream end of a river bar (figure __).

- The gold may drop out of the stream's sediment load due to a reduction in stream velocity.

- Just above bedrock or clay layers or cemented layers such as "catch cow" is often the highest concentration.

- Streams may meander or change course and the new streambed may no longer coincide with the previous channel or pay streak.

- If a stream changes course and continues to deepen its new channel it may cut down through older stream deposits leaving remnants (bench deposits) perched along its banks.

- When near the hard rock source, the gold particles are usually rough, relatively large and often attached to quartz particles.

- With distance, the gold particles become smoother, more rounded, flatter and smaller.

ALLUVIAL SAMPLING AND PROCESSING

- More alluvial mine failures can be attributed directly to improper sample handling and processing practices than to any other reason.

- Alluvial ores are very difficult to sample due to the small amount of gold particles and their erratic distribution in a deposit.

- The inclusion or loss of a single particle of gold (nugget effect) usually has a large impact on the estimated grade of the sample (figure 3).

- The larger the sample, the better.

- Other sampling problems include accidental or intentional contamination and the use of inappropriate sampling, sample processing and evaluation methods.

- Important Sampling tips:

    a) Don't split samples;

    b) Don't fire assay samples if you are going to use gravity to recover the gold later (you will overestimate the value);

    c) The total volume of each alluvial sample should be processed with equipment similar to that which would be used for full-scale recovery;

    d) Don't use equipment that has been used with gold concentrates, you will contaminate the sample;

    e) Don't use jigs because they are too difficult to clean;

    f) Sample processing equipment must never be located in the same room or even within 100 m (330 ft) of a concentrate upgrading, weighing or storage area;

    g) Make sure that you thoroughly clean all sampling and processing equipment to prevent the contamination of samples;

- Remember, a bad sample is worse than no sample at all.

BULK SAMPLES

Shafts

- Shafts may be useful in ground that is too deep for machine-excavated trenches or pits.
- In unconsolidated (loose) ground, shafts usually must be cribbed with timbers to prevent caving or sloughing.
- In cemented ground, drilling and blasting may be required.

- It is usually preferable to process the entire volume of gravels removed from the shaft.

- Shafts may in some cases be essential to correct the interpretation of drilling values.

Pits

- Hand dug pits

- Hydraulic excavated pits or "land dredge" pits can be used to determine the richness of the deposit, to confirm drill information, and to aid in mine planning

- A regular grid of underwater Missile dredge pits can be used to determine the richness of the deposit and to aid in mine planning

- It is important to record the results of sampling and mark sample locations for future reference.

ALLUVIAL DRILLS

- Drills can reduce the risks of alluvial mining by helping to determine the locations and grade of deposits.

- Drill samples are relatively small therefore require great care and attention to all aspects of drilling, sample recovery and sample processing.

- Small diameter drill holes (less than 4 inches) are too small to estimate the richness.

- The purpose of a drill program is sample recovery and a good driller will care at least as much about the careful recovery of the sample as he does about the completion of the hole.

- It is not wise to choose a driller strictly on the basis of lowest cost; it is better to ask for references and check with contacts in the industry.

- The operating condition of the drill and its regular maintenance should also be inspected.

BANKA (CHURN) DRILLING

- In loose ground, the churn drill drives a casing into the ground ahead of the drill bit in order to obtain a relatively undisturbed sample core (figure 4).
- A drive shoe on the bottom of the casing provides a cutting edge and forces the gravels into the casing as it is driven down.
- Inside the casing, a chisel bit connected to a rope or wire line is dropped repeatedly onto the core of gravels to break it up and prepare it for removal.
- Water (if not already present) is added to the hole and a bailer is dropped to the bottom of the hole to remove the sample sludge.
- The bailer is a cylinder with a one-way check valve on the bottom that allows the sludge to enter.
- After a loaded bailer is hoisted out of the drill casing, its contents are washed out into a mud box and the bailing process is repeated until all the sludge is removed from the hole.
- The process of driving the casing, drilling the core and bailing the sample continues for each sample interval until bedrock or the bottom of the pay gravel horizon is reached.
- To avoid contamination of the sample, the drillers should avoid drilling and bailing below the casing and leave 2 to 3 in plug of sample above the casing shoe.
- Whenever boulders are encountered in a hole, the drill bit must hammer below the casing shoe and try to break the rock so that further drilling can continue.
- Undersize (small) samples are a result when rocks partially block the drive shoe or from tight ground which moves down with the casing and forces the gravels outside of the casing.
- Pressure from ground water can also force excess material in from below the casing.
- The bailer may not capture the slurried drill cuttings and higher density particles such as gold may have been carried down the hole either to salt the lower portions or be lost.

- Don't get carried away with volume correction calculations.

SOLID AUGER DRILLS

- Used extensively in northern Canada in permafrost conditions.
- Relatively cheap method of drilling (but not as cheap as Banka Drilling).
- Auger Drills will work in consolidated or semi-consolidated soils and gravels.
- Sample collection can be problematic if the holes are very wet.
- Drilling progress through large hard boulders can be very slow.
- Higher drilling rate than Banka drills (100 to 200 ft/day vs 30 to 40 ft/day)
- Drill rods are made of solid steel bar with steel flights welded in a helical path around it.
- There is no hammer action, just rotation and down pressure.
- Rotation of the augers brings the sample to surface.
- Sample is collected in a large flat steel pan.
- Best to sample continuously without pulling drill rods until the bottom of the hole.
- Unlike reverse circulation drills, auger drills do not provide instant samples.
- However variations in the sound and vibration of the drill help to determine the depths at which soil changes occur.
- Auger drills are relatively lightweight and can be mounted on all terrain-tracked vehicles.

GEOPHYSICAL METHODS

- Ground Penetrating Radar
- Seismic Refraction Methods
- Magnetometer Surveys

SAMPLE PROCESSING

- Samples are usually processed on small testing sluices (Long Toms or Warriors).
- The testing sluice must be easy to clean thoroughly between samples. (jigs are no good, some screens are no good)
- Wooden, porous or rusty sluices are extremely difficult to clean and can carry over gold values between samples.
- The hopper should have wash bars and an adjustable slope to allow holding and washing the sample to break up any lumps of clay prior to releasing the slurry into the sluice run.
- A stationary screen should be used to remove any coarse gravel, but may not be necessary for drill samples.
- The testing sluice run should be fitted with medium to lightweight expanded metal riffles, held down tightly on top of porous, easily cleaned matting.
- Don't use cocoa matting because it is almost impossible to clean between samples.
- A steady supply of clean water must be provided to a depth of 10 to 20 mm (0.4 to 0.8 in) above the expanded metal riffles.
- A bucket should be placed at the discharge of the testing sluice to check for gold losses.
- The concentrates from the testing sluices are upgraded by gold panning to a heavy mineral or black sand concentrate.
- Even experienced panners must exercise extreme care to prevent gold losses during panning.
- The highest and most unpredictable gold losses occur due to careless or rapid gold panning.
- Screening the drill sample before panning with an easily cleanable sieve helps reduce losses.
- The oversize gravels should be checked for gold nuggets before discarding.
- Any magnetic minerals should be removed with a magnet.

- A magnet should then be used to pick up and release the magnetic particles several more times in various containers to ensure that gold particles are not rejected.

- The remaining concentrate can be amalgamated with mercury and then treated with nitric acid to remove the gold particles.

Don't Salt The Sample!

- Don't use testing sluices or other sample processing equipment for upgrading concentrates.

- Stay at least 100 meters (300 ft) away from any concentrate upgrading, amalgamation, weighing, or storage area.

- Mechanical screens and testing sieves usually contain several pockets that can hold gold and contaminate samples.

Don't Poison Yourself With Mercury Or Burn With Nitric Acid!

- Always use extreme caution when handling mercury and nitric acid.

- Both are very poisonous and nitric acid is extremely corrosive.

- Work in a well-ventilated place preferably out of doors or use a fume hood.

- Never breathe the fumes.

- When stored, keep mercury and nitric acid in sealed identified containers, out of reach of children in a locked cabinet.

- Do not store mercury or nitric acid or any of the containers in your kitchen, mercury can stick to metal pans and end up in your food.

- When handling these compounds, always wear sealed latex gloves to prevent absorption into skin and safety glasses to protect your eyes.

- Don't eat or smoke when handling these chemicals.

- When handling mercury in samples, keep it under water to help keep its vapors from getting into the air.

- Never add water to acid, always add acid to water using a dropper.

- When you are finished working with mercury and nitric acid always seal and store containers and wash your hands thoroughly.

- If you are unsure of proper handling procedures for these compounds do not use them.

MINE PLANNING

- You need to do exploration for mine planning
- Mine planning saves you money:
- You can mine in an organized and efficient manner;
- You only mine gravels which have good gold values;
- You don't cover pay gravels with tailings and you know where you are going to be mining next;
- You don't waste time and money clearing and digging where there is no gold
- You can move your waste and tailings more cheaply;
- You can mine at the lowest costs; and
- You can reclaim the land while mining.

DEVELOPMENT OF A MINING PLAN

- Exploration to determine gold values and location of gravels
- Layout of mining system including:

  a) Type of mining equipment;

  b) Pit locations and pit size;

  c) Drainage of mining cuts;

  d) Removal and stockpiling of waste overburden;

  e) Sequence of mining;

  f) Establish control of surface water through diversions,

  g) Drains and ditches;

h) Layout settling ponds and facilities;

i) Plan for efficient water use; and for efficient on-going reclamation.

RECLAMATION

- ❑ Clear the forest only where you need too, but clear those areas thoroughly.
- ❑ Fall all the dead trees to prevent hazards to workers.
- ❑ Avoid clearing steep hillsides where erosion will be a problem.
- ❑ Refill your old mine pits with tailings as you mine the next pit.
- ❑ Excavate drains in any pits you can't refill to prevent stagnant water from accumulating and spreading malaria.
- ❑ Make sure all disturbed areas are covered with fine soils.
- ❑ Pump or spread fine soils over any coarse rock or tailings piles.
- ❑ Don't pile tailings in steep piles or in locations where they will wash into streams or rivers.

STREAM DIVERSIONS

- ❑ Make the channel of any stream diversions at least as deep and 1.5 times wider than the natural channel.
- ❑ Line the outsides of curves of the diversions with coarse gravels, cobbles or boulders to prevent erosion.
- ❑ Make the diversion as long as the original stream channel or use drop structures to maintain the same gradient.

LAYOUT OF SETTLING PONDS

Why Use Settling Ponds?

- ❑ To reduce pumping and/or water delivery costs
- ❑ To conserve water required for operating sluiceboxes

- To maintain fresh drinking water downstream
- To minimize potential harm to the environment
- To improve public relations for gold miners. Settling ponds are highly visible evidence of an effort being made to protect the environment.

Types Of Settling Ponds

- Old mine cuts can be refilled
- with tailings and improve water quality;
- In some circumstances, low lying areas may be dammed and filled with tailings;
- Tailings ponds can be constructed using dams or excavations;
- In some circumstances vegetation can be use to slow down tailings water and filter it cleaner.

How To Design A Settling Pond

- It is best and cheapest if settling ponds are included in the overall mine plan. For example fill in old pits with tailings.
- The larger the surface area of the pond, the better it will settle. This is because the slurry will have more time to settle.
- Ponds should be at least twice as long as they are wide
- Ponds should be deep enough to store all the sediment generated by mining
- The tailings water must flow slowly through the pond or the fines will not settle.
- Don't let the flow of slurry short-circuit through the pond.
- Use ditches and berms to direct other cleaner waters (from rainfall) away from the settling ponds wherever possible.

DESIGN OF DAMS

- General Concepts, detailed designs are site-specific and engineered to suit.
- Grubbing (removal of vegetation) where required.

- Selection of materials for construction.
- Filling and compacting layers of soils.
- Sealing the face.
- Providing drainage inside the dam.
- Armoring the upstream face.
- Armoring the spillway.

PUMPING

- There are many different styles of pumps have been developed to move water and solids.
- There are centrifugal pumps (horizontal and vertically mounted), submersible pumps, diaphragm pumps, diskflo pumps and jet pumps.
- Horizontal centrifugal pumps are the most common used in alluvial mining because they are relatively inexpensive and can be powered directly with diesel engines.

How To Select Centrifugal Pumps

- You should rely on a pump manufacturer or an engineer to help you select a pump that is most suitable for your conditions.
- To select a pump you must know:

  a) If the water will be clean or dirty, most trash pumps will only pump gravels for a short while;

  b) For pumping gravel, the maximum size of gravel, the density and abrasiveness of the gravel;

  c) What volume of water or slurry flow is required;

  d) What pressure is required at the outlet (as in a hydraulic monitor);

  e) What pressure is required to deliver that water volume to its destination (length, diameter and type of pipe);

  f) The type of pump inlet;

  g) Whether clean (gritless) water is available for gland sealing;

h) Which type of drive is preferred; and

i) The duty required (hours of operation, operating conditions)

PUMPING PRECAUTIONS

Pump Inlet

- The pump inlet needs to be protected against trash, sticks trees and rocks from entering into the pump by proper placement and with easily cleanable screens.

- The inlet needs to be submerged deep enough to avoid running dry (major concern will burn out most pumps) and deep enough to avoid vortex formation resulting in the entrainment of air (generally 2 to 3 pipe diameters)

- It needs to be high enough off of the bottom so it doesn't suck in rocks and bottom material (generally 12 pipe diameters).

- If practical the pump should always be located below the water reservoir it draws from, this is the most problem free installation.

Dirty Water And Gravel

- Dirty water or gravel will damage pumps designed for clean water.

- Coarse gravels (+1/4 inch) will require hardened metal liners.

- Fine gravels (-1/4 inch) require rubber lined pump casings and impellors.

- Gravel slurries are heavier and require more energy to pump than water.

- Pumps suitable for pumping gravels have large impellor clearances, open impellor designs and low speeds to reduce abrasion this results in low pumping efficiencies compared to pumps designed for water only. You will waste fuel if you use them for pumping water.

Suction Lifts

- It is often easier to install the pump above the water source and rely on the pump to suck the water up, but be wary of the following:

  a) The pump may have to be primed each time it is started,

b) It may have to have the air bled from its highest point frequently due to air entrainment, pipe fitting leaks, or just the dissolution of air from the water try to avoid air pockets

c) You have to select a pump with a suction lift; some pumps cannot tolerate suction lifts.

d) You may operate the pump above its recommended suction lift resulting in cavitation.

- Cavitation is the formation of water vapor (into gas bubbles) due to the pumps high suction forces (low pressures). When these little bubbles enter the pumps impellor they collapse resulting in considerable damage.

ASSESSING GOLD RECOVERY EFFICIENCY

Some common gold recovery misconceptions

FINE GOLD FAIRY TALES

- These are the time honored fairy tales used to determine the gold recovery efficiency of equipment.

- PRESENCE OF FINE GOLD – (FINE GOLD FAIRY TALES). The presence of fine gold is not a valid recovery test because even the crudest device will recover some proportion of the fine gold in an alluvial deposit.

- ABSENCE OF COARSE GOLD – (NUGGET NOTS). The absence of coarse gold or nuggets is not a valid recovery test because some types of riffles (such as fine expanded metal) are not efficient nugget catchers.

- INITIAL CONCENTRATION – (TURBULENCE TRAUMA). A high concentration of gold in the first few ft of a sluice run is not a good indicator of recovery efficiency. Radiotracer testing has revealed that even sluiceboxes with overall recoveries of less than 30% still had most of the recovered gold in the first few ft of the sluice run.

- TRIAL AND ERROR – (TRIAL AND ERROR TRIVIA). False conclusions will result when the efficiency of modifications are based on the quantity of gold recovered. This is due to the wide variations in the size distributions and quantities of gold present in different areas of an alluvial deposit. Miners are often unable to accurately estimate the gold values in either the feed or tailings gravels.

- EMOTIONAL ATTACHMENT. The excellent recovery characteristics of this device were proven by our ancestors long before (the scientific method of investigation).

- LONG TERM SURVIVAL, The long-term survival of an alluvial gold mine is dependent on many factors. Operations with high-grade gold deposits will survive even if they employ poor recovery and mining practices.

- FATALIST PHILOSOPHY. Yes I'm losing some gold, but the amount of gold that I am currently losing is inevitable and I'm still making money (in spite of myself). If you can't get more of the gold the way I'm presently operating, I'm not interested.

CONVENTIONAL ALLUVIAL TESTING

- Testing sluiceboxes with conventional sampling and evaluation techniques is very costly, time consuming, and problematic.
- Most alluvial gold ores are of very low value and contain a very small number of gold particles in a large volume of pay gravels.
- The effect of a single coarse gold particle can cause large random errors (nugget effect).
- In addition, the uneven distribution of gold particles in an alluvial deposit often produces large random sampling errors.
- The best analogy of the nugget effect is a raisin cake with only three raisins.
- After you have cut the cake into pieces, you will likely be stuffed with cake before you find all of the three raisins.
- Sluiceboxes loose coarse gold particles and the presence or absence of one of these in a tailings sample can lead to high unpredictable errors (nugget effect).
- The collection of head samples is even more impractical than tailings samples due to the more frequent occurrence of coarse gold particles.
- Every time conventional samples are upgraded, additional errors are introduced due to the inefficiency of recovery equipment.
- Significant losses are often discovered several months after testing, when it is too late for modifications and more tests in the same season.

NUCLEAR TRACERS

What are nuclear tracers?

- When alluvial gold particles are placed in a nuclear reactor, some of their nucleuses absorb an extra neutron and form gold's radioactive isotope (Au198) which can be used as a tracer.

How do we find them in a sluicebox?

- If these gold tracers have sufficient radioactivity and are relatively close, scintillometers can be used to identify and isolate the tracers.

Why do I make the gold particles radioactive?

- The gold particles are made radioactive so that very small particles can be located easily with a scintillometer and therefore used to determine gold recovery efficiency.

Do I glow in the dark?

- Radioactive gold tracers are very safe to work with because they have very low levels of radiation and they decay rapidly to plain old gold.

How is a radiotracer test done?

1. First the sluicebox is inspected and the feed rates of gravel and water flows are measured.

2. The radiotracers are added 1/2 way through the clean-up cycle but at least 8 hours before clean up.

3. The radiotracers are located (mapped) in the sluicebox using a scintillometer.

4. When the sluicebox is cleaned up, a scintillometer is used to check for losses.

5. When the concentrate is upgraded, a scintillometer is used to check for losses.

6. Once the final gold concentrate is available, it is dried, screened, and the radiotracers are picked out one by one.

7. If the concentrate is an amalgam of mercury, the mercury must be dissolved in nitric acid before the radiotracers can be picked out.

SLUICEBOX AND RIFFLE DESIGN

SLUICEBOXES

- A rectangular flume containing riffles through which diluted slurry of water and alluvial gravel flows.
- Matting or carpet is usually placed under the riffles to help retain the gold particles.
- To remove the concentrates, sluiceboxes are shut down and the riffles and matting are taken apart and cleaned.
- Most popular gold recovery device
- Simple
- Reliable
- Cheap to build
- High concentration ratio.
- Can be very selective and efficient gold recovery devices if designed and operated according to recent Canadian research.
- Generally limited to 200 mesh (74 microns) minimum gold particle size.
- Need much higher grades to justify more sophisticated primary gold recovery equipment such as centrifugal concentrators and/or flotation and/or leaching.

RIFFLE THEORY

- The sluicebox was used for thousands of years but no one really knew how it worked until recent research by Poling, and Clarkson.
- Sluiceboxes are actually centrifugal concentrators with settling velocity playing a minor role in gold recovery.
- Due to their higher density, gold particle tend to segregate to the bottom of the slurry flow where they form a streamline that is diverted by a low-pressure zone into a riffle.
- Under ideal conditions, this ribbon of slurry will be overturned and will continue flowing in a circular path to form a vortex.

- At the bottom of this vortex, centrifugal and gravitational forces combine to drive gold particles into or beside the matting.

- The slurry velocity provides the energy which powers the vortex.

- If the riffles are too close, too far apart, too tall, or if there is not enough energy in the vortex, the vortex will not be fully formed and gold recovery will suffer.

- If the slurry velocity is too high, extreme turbulence and the resulting scouring will also cause gold losses.

EFFECT OF SCREENING

- All wet gravity concentrators operate more efficiently with pre-screened and deslimed feed.

TYPES OF SCREENS

- Stationary

- Trommels/scrubbers;

- Vibrating screen decks.

EFFECT OF FEEDERS

- Conveyors

- Apron feeders

- Manned monitors

STANDARD RECOMMENDATIONS FOR SLUICEBOXES

- Field and laboratory test work has indicated that sluicebox runs should be designed to the following specifications for optimum gold recovery:

- Every sluice run should have a section of expanded metal riffles and a section of angle iron riffles in series;

- The expanded metal section should be sized to handle 8 loose cubic yards per foot of width and consist of coarse expanded metal mesh (4 to 6 lbs/ft2) fitted tightly on top of Nomad matting;

- Optimum slurry velocities for the expanded metal riffles section will range from 5 to 6 ft per second. The slopes should be set at a slope at which they do NOT pack and DO tend to deposit a crescent of heavy minerals and gold directly downstream of each individual riffle (loose gravels should partially fill the rest of the riffle);

- The expanded metal section of the sluicebox should be 12 to 16 ft long and followed or preceded by 8 ft of angle iron riffles;

- The angle iron riffle section should be approximately one half the width of the expanded metal riffle section and have to be set at a steeper gradient (slurry velocity of 6 to 8 ft per second) to avoid packing (care must be taken to reduce rooster tails where runs are narrowed);

- The one-inch angle iron riffles should be aligned at 15 degrees from the sluicebox's vertical towards to top of the box and they should be located with a clear distance of 2 to 2.5 inches between each riffle (best spacing is dependent on the type of pay gravels);

- The angle iron riffles should be fitted tightly on top of Nomad matting (light hardware screen may be inserted between the riffles and the matting to prolong the life of the matting); and

- Nuclear tracers indicated that the gold particles can migrate down the sluice run (especially during start up periods) therefore sluice runs that are easily cleaned up will allow more frequent clean ups (every 24 hours) to further reduce gold losses.

UPGRADING CONCENTRATES

WHY DO WE USE GRAVITY METHODS?

- There is a large difference between the weight of gold (SG of 15-19) versus common waste minerals (SG of 2-5);

- Gravity concentration devices are cheap to purchase and easy to operate;

- They commonly deliver the high ratios of concentration required for low-grade alluvial gold ores.

- Pre-Screening is important for best performance

When doesn't gravity work?

- Gold particles that are very fine (-0.074 mm), very flat, or hydrophobic (not easily wetted by water) are difficult to recover with gravity methods.

Gravity concentrate upgrading methods

- Hand panning;
- Small sluices (Warriors);
- Cones;
- Jigs; and
- Mineral concentrating tables.

MINERAL JIGS

- Mineral Jigs are a form of gravity concentration performed by pulsating water through a bed of dense particles (ragging) lying on a screen.

- This bed is alternately dilated and compacted by the pulsed flow water flow.

- Lighter particles flow over top of the bed, while heavy particles are drawn down to and through the bed into a hutch.

- Since metal concentrate is always contained in the hutch theft is easier to prevent (except for gold contained above the screen).

- Jigs are capable of processing relatively coarse feed material, but their performance is improved by screening to 1/4 inch (6 mm).

- Jigs work best with a solids density of 30 to 50% (much thicker than for sluices).

MERCURY AMALGAMATION

Why is it necessary to pre-concentrate with gravity methods before amalgamation?

- Reduces the amount of material which must be amalgamated;
- Less mercury is required;
- Less mercury and gold is lost to the environment.

What is mercury amalgamation?

- Mercury amalgamation depends upon the wetting and alloying of metallic gold and mercury.

The gold particles must be clean

- The effectiveness of amalgamation is depends upon the surface of the gold and the time available to contact the mercury.
- If the gold particles are covered with oxide films or oil films they must be cleaned prior to amalgamation.
- A 3 percent solution of sulfuric acid is used to dissolve oxide films from mercury and gold surfaces and the injurious action of oils may be eliminated by adding 4 to 5 percent lime.

Why do miners use mercury amalgam?

- Mercury amalgamation is very effective at separating the fine gold particles and waste minerals with little preparation or specialized equipment required;
- Amalgamation is a very inexpensive process which requires only simple, readily available equipment; and
- Mercury amalgamation can be performed quickly and in small lots (thus allowing the gold production from each dredge or sluicebox to be measured individually on a daily basis).

Types of amalgamation

- Pan or bucket amalgamation a concentrate is mixed by hand with mercury until amalgamation;

- Copper plate amalgamation a thin film of slurry flows over a copper plate which has mercury adsorbed on its surface - the amalgam is removed by scraping it off of the copper plate

- Sluicebox mercury pockets of mercury are located in the sluicebox in an attempt to recovery gold usually results in high losses of mercury and gold

- Barrel or ball mill amalgamation concentrates, steel balls and mercury are tumbled in a sealed ball mill at slow speeds

GUYANESE METHODS

- A typical amalgamation process was as follows:

- The mercury (one or two tablespoons) was mixed with the final "black sands" concentrate in 20 liter plastic pails, often with bare hands;

- Once the gold has amalgamated (been wetted by mercury), most of the black sands are removed by washing or "pumping" them out of the bucket (high gold and mercury losses are common during this stage);

- Then hand panning is conducted to remove the remaining black sands and to clean the amalgam;

- The excess mercury is then removed from the amalgam by squeezing it through a cloth the excess mercury which comes through the cloth is collected for reuse;

- The final semi-solid amalgam was pressed into small iron pans; and

- Then the small pans were heated (in a retort) to drive off the mercury.

HOW TO REDUCE MERCURY LOSSES AND HEATH HAZARDS

Upgrade and screen your concentrates first

- Sluicebox concentrates should be upgraded with gravity methods (such as another smaller sluicebox) a second time to reduce the volume of the final concentrate.

- This also reduces the amount of mercury required for amalgamation and reduces mercury and gold losses to the environment;

Use rubber gloves

- Rubber gloves reduce potential absorption of mercury through the skin.

- Rubber gloves should be used to handle mercury at all times.

- Mercury should be kept well sealed and/or under water;

Wash the amalgam in a jig box

- When mercury bearing gold concentrates are washed and panned in rivers both gold and mercury is lost, and the rivers become polluted.

- Mercury bearing concentrates should be washed, panned and filtered in a large closed container "jig box" where any mercury and gold losses can be recovered by reprocessing these concentrates on a weekly or monthly basis; and

Use a retort

- Mercury vapors are very harmful to your health.

- It is extremely dangerous to roast the excess mercury from compressed filtered amalgam/gold buttons without the use of a retort, or with leaky retorts, or using stoves and cooking appliances, which were otherwise used in the preparation of food.

- This is could easily result in the inhalation and ingestion of excessive amounts of mercury in workers.