

# NERCO CON MINE ARSENIC PLANT - ENVIRONMENTAL MANAGEMENT THROUGH

## RESOURCE RECOVERY

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### Abstract

This paper deals with the Nerco Con Mine arsenic trioxide plant. This operation has demonstrated that a major environmental liability can become an asset through commitment to resource recovery.

The mine was originally owned and operated by Cominco Ltd. From 1940 - 1970, the gold ore was refractory in nature, and was roasted, prior to cyanide leaching and gold precipitation. An arsenic trioxide sludge was produced as a byproduct, and over 70,000 tons were stockpiled.

As a condition of the 1981 water licence, the mine was required to establish environmentally acceptable storage areas. Rather than install a potential long-term liability, an Arsenic Plant was constructed in 1983, to recover the arsenic trioxide as a high grade product using a weak acid leach and crystallization process, tested at Cominco's Technical Research Centre.

When the plant was operating consistently, it was found that the chemistry was unreliable. Leach and crystallization modifiers were felt to be the problem, but were not identified, or removed in the existing process. The plant was shut down in late 1985 and used for tailings water treatment, while further research work continued. This identified the need for several process additions.

Nerco Minerals Inc. purchased the mine in late 1986, and directed a successful remodelling and start-up program in early 1987. The plant is now producing a high purity, crystalline product. Residues from the process contain significant gold and silver values.

## General

Nerco Con Mine, Ltd. is located near the City of Yellowknife on the north shore of Great Slave Lake. The mine was operated by Cominco Ltd. until late 1986, at which time it was purchased by Nerco Minerals Inc. It was the Northwest Territories' first gold mine, pouring the first two bricks on September 5, 1938.

In 1941 a roasting plant was added to the cyanidation mill to treat the refractory gold ore. A wet scrubber was operated downstream of the roaster to retrieve the arseniferous wastes from the roaster off gases. The scrubber effluent was pumped to arsenic storage basins where the slurry was allowed to settle by gravity, forming an arsenic trioxide sludge. The supernatant was decanted and returned to the scrubber for re-use.

Initially one rock basin located on the property was used for storage of the arsenic sludge but later a second basin from the adjacent Negus Mine was used. Accumulation of arsenic sludge continued until November 1970, when the amount of gold-bearing arsenopyrite dropped and roasting was discontinued.

### Storage of Arsenic - A Long-Term Problem

The two storage basins contained over 70,000 tons of arsenic sludge and posed a potential environmental hazard. In the summer the surface of the sludge would partially dry out resulting in airborne arsenic trioxide. Surrounding surface water and groundwater were considered threatened by leachate containing soluble arsenic which could possibly escape through the deteriorating dams.

The sludge contains 50% arsenic trioxide as well as 0.70 oz/ton gold and 1.20 oz/ton silver. The material is extremely difficult to handle. It is toxic, very fine, with an average particle size of 85% minus 5 microns, and forms a thixotropic mass containing 35% moisture.

During the late 1970's, the storage ponds became an issue with the N.W.T. Water Board. Conditions were included in the Con Water Licence to submit "detailed proposals for the containment and reclamation of all arsenic oxide storage areas located on the property..."

Cominco Ltd. contracted a consulting engineering firm to undertake a review of alternative methods of dealing with the arsenic sludge. The alternatives considered were divided into three main categories:

- ° Chemical Fixation Methods - involved the addition of chemicals that will react with the arsenic to form insoluble arsenic compounds.
- ° Physical Processing Methods - involved the containment of the arsenic sludge within an impermeable system.
- ° Resource Recovery Methods - involved the processing of the arsenic sludge to recover precious metals and the arsenic trioxide for re-use.

All of the alternatives were evaluated on the basis of their process feasibility potential for eliminating emissions of arsenic to the environment and economics. Chemical fixation methods and physical processing methods were eliminated due to their high capital and/or operating costs. There were also leaching risks associated with the chemical fixation methods.

Resource recovery was considered technically feasible but the high capital and operating costs meant that a detailed marketing study was required. There were also potential environmental problems associated with the proposed pyrometallurgical process, particularly in the areas of fume and dust control.

Attention was turned toward a new physical containment method which, if successful, would provide a politically and environmentally acceptable alternative. Studies to freeze the sludge in-situ, either naturally or artificially, were initiated. It was concluded that although technically feasible, it would be a costly and difficult method to execute. Long-term monitoring would also be required.

### Resource Recovery

A resurgence of market prices for arsenic trioxide in 1980 rekindled interest in the resource recovery alternative.

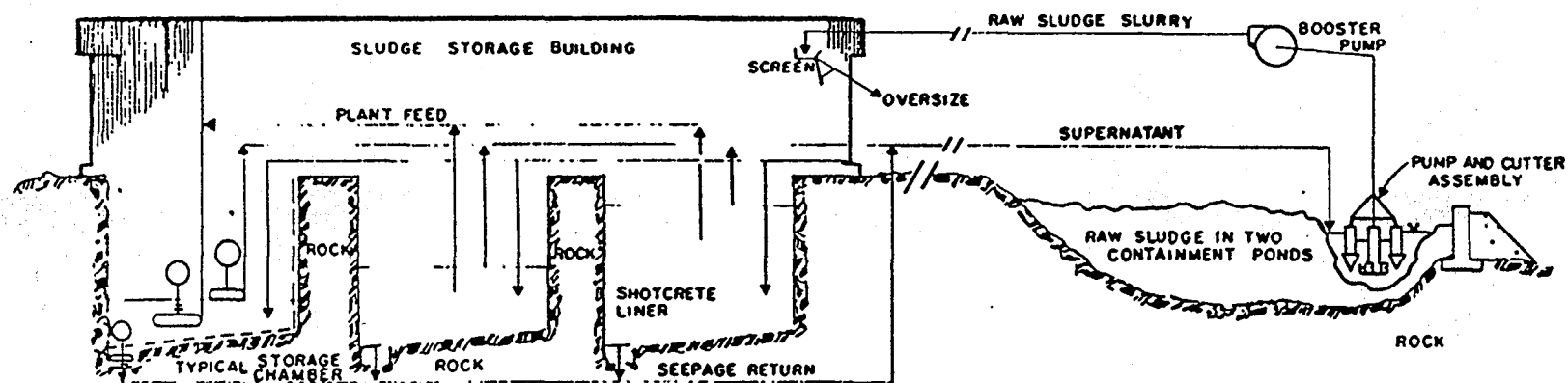
Cominco researchers were aware of the potential of a hot water leach and precipitation process, from work done on other material at their metallurgical complex at Trail, B.C. Although the capital and operating costs of the hot water leach process were higher than a fuming method, the leach process was chosen as being environmentally superior. A laboratory test program was conducted at the Technical Research Centre in Trail during 1980, which established the process design parameters for a full scale plant.

Detailed engineering was then conducted, and Cominco Ltd. received approval from the Water Board in March 1981 to proceed with plans to build the Con Arsenic Trioxide Plant. The plant was built in 1982, and commissioned in early 1983.

### Process Design

A system had to be designed that would ensure a constant raw sludge supply, but reclaiming sludge in the winter was out of the question. The system had to be able to reclaim 10,000 tons of raw sludge in the summer and stock it in protected storage for easy winter recovery to feed the plant.

Tanks for stocking the reclaimed sludge were rejected in favour of water-tight chambers excavated below grade in solid rock. Three chambers were blasted out, each 40 feet deep and 60 feet in diameter. These were shotcreted, with drainage sumps cut into the underlying rock so that the chambers could be monitored for seepage. The chambers are covered with a low building, heated to prevent freezing of the material.



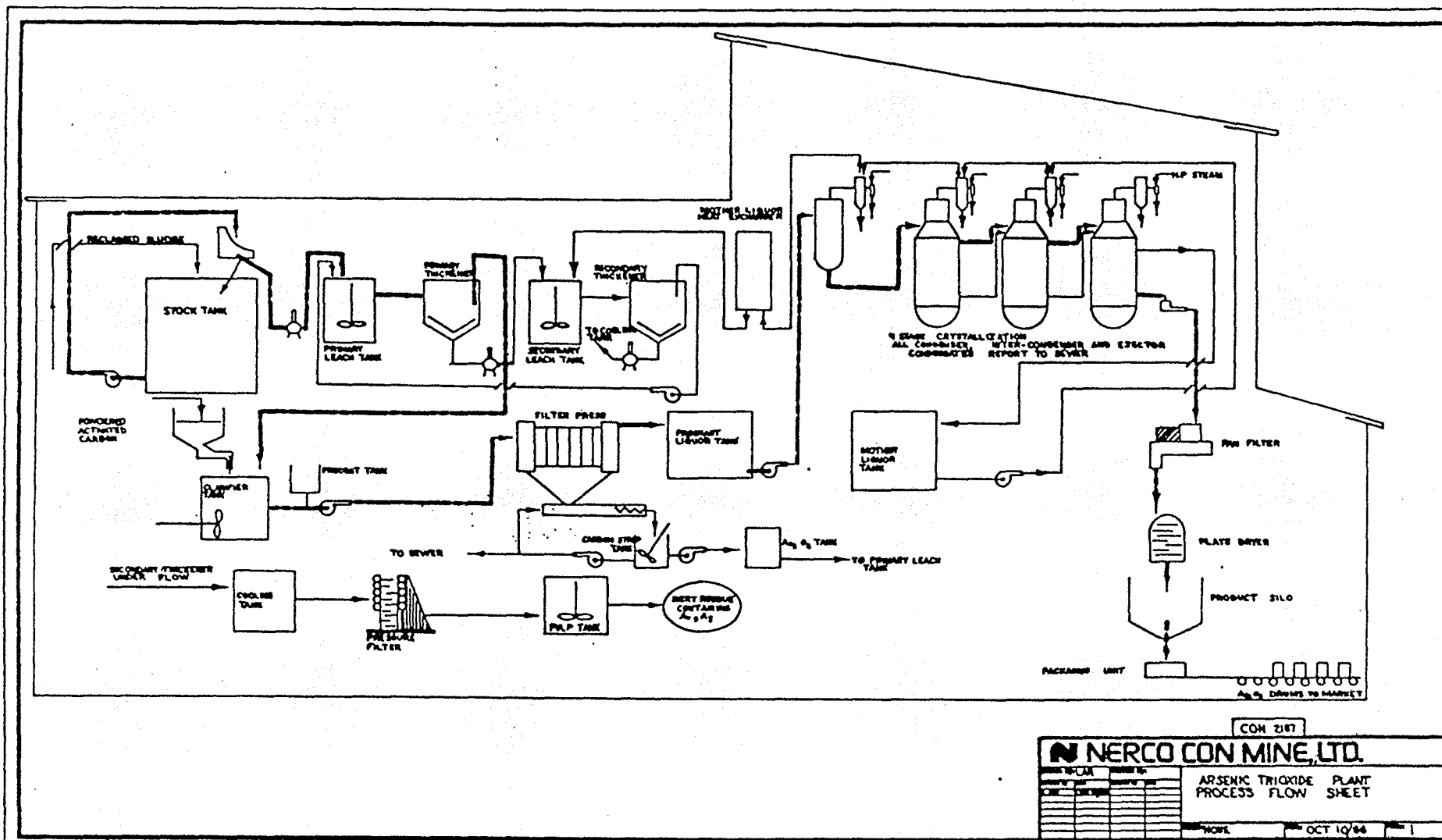
SLUDGE STORAGE AND RECOVERY SYSTEM

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SLUDGE STORAGE AND RECOVERY SYSTEM  
PROCESS FLOW SHEET

DRAWING NO. CON. 2188

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The extraction process is a two stage countercurrent leach operating at 95°C. The primary stage treats raw arsenic sludge at 20 stpd, extracting over 90% of the available arsenic trioxide, and the secondary stage recovers the remainder. Key process developments are the addition of small amounts of hydrogen peroxide to enhance the leach kinetics, and clarification methods which include thickening followed by powdered activated carbon filtration to remove crystallization modifiers and enhance product purity.

The hot pregnant liquor is subjected to four stages of evaporative cooling and crystallization in growth type units. Over 75% of the process heat released in crystallization is recovered using mother liquor recycle as the cooling medium in surface condensers. In winter, the remaining 25% is used to pre-heat incoming ventilating air. This is believed to be the first commercial application of this technology to produce arsenic trioxide, which is an extremely difficult material to crystallize successfully.

The product from the final stage is dewatered to less than 0.1% moisture and stored in a silo capable of holding four days' production. The arsenic trioxide produced is 99.8% pure and is packaged in extra strength 45 gallon steel drums in 1,000 lb. increments.

The 8 stpd of residue left after the arsenic trioxide is recovered contains 1.2 oz. of gold/ton and 3.5 oz. of silver/ton. This material is currently being stockpiled. Metallurgical evaluation is underway to determine the requirements for precious metals recovery. Final inert residues will be disposed of in the tailings pond, along with 750 stpd of mill tailings.

#### Problems Associated with Start-up and Operation

As might be expected when starting a plant using untested technology to produce a new product, there were many areas in the plant which required modifications of the process and/or the equipment. The majority of the problems could probably have been avoided by completing a more rigorous metallurgical research and process design program, and by ensuring that adequate hygiene management equipment and procedures were in place, prior to attempting construction and start-up.

From a process standpoint, a major problem was the transport of corrosive, high density slurry in small volumes. In several areas, piping had to be replaced to minimize flow restrictions, increase process flexibility and make allowance to flush out lines. Several pumps had to be replaced to reduce damage to the product, increase or decrease flow rates, reduce maintenance requirements and improve ease of operation.

An area of immediate concern was the dewatering plant. A solid bowl centrifuge was chosen for primary dewatering, however it degraded the final product. A cake was produced which had high moisture content, could not be successfully dried and could not meet product size specifications.

The centrifuge was replaced with an horizontal pan filter which achieved an acceptable discharge moisture content without degrading the product. The dryer discharge was thereby free flowing and dust free.

Unfortunately, the pan filter and dryer have proven to require excessive operator attention and maintenance. By virtue of the equipment design, neither operation or maintenance can proceed in an environmentally acceptable fashion. This area of operation is currently being evaluated in order to identify and install equipment which will perform the same function, while improving worker health and safety.

Crystallization of arsenic trioxide proved to be difficult from a metallurgical and operational standpoint. Several design problems were found with the crystallizers and their condensers. Three of four units were modified and the fourth was completely replaced. Instrumentation for the crystallizers proved unreliable, resulting in difficult operation. Extensive modification of instrumentation was necessary to allow consistent operation.

As constructed, the plant had very poor ergonomics. Extensive modification was required to allow access to operating areas, equipment, manways, control valves, etc. Plant lighting was very poor, and extensive modification was required.

After two years operation, several mechanical modifications allowed plant availability to exceed 90%. Operator hygiene also improved significantly over this period, proving that the plant could operate consistently and safely. It became obvious, however, that more research work was required, if the plant was to produce consistently.

The presence of crystallization modifiers was suspected to be the cause of inconsistent metallurgical performance. These modifiers were felt to be associated with organic material, which formed part of the feed stock, in varying amounts. This was evidenced by a yellow tint in the crystallization liquor, which varied in intensity as production rates rose and fell. Product colour also varied, between a buff colouration during periods of poor productivity, and near-white when productivity was good.

The plant was shut down in late 1985, and converted to a water treatment plant in order to treat tailings pond water on an emergency basis. During an eight month period, research work continued, in an attempt to identify the crystallization modifiers, and determine the process requirements necessary to ensure their removal.

A laboratory scale mini-plant was constructed in mid-1986. A test program was undertaken which was much more rigorous than the laboratory work used to model the initial design. As a result, the research team was successful in duplicating the inconsistent metallurgical performance experienced in the full scale plant. This allowed evaluation of process modifications which would remove crystallization modifiers and allow consistent production to proceed.

A carbon filtration system was developed which includes mixing of powdered activated carbon with the crystallization liquor, then removing the carbon using a filter press. The resulting solution is water clear, and crystallizes quickly and reliably. Product purity and colour are excellent.

Nerco Minerals Incorporated purchased the Con Mine from Cominco in late 1986. The arsenic plant was modified to incorporate the carbon filtration system, and re-started in early 1987. Productivity and product purity have been excellent, and the plant continues to improve its availability.

#### Hygiene Control: Training of Operating and Maintenance Personnel

The people working at the Con Mine in 1983 were effective in the operation and maintenance of a 40-year old gold mill. Training these people to work in an environment which included high pressure steam, pumps with mechanical seals, extensive instrumentation, high temperature slurries and a complex hygiene control program proved to be difficult. This difficulty was compounded when key equipment items failed to perform their requirements as designed.

At start-up in 1983, a formal training program was non-existent for any aspect of the operation or its maintenance. As might be expected, several problems were encountered with operator hygiene, plant operating consistency and maintenance procedures.

Training programs now in place include a comprehensive indoctrination, written job procedures for routine and non-routine work, a modular operations training program, respirator training, welding safety and tank entry training and equipment maintenance training for some of the equipment items peculiar to the plant.

The training programs are integral to the hygiene control program, which includes extensive environmental and biological monitoring, a comprehensive plant entry/decontamination procedure, respiratory protection and engineering controls throughout the plant.

#### Conclusions

The plant modifications, re-commissioning and re-start directed by Nerco Minerals has been very successful. A major component of this success has been the commitment to extensive training of operators and tradespeople in both hygiene control and a specialized area of work.

The plant is now operating at close to 90% availability. The product purity is very high, at +99.8%  $\text{As}_2\text{O}_3$ . Product colour is near white, generally +92% reflectance, and +96% lightness using a chromameter.

The commitment by Cominco Ltd. and Nerco Minerals to pursue resource recovery of a toxic waste has involved a high degree of risk. Over the long term, however, it will ensure that the arsenical wastes are permanently stabilized.

In about five years, the two containment ponds will no longer exist. Three products, being arsenic trioxide, gold and silver will have been produced in sufficient quantity to pay off the plant's operating costs. In this way, an environmental liability will have become an economic asset.



### References

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2. Cominco Ltd., Trail Research Centre Reports.