

## APPENDIX A.--MINING AND MINERAL PROCESSING TERMS

The following definitions are provided to assist the reader who may not be familiar with some of the mining terms used in this handbook. Most of the definitions are paraphrased from the Bureau's Special Publication, "A Dictionary of Mining, Mineral, and Related Terms," compiled and edited by P. W. Thrush, 1968.

**abandoned mine; abandoned workings**--Excavations, either open, caved, or sealed, that are deserted and in which further mining is not intended.

**acid mine water, acid mine drainage (AMD)**--Mine water which contains sulfuric acid, mainly due to the oxidation of iron pyrite.

**activator (flotation mill)**--A reagent that facilitates flotation of selected mineral species in a flotation cell. See "depressant."

**adit**--A horizontal or nearly horizontal passage driven in rock from the surface for the working or dewatering of a mine.

**amalgamation**--The process by which mercury is alloyed with some other metal to produce an amalgam. Used at one time for the extraction of gold and silver from pulverized ores.

**ANFO**--Blasting agents comprised of a mixture of ammonium nitrate and fuel oil.

**arrastre; arrastra**--A circular rock-lined pit in which broken ore is pulverized by stones attached to a pillar and dragged around the pit. The arrastre was in common use in the western and southwest United States in the 18th and 19th centuries.

**arsenopyrite**--Iron-arsenic sulfide, FeAsS.

**assay**--(1) (verb) to determine the amount of metal contained in an ore; (2) (noun) the result of making such a determination. Note: difference between assay and analysis: in an analysis all of the chemical constituents are determined; in an assay only certain constituents are determined, usually those of commercial interest.

**ball mill**--A rotating horizontal cylinder in which nonmetallic materials are ground using various types of grinding media such as quartz pebbles, porcelain balls, or steel balls.

**barren solution**--Leaching solution that has been chemically stripped of metal values. Typically, the barren solution is recharged with leaching agent and recycled.

**beneficiation**--The processing of ores for the purpose of (1) regulating the size of a desired product, (2) removing unwanted constituents, and (3) improving the quality, purity, or assay grade of a desired product.

**blasting cap**--An enclosed metal shell containing a charge of detonating compound which is ignited by electric current or the spark of a fuse. Used for detonating high-yield explosives.

**blasting gelatin**—A high-yield explosive consisting of nitroglycerin and nitro-cotton. It is a strong explosive and is a rubber-like, elastic substance that is unaffected by water.

**blasting machine**—A portable device that generates enough electric current to detonate electric blasting caps.

**bore hole**—An exploratory or prospecting hole made by drilling.

**carbon column**—A columnar tank containing activated charcoal in which metal values are adsorbed by the charcoal from a pregnant leach solution circulated within.

**carbon-in-leach (CIL)**—A recovery process in which a slurry of gold ore, free carbon particles, and cyanide are mixed together. Cyanide dissolves gold from the ore and the gold is simultaneously adsorbed onto the carbon. The carbon is separated from the slurry and the gold recovered.

**carbon-in-pulp (CIP)**—A process to recover dissolved gold from a cyanide leach slurry. Coarse activated carbon particles are moved countercurrent to the slurry absorbing gold as it passes through the circuit.

**carbon stripping**—Process wherein metal-laden charcoal from the carbon columns is stripped of metal values with a hot caustic solution. The stripping solution is then passed to electrowinning cells where the metals are electroplated on steel wool cathodes.

**carbonate rocks**—Rocks composed primarily of the mineral calcite,  $\text{CaCO}_3$ .

**chalcopyrite**—Copper-iron sulfide,  $\text{CuFeS}_2$ .

**Chilean mill; edge runner**—A mill having vertical rollers running in a circular enclosure with a stone or iron base or die. There are two classes: (1) those in which the rollers gyrate around a central axis, rolling upon the die as they go (the true Chilean mill), and (2) those in which the enclosure or pan revolves, and the rollers, placed on a fixed axis, are in turn revolved by the pan.

**cistern**—A settling tank for liquid slag, slurry, or pulp.

**claim**—An area of land claimed by an individual or corporation for the ultimate purpose of mineral extraction. The dimensions of a lode claim are 183 m by 457 m (600 by 1,500 ft); for a placer claim, 183 m by 402 m (600 by 1,320 ft).

**cleaner cell, recleaner cell**—Secondary cells in a flotation mill for the retreatment (flotation) of concentrate from the primary (rougher) cells.

**collar**—The term applied to the timbering or concrete around the mouth or top of a shaft. The junction of a mine shaft and the surface.

**collector (flotation mill)**—A reagent that aids or facilitates the attraction of mineral particles to the froth in a flotation cell. Xanthate is a common collector in use from the 1930s to date.

**comminution**—The reduction of solids to minute particles by crushing and grinding to liberate metal values.

**commodity**—Mineral product produced at mine or mill (e.g., gold, silver, copper).

**concentrate; mineral concentrate**—(noun) Enriched ore after the removal of waste in a beneficiation mill. Usually referred to in the plural form, "concentrates."

**concentrate**—(verb) To separate metal or ore from the associated gangue or barren rock.

**concentrator**—Mill or plant in which ore is concentrated by removing unwanted constituents.

**conditioner (flotation mill)**—Substances added to the pulp in a flotation mill to maintain the proper pH to "protect" certain salts such as NaCN that would decompose in an acid circuit. Sodium carbonate (Na<sub>2</sub>CO<sub>3</sub>) and calcium oxide (lime—CaO) are the most common conditioning agents since most flotation pulps should be alkaline.

**country rock**—General term applied to the rock surrounding and penetrated by mineral veins; in a wider sense applied to the rocks invaded by and surrounding an igneous intrusion.

**crosscut**—(1) A passageway driven at right angles to the main entry to connect it with a parallel entry or air course. (2) A horizontal opening driven across the course of a vein or in general across the direction of the main workings.

**crusher**—A machine for crushing rock or other materials. Among the various types of crushers are the ball mill, gyratory crusher, Hadsel mill, hammer mill, jaw crusher, rod mill, rolls, stamp mill, and tube mill.

**cyanide**—A salt or ester of hydrocyanic acid. In aqueous solution, cyanide is used to dissolve metal values from gangue material for later recovery.

**cyanidation**—Recovery process involving the use of cyanide compounds to dissolve metal values.

**cyclone; cyclone classifier**—A device for classification by centrifugal means of fine particles suspended in water whereby the coarser grains collect and are discharged at the apex of the vessel, while the finer particles are eliminated with the bulk of the water at the discharge orifice.

**decline**—An access to an underground mine which descends at an appropriate angle, often in a spiral fashion (spiral decline).

**deposit**—See "mineral deposit."

**depressant (flotation mill)**—A reagent that causes selected mineral species to sink in a flotation cell. See "activator."

**detonating fuse**—A fuse consisting of a high-yield explosive that fires the charge without the assistance of any other detonator. It consists of a core of pentaerythritol tetranitrate (P.E.T.N.) enclosed in tape and wrapped with textile countering yarns. Usually the fuse is reinforced or completely enclosed in a strong waterproof plastic outer cover. The finished external diameter is normally about 5 mm (0.2 in). "Primacord" is the best known brand name. Also known as detonating cord.

**detonator**—A device for producing detonation in a high-explosive charge initiated by a safety fuse or by electricity.

**developed prospect**—Prospect wherein infrastructure is in place and mine development has been completed but property has not produced ore.

**dolomite**—A rock-forming carbonate mineral,  $\text{CaMg}(\text{CO}_3)_2$ .

**dore'**—Gold and silver bullion which remains in a cupelling furnace after lead has been oxidized and skimmed off.

**dredge**—A raft or barge on which is mounted machinery for the excavation and washing of alluvial deposits or gravel for gold, tin, platinum, diamonds, etc.

**drift**—A horizontal passage underground. A drift follows the vein, as distinguished from a crosscut, which intersects it, or a level or gallery, which may do either.

**drill steel**—A round or hexagonal steel rod for boring in coal, ore, or rock.

**dump**—A pile or heap of waste rock material or other non-ore refuse near a mine.

**dynamite**—An industrial explosive which is detonated by blasting caps. The principal explosive ingredient is nitroglycerin or specially sensitized ammonium nitrate.

**electrowinning**—Recovery of a metal from an ore or solution by electrochemical processes.

**explored prospect**—Prospect on which resources have been defined.

**face**—The surface exposed by excavation. The working face, front, or forehead is the face at the end of the tunnel heading, or at the end of the full size excavation.

**flotation**—The method of mineral separation in which a froth created in water by a variety of reagents floats some finely crushed minerals whereas other minerals sink.

**flotation cell**—Device in which froth flotation of ores is performed.

**fuse**—A core of black powder wrapped with hemp or cotton threads or tape, with various waterproofing compounds between each.

**frother**—A reagent which serves to stabilize the froth in a flotation cell until it can be scraped off into the concentrate launder.

**galena**—Lead sulfide,  $\text{PbS}$ .

**glory hole**—A funnel-shaped excavation, the bottom of which is connected to a raise driven from an underground haulage level.

**GPS receiver**—A hand-held radio receiver which receives latitude/longitude coordinates from an earth-orbiting satellite.

**gravity mill**—A process in which heavy metals or minerals are separated from waste by the action of agitation and gravity on materials suspended in a liquid, usually water.

**grizzly**—A device for the coarse screening of bulk materials. A rugged screen for rough sizing at a comparatively large size (for example, 150 mm or about 6 in).

**hand auger**—A tool modeled after the carpenter's drill used in soil sampling.

**HCl**—Hydrochloric acid.

**headframe**—The vertical steel or timber frame at the top of a shaft which carries the sheave or pulley for the hoist.

**heap leach**—A recovery process in which prepared ore is stacked in heaps on impervious pads and a solvent percolated through the heap to dissolve selected metal values.

**heavy metal**—Principally the metals zinc, copper, cobalt, and lead. Sometimes the term is used to include one or more of the following metals: bismuth, cadmium, gold, indium, iron, manganese, mercury, nickel, palladium, platinum, silver, thallium, and tin.

**Hg**—Mercury.

**highwall**—The unexcavated face of exposed overburden and coal or ore in an opencast mine or the face or bank on the uphill side of a contour strip mine excavation.

**hoist**—(1) A drum on which wire rope is wound in the engine house as the cage or skip is raised in the hoisting shaft. (2) An engine with a drum used for winding up a load from a shaft.

**H<sub>2</sub>SO<sub>4</sub>**—Sulfuric acid.

**impoundment**—An area, often contained by a dam, used as a water supply for a mining or milling operation or as settling ponds for tailings slurries.

**inclined shaft or incline**—A nonvertical shaft; usually along the dip of a vein.

**industrial mineral**—A mineral valued for its physical or chemical properties rather than its metal content (e.g., garnet, kyanite, borate minerals, clay, etc.).

**infrastructure**—Ancillary facilities such as power, water, and sanitation systems, access and haul roads, shops, offices, warehouses, etc., at a mine site.

**initiation**—The process of causing a high explosive to detonate.

**iron oxide**—iron (and possibly other metallic ions) in combination with oxygen.

**jaw crusher**—A primary crusher designed to reduce large rocks or ores to sizes capable of being handled by any of the secondary crushers. It consists of a moving jaw, hinged at one end, which swings toward and away from a stationary jaw in a regular oscillatory cycle.

**jig; mineral jig**—A machine in which the feed is stratified in water by means of a pulsating motion and from which the stratified products are separately removed, the pulsating motion usually being obtained by alternate upward and downward currents of the water.

**jig plant**—A recovery plant that uses mineral jigs to recover mineral values.

**latitude**—Locational coordinate expressed in degrees, minutes, and seconds north or south of the equator.

**leach pad**—A specially prepared area covered by an impervious liner on which ore is placed for leaching.

**leaching**—(1) The removal in solution of the more soluble minerals by percolating waters. (2) Extracting a soluble metallic compound from an ore by selectively dissolving it in a suitable solvent, such as water, sulfuric acid, hydrochloric acid, cyanide, etc.

**level**—A main underground roadway or passage driven along the level course to afford access to the stopes or workings and to provide ventilation and haulageways for the removal of ore.

**limestone**—A rock composed primarily of the mineral calcite,  $\text{CaCO}_3$ .

**limonite**—Iron hydroxide,  $\text{HFeO}_2$ .

**long tom**—A long trough or sluice for washing gold-bearing sand and gravel.

**longitude**—Locational coordinate expressed in degrees, minutes, and seconds east or west of the Greenwich meridian.

**marble**—A metamorphic carbonate rock, generally derived from limestone.

**marcasite**—Iron sulfide,  $\text{FeS}_2$ .

**Merrill-Crowe plant**—A method of recovering metal values from solution by precipitation with zinc dust.

**mercury fulminate; mercuric fulminate; mercuric cyanate; fulminate of mercury**—A mercury compound used in the manufacture of blasting caps and detonators for detonating explosives.

**mesh**—The number of openings per unit area of a screen (sieve).

**methane**—A tasteless, colorless, nonpoisonous, explosive, and odorless gas, formed by the decomposition of organic matter. Methane is the most common explosive gas found in coal mines.

**mill**—A mineral treatment plant in which crushing, grinding, and further processing of ore is conducted to produce a product.

**milling**—The processing of ore to produce a product.

**mine**—An excavation for the extraction of ore or other economic minerals.

**mine development**—The term used to describe the operations involved in preparing a mine for ore extraction. These operations may include tunneling, sinking, crosscutting, drifting, and raising.

**mineral**—An inorganic substance occurring in nature, though not necessarily of inorganic origin, which has (1) a definite chemical composition or, more commonly, a characteristic range of chemical composition, and (2) distinctive physical properties or molecular structure.

**mineral dressing**—Physical and chemical concentration of raw ore into a product from which a metal can be recovered at a profit. Mineral dressing processes are also applied to industrial wastes to retrieve useful byproducts.

**mineral deposit**—A surface or underground body of mineral matter that may be utilized for its industrial mineral or metal content.

**mineral location**—A location where the occurrence of mineralized materials has been noted.

**mining district**—An area or region characterized by the occurrence of specific mineral suites or the nature of mineral deposits.

**NaHCO<sub>3</sub>**—Sodium bicarbonate.

**NaCN**—Sodium cyanide.

**non-energy leasable commodity**—Leasable commodities such as phosphate, salt, sulfur, etc. that are not sources of energy (such as coal, uranium, etc.).

**open-pit mining; opencut mining**—A form of operation designed to extract minerals that lie near the surface. The mining of metalliferous ores by surface-mining methods is commonly designated as "open-pit mining" as distinguished from "strip mining" of coal and the "quarrying" of other nonmetallic materials such as limestone, building stone, etc.

**ore**—A mineral, or mineral aggregate, containing precious or useful metals or metalloids, and which occurs in such quantity, grade, and chemical combination as to make extraction commercially profitable.

**ore bin**—A receptacle for ore awaiting treatment or shipment.

**ore body**—Generally, a solid and fairly continuous mass of ore which may include low-grade ore and waste as well as high-grade material.

**ore chute**—An inclined passage, from 0.9 to 1.2 m (3 to 4 ft) on a side, for the transfer of ore to a lower level in underground workings.

**ore deposit**—A general term applied to rocks containing minerals of economic value in such amount that they can be profitably exploited. Also applied to deposits which, though they may not be immediately capable of profitable exploitation, may yet become so by change in the economic circumstances that control their value.

**past producer**—Mining property that has produced ore in the past.

**pH**—A measure of the degree of acidity or basicity of a solution. At 25° C, a pH of 7 is neutral. Acidity increases with values below 7, and basicity increases with values above 7.

**pine oil**—A commercial distillate of wood widely used as a frothing agent in flotation processes.

**pit**—Surface excavation of relatively large dimensions from which ore and waste has been extracted.

**pit, exploration**—Small (usually less than 5 m deep) pit excavated to explore for minerals.

**placer**—A mineral concentration resulting from weathering processes usually involving running water. Placer deposits are typically composed of heavy minerals, with gold, platinum, tin, and diamonds being the most important.

**Public Land Survey (PLS) system**—Locational system whereby areas of land are divided into 36-square mile increments north or south of a base line and east or west of the principal meridian established for the general region. Pamphlets, booklets, and other published information that describe the PLS system and how to use the system are available at most USGS Map Sales offices.

**portal**—(1) The surface entrance to a drift, tunnel, or adit. (2) The entrance to a mine.

**powder**—A general term for explosives, including dynamite, but excluding caps.

**pregnant solution**—Metal-laden solution (cyanide, acid, etc.) resulting from a leach process.

**prill**—Spherical particle about the size of a buckshot. Used in describing the shape of ANFO pellets.

**primacord**—A fuse composed of an explosive core within a textile or plastic covering. Used to detonate the explosives that are in direct contact with it.

**principal meridian**—The meridian on which the PLS coordinates are based for a given region.

**prospect**—(1) A mineral property, the value of which has not been proved by exploration. (2) Nonproducing mining property under development or considered worthy of such attention.

**processing plant**—Facility for processing ore into concentrates, dore', or other intermediate products.

**pulp**—A mixture of ground ore and water capable of flowing through suitably graded channels as a fluid.

**pyrite**—Iron sulfide, FeS<sub>2</sub>.

**pyrrhotite**—Iron sulfide, Fe<sub>1-x</sub>S.

**quadrangle**—The USGS 1:250,000 (1 x 2°) map series.

**quarry**—A surficial opening or pit from which building stone, such as granite, marble, slate, etc., is extracted.

**radon**—A heavy, radioactive gas.

**range**—PLS coordinate expressed in 36-square mile increments east or west of the principal meridian.

**raw prospect**—A mineral location on which no significant exploration or other work has been done.

**reagent**—A chemical or solution used to produce a desired chemical reaction; a substance used in assay or flotation.

**retort**—A device used to distill off and recover mercury from amalgam.

**rib**—The side of a pillar or the wall of a mine entry.

**rind, rinding, weathering rind**—Weathered surface of rock.

**rockfall**—The relatively free-falling of a detached segment of bedrock of any size from a cliff, steep slope, cave, or arch.

**rod mill**—A mill for fine grinding employing long steel rods to grind the material.

**roentgen**—A measure of X-ray or gamma ray radiation.

**roentgen equivalent man (REM)**—A unit of absorbed radiation dose in humans.

**rougher flotation cell**—The primary cell(s) in a flotation mill. Typically, discharge from the rougher cells is directed to "cleaner," or secondary cells, for further treatment.

**SAG mill; semiautogenous grinding**—A grinding mill in which a portion of the grinding is accomplished by attrition of the material being ground. Grinding is aided by the addition of steel balls or rods.

**section**—PLS coordinate of a 1-square mile portion of the 36-square mile area defined by township and range.

**section subdivision**—PLS coordinate expressed as 1/4, 1/16, or 1/64 of a section.

**sediment**—Solid material, both mineral and organic, that is in suspension, is being transported, or has been moved from its site of origin by air, water, or ice and has come to rest on the earth's surface either above or below sea level.

**sedimentation**—The settling of solid particles of soil, coal, or minerals from liquid as a result of either gravity or centrifuging.

**shaft**—An excavation of limited area compared with its depth, made for access to underground mine workings. Used for hoisting and lowering men and material, or ventilating underground workings.

**sluice; sluice box**—A long trough-like box set at an angle of about 1 in 20 through which placer gravel is carried by a stream of water. The gravel is washed away while most of the gold or other heavy materials are caught by riffles or blankets on the floor of the sluice.

**slurry**—Fine solid particles suspended in a liquid, typically water, of a consistency that allows flow by gravity or pumping.

**solution mining well**—See "well."

**solution pond**—A pond, usually associated with heap leaching operations, used to hold either pregnant (metal-bearing) or barren leach solutions.

**sphalerite**—Zinc-iron sulfide, (Zn,Fe)S.

**stamp battery; gravity stamp**—A machine for crushing ore used particularly in gold milling. It consists essentially of a crushing member (composed of a stem, head, and shoe) which is dropped on a die, the ore being crushed in water between shoe and die. An important crushing machine in the past but now becoming obsolete.

**stamp mill**—An apparatus (also the building containing the apparatus) in which rock is crushed by a stamp battery.

**stibnite**—Antimony sulfide,  $Sb_2S_3$ .

**stockpile**—A pile of ore set aside for future processing.

**stope**—An underground excavation from which ore has been removed.

**subsidence**—A sinking of a part of the earth's surface due to the collapse of underlying underground openings.

**sulfide**—A group of minerals in which metallic ions are combined with sulfur.

**sump**—An excavation in a mine used to collect water.

**surface-underground mine**—A mining operation that uses a combination of surface and underground mining methods.

**table; vibrating table; concentrating table**—A rectangular table equipped with riffles that concentrates gold or heavy minerals through vibration of material in a stream of water.

**tailings pond**—A pond with a constraining wall or dam to which mill effluents are run. Clear water may be returned after settlement, via penstock(s) and piping.

**tailings**—The refuse material resulting from the washing, concentration, or treatment of ground ore. The term, as used in the mineral industry, is used in the plural form.

**timber**—Any of the wooden props, posts, bars, collars, lagging, etc., used to support mine workings.

**township**—PLS coordinate expressed in 36-square mile increments north or south of the base line associated with the principal meridian.

**tram**—(1) A small wagon, tub, etc., for carrying minerals. (2) A boxlike wagon, running on a tramway or railway in a mine, for conveying coal or ore.

**tramway**—(1) A roadway having plates or rails on which wheeled vehicles may run. (2) A suspended cable system along which material, such as ore or rock, is transported in suspended buckets.

**tunnel**—A horizontal or nearly horizontal underground passage that is open to the atmosphere at both ends. The term is loosely applied in many cases to an adit. An adit, if continued through a hill, would then be a tunnel.

**type of operation**—The type of mining/milling operation that exists or has existed on a site.

**underground mine**—A mine wherein ore is extracted using underground mining methods. Contrast with "surface mine."

**waste**—The barren rock in a mine. It is also applied to the part of the ore deposit that is too low in grade to be of economic value at the time. This material may be stored separately in the event that it may become economic in the future.

**waste dump; spoil pile**—The area where mine waste or spoil materials are discarded.

**well**—Borehole used in solution mining or extraction of oil, gas, or geothermal water or steam.

**winze**—A vertical or inclined opening or excavation connecting two levels in a mine, differing from a raise only in construction. A winze is driven downward and a raise is excavated upward. When the connection is completed, the opening is referred to as a winze at its top and as a raise at its bottom.

**xanthate**—Common specific promoter used in flotation of sulfide ores.

## APPENDIX B.—TYPICAL MINERAL PROCESSING METHODS

Mine-run ore, with a few exceptions, must be "beneficiated" prior to further processing. "Beneficiation," commonly referred to as "milling," is the processing of ores for the purpose of (1) regulating the size of a desired product, (2) removing unwanted constituents, and (3) improving the quality, purity, or assay grade of a desired product.

Ore processing methods may be as simple as washing, screening, and drying, as in the case of sand and gravel, or highly complex as in multi-product flotation of copper, lead, zinc, silver, and gold ores.

For purposes of AML site investigations, four typical processing methods are discussed. These include amalgamation, gravity milling, two-product flotation, and heap and vat leaching.

### Amalgamation

The amalgamation gold recovery method has been used throughout the world for hundreds, perhaps thousands, of years. In the United States it was commonly used from colonial times until the 1960s and was widely used in conjunction with sluice operations or associated with stamp mills or other methods of liberating free gold from the host rock.

Gold (and other metals), when brought into contact with metallic mercury, will "amalgamate;" i.e., the liquid mercury will alloy with the surface gold to form a mercury-coated particle which has surface properties similar to those of pure mercury. The amalgamated particles will coalesce or cling together much as drops of pure mercury will collect into a single puddle. When mercury has amalgamated as much gold as possible, the result is a gray plastic mass of "amalgam." When heated in a retort, the mercury is distilled off leaving behind metallic gold ("sponge gold").

Larger amalgamation operations commonly used amalgamation plates for recovering gold. These are copper plates heavily coated with mercury (copper also amalgamates with mercury). Placer material or crushed gold ore is washed over the plate(s) as a thin pulp. The heavy gold particles fall to the bottom and are amalgamated by the mercury. When the mercury is saturated with gold, it is scraped off and new mercury applied to the plates. The amalgam is squeezed through canvas or chamois to remove excess mercury prior to retorting. Mercury vapor from the retort is condensed and reused. Amalgamation of high-grade ore or concentrates often was accomplished by agitation with mercury in a revolving barrel (barrel amalgamation).

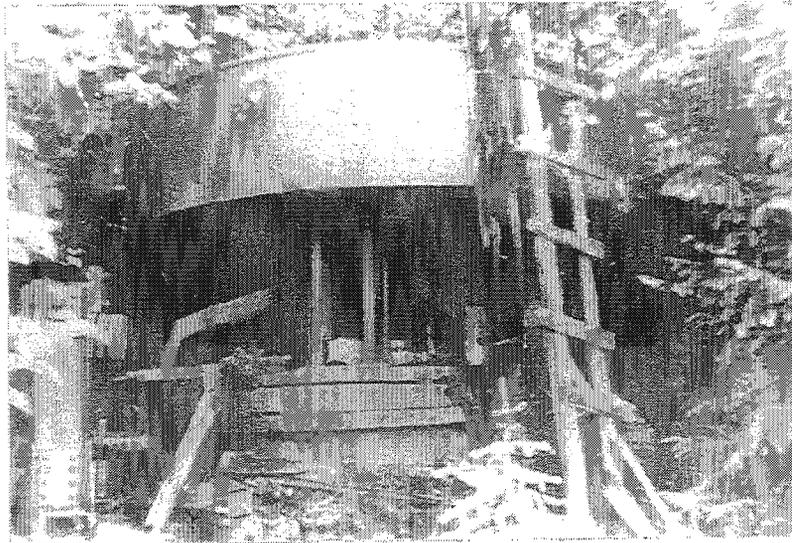
Smaller operations and individual miners often placed liquid mercury directly into sluices or gold pans. When the mercury was saturated, it often was heated in the pan over an open fire, thereby discharging mercury vapor directly into the atmosphere. Eventually the mercury vapor condensed to the liquid state and fell onto vegetation, the ground, or into surface waters. In many instances, metallic mercury was, by virtue of accident or inefficient operating procedures, spilled on the ground or washed into streams or other surface waters.

It could be argued that mercury contamination, because of its toxicity and persistence, presents the greatest hazard when considering mineral process-related contamination.

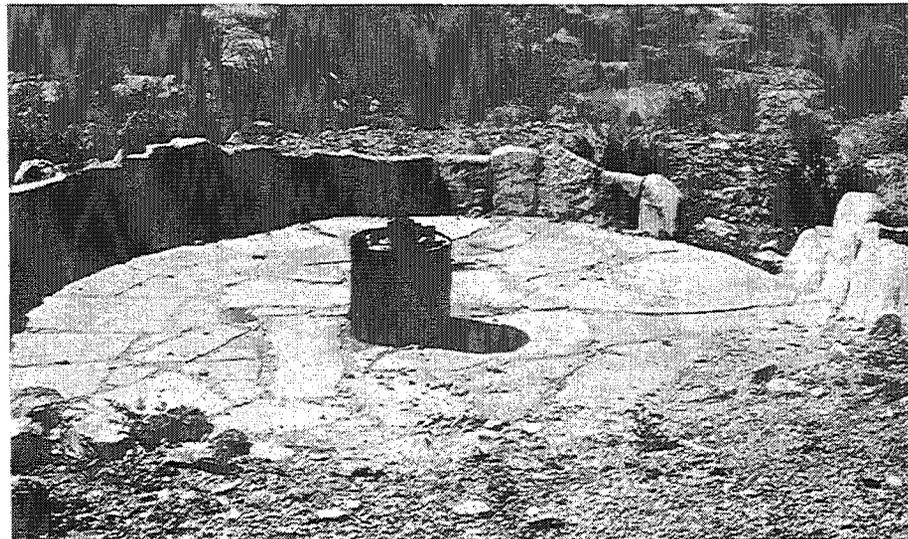
Indications of possible amalgamation operations include, but are not limited to, wooden or metal troughs up to several meters in length ("long toms"—the troughs may or may not have cleats or "riffles"

at regular intervals normal to the longitudinal axis), large copper trays attached to sluices or troughs, presence of mercury flasks, liquid mercury in adjacent streams or other surface waters, stamp mills, Chilean mills, or arrastres.

Figure B-1 is a Chilean mill at an abandoned mine in Alaska; figure B-2 shows the remains of an arrastre (arrastre; arrastra . . . a circular rock-lined pit in which broken ore is pulverized by stones attached to a pillar and dragged around the pit. The arrastre was in common use in the western and southwest United States in the 18th and 19th centuries.)



**Figure B-1.—Chilean mill.**



**Figure B-2.—Remains of an arrastre.**

Figure B-3 illustrates a stamp battery, a part of a stamp mill. It is not very often that a battery is found in this good of condition. More likely only the remains, or parts, are encountered as shown in figure B-4--note the stamp rods in the left-center of the photograph and compare to figure B-3.

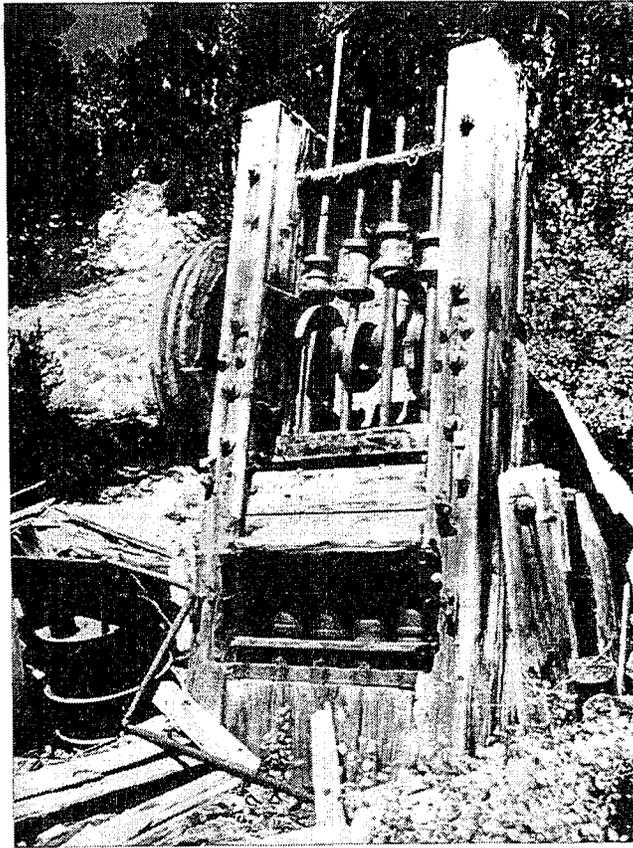


Figure B-3.--Stamp battery.

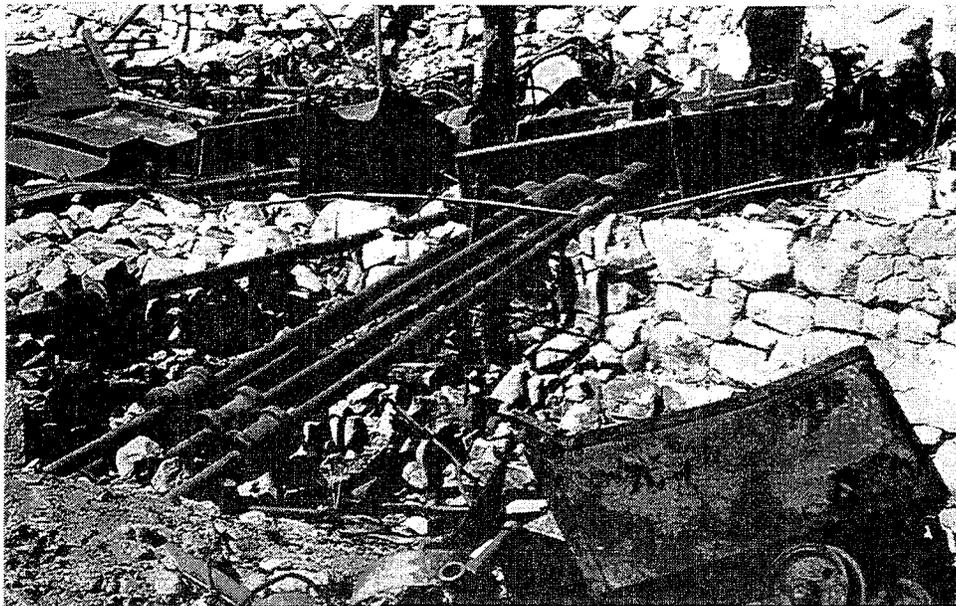


Figure B-4.--Stamp rods are evidence of a former stamp mill.

## Gravity Mill

Gravity mills often are used to separate heavy minerals such as garnet, ilmenite, and scheelite or heavy metals such as gold from the waste rock. Depending on the nature of the ore, the process may or may not include a flotation circuit.

The following description and flowsheet of a typical gravity mill are repeated from Camm, p. 24:

Mine-run ore is initially crushed by a jaw crusher. The discharge is sent to a double-deck screen where the plus 1.9-cm (3/4 in) fraction discharges onto a conveyor belt and is fed to a cone crusher. The minus 1.9-cm (3/4 in) fraction from the jaw and cone crusher is conveyed to vibrating screens. Oversize from the screens is returned to the cone crusher and the undersize is slurried and fed to the jig.

Tails from the jig go to the rod mill where grinding occurs in closed circuit with a cyclone classifier. Overflow from the cyclone is pumped to a spiral classifier. Size fractions from the classifier are sent to a series of tables to produce a high-grade concentrate, a middling product, and tailings. The middlings are combined and recycled through the rod mill.

Table concentrates are sent to a flotation cell where any sulfides present are floated off. Underflow from the float cell is combined with the concentrates from the jig and then thickened and dried. Tailings are thickened and sent to the tailings pond.

A simplified flowsheet for the gravity mill is presented in figure B-5.

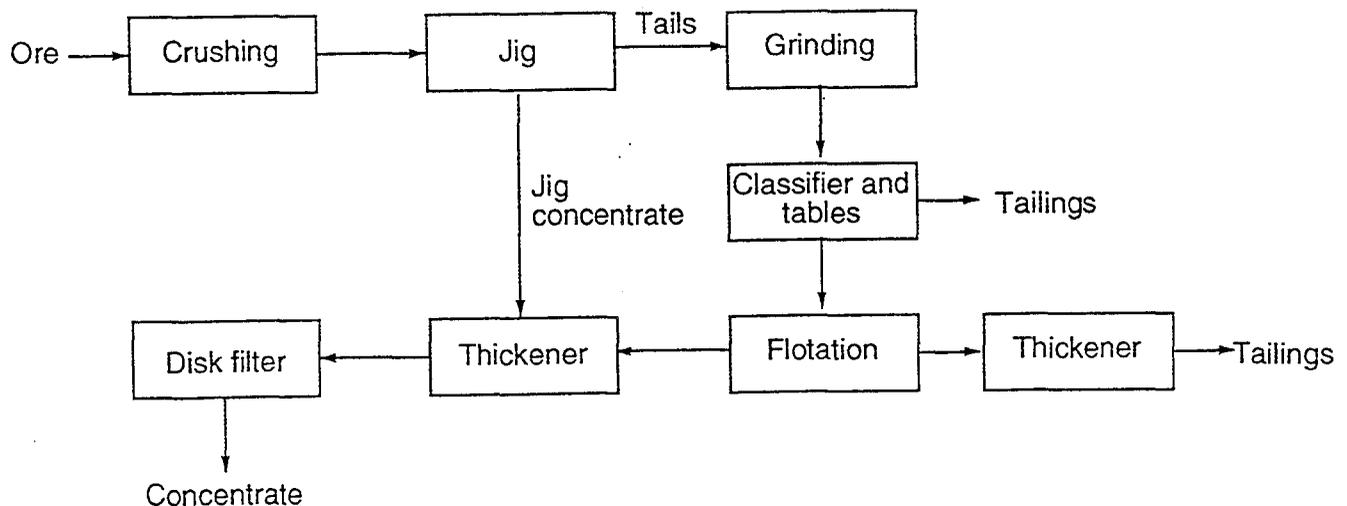


Figure B-5.--Gravity mill flowsheet.

Indications of a possible gravity mill include, but are not limited to the presence of a mineral jig, cyclone or spiral classifiers, or concentrating tables. Figures B-6 and B-7 illustrate a mineral jig and a concentrating table, respectively.

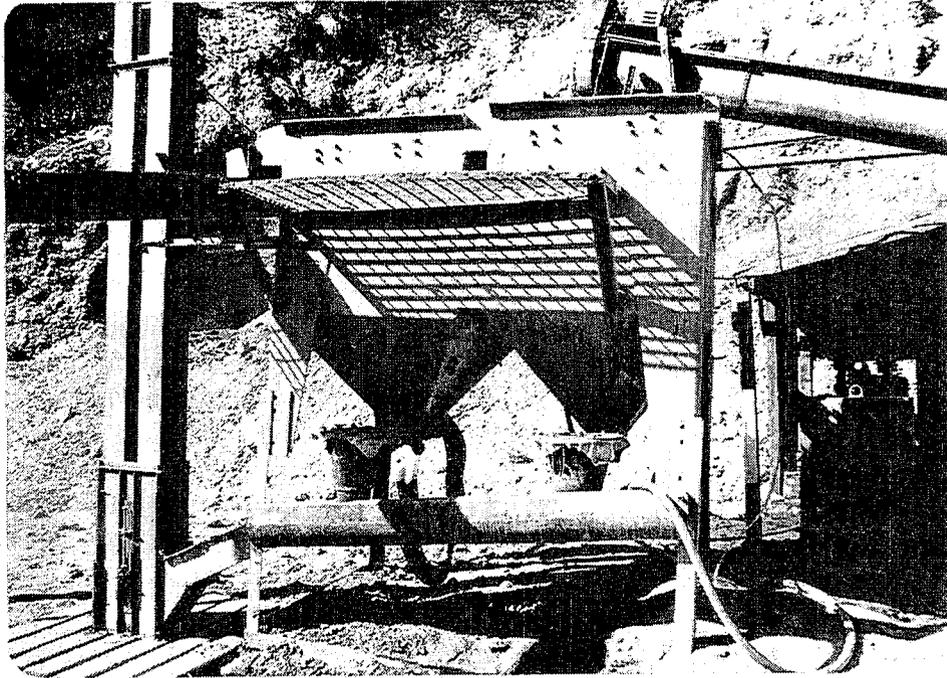


Figure B-6.—Mineral jig. (Courtesy Curtis Tungsten, Inc.)

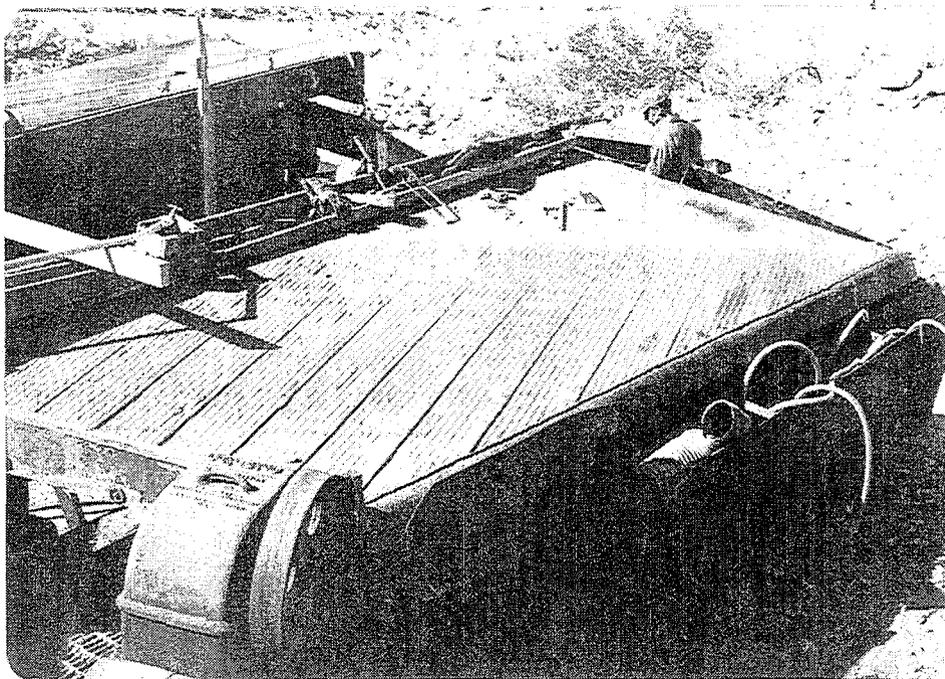


Figure B-7.—Concentrating table. (Courtesy Curtis Tungsten, Inc.)

## Two-Product Flotation Mill

Flotation is a method of mineral separation in which a number of reagents (frothers, activators, depressants, collectors, and conditioners) selectively floats or sinks finely crushed minerals in an enclosed flotation cell. The process is particularly amenable to base metal sulfides. The types of reagents usually associated with flotation mills are presented on table 1 in the text.

The following description of a two-product flotation mill and associated flowsheet is repeated from Camm, p. 22.

Mine-run ore is initially crushed and sized in a series of crushers and vibration screens to approximately minus 1.6 cm (5/8 in). Crushed ore is then ground in rod mills and passed through cyclones. The oversize is ground in ball mills then pumped back to the cyclones to achieve a minus 200 mesh flotation feed. Cyclones undersize is sent to the first product rougher flotation cells. These rougher concentrates pass to cleaner cells where they are further concentrated. Tails from the cleaner cells and middlings from the rougher cells are recirculated through the first flotation circuit. Concentrates from the cleaner cells are thickened and dried prior to stockpiling for shipment.

Tails from the first product rougher cells flow to the second flotation circuit. Rougher concentrates are further treated in the second cleaner cells. As with the first product circuit, tails from the cleaner cells and middlings from the rougher cells are recirculated through the second product flotation circuit. Tails from the rougher cells are sent to the tailings pond and the concentrates are thickened, dried, and stockpiled for shipment.

A flowsheet for a typical two-product mill is presented in figure B-8.

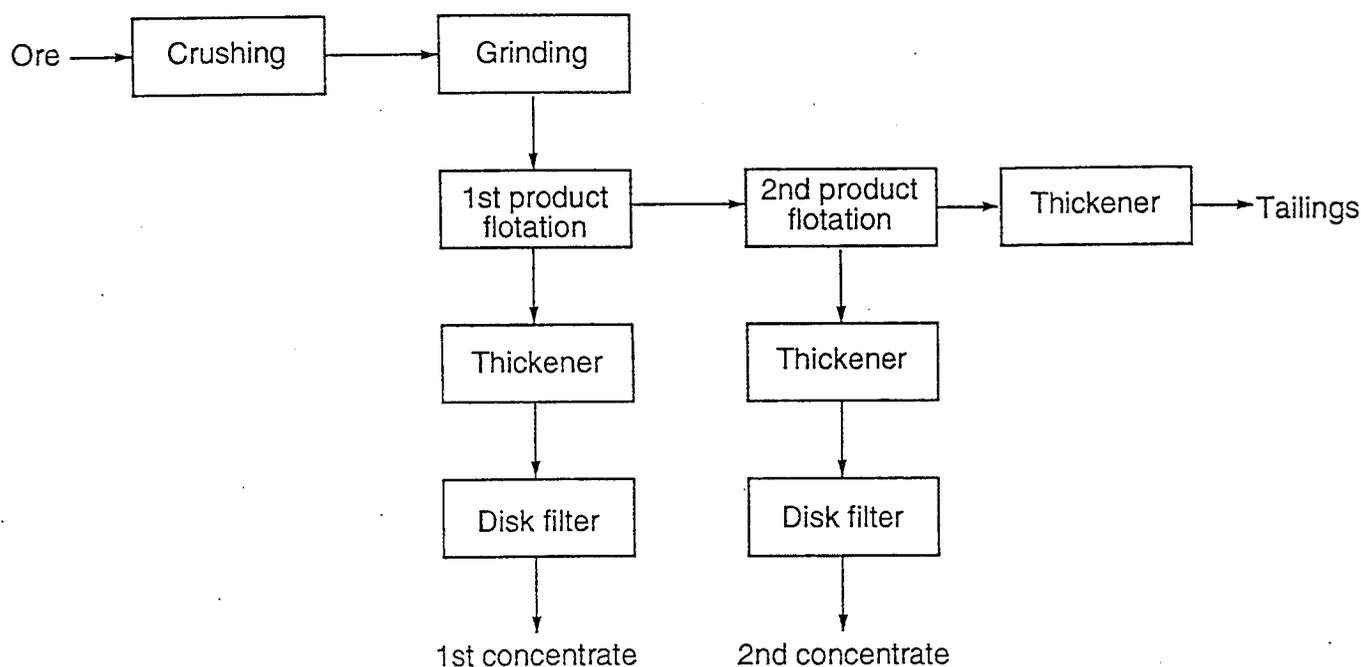


Figure B-8.—Typical flotation mill flowsheet, two-product.

Indications of a possible flotation mill (1-, 2-, or 3-product) include, but are not limited to the presence of flotation cells, conditioning tanks, and barrels, bins, or other containers whose markings may indicate their use for transport or storage of reagents associated with flotation operations. Common reagents used in flotation include, but are not limited to, xanthate, pine oil, sodium cyanide (NaCN), lime (calcium oxide--CaO), alum, alcohol frothers, among others (fig. B-9). Refer to table 1 in the text for an expanded list of reagents under the heading "Sulfides."

Figure B-10 shows a bank of flotation cells; figure B-11 illustrates a ball mill and classifier. A thickener, used for dewatering, is illustrated in figure B-12.



**Figure B-9.**—Labels on barrels and other containers may indicate the type of reagents used at an abandoned mine or mill.

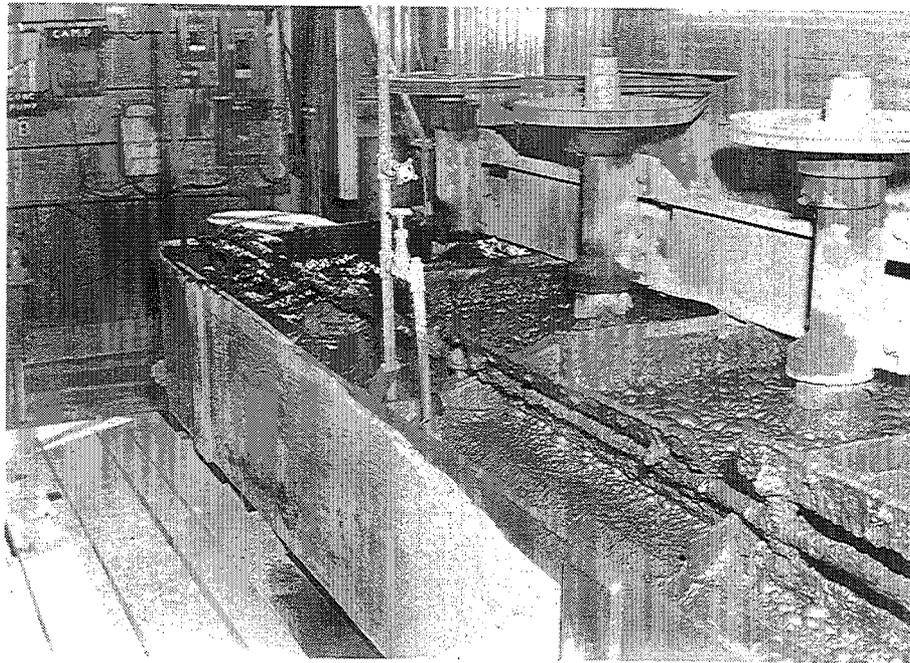


Figure B-10.—Bank of flotation cells.

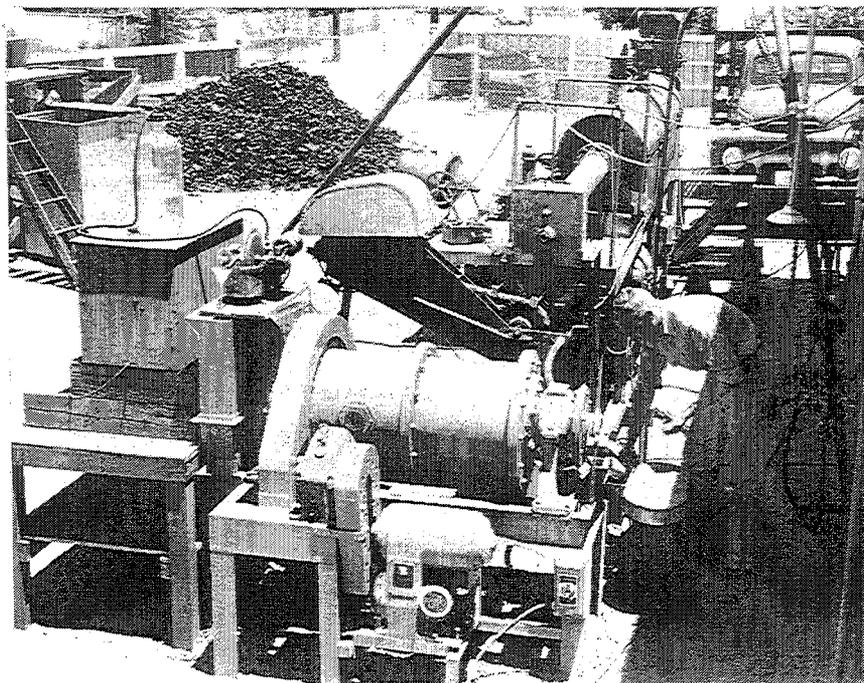


Figure B-11.—Ball mill and classifier.

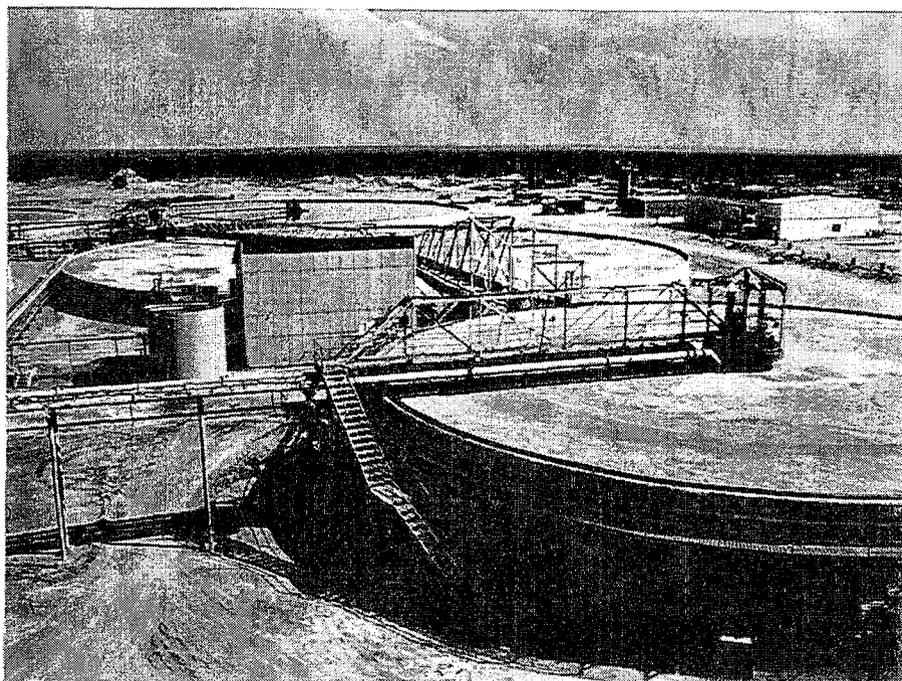


Figure B-12.--Thickener.

### Heap-Vat Leach Mill

Heap and vat leach processes use a chemical property of cyanide (in some cases acid or other solvents) to dissolve metal values from ore. Metal values contained in the cyanide solution are subsequently adsorbed on activated charcoal, stripped from the charcoal by a hot caustic solution, electroplated on steel wool cathodes, then smelted to produce a dore' product.

Cyanide leaching processes were employed in Nevada and southern California near the turn of the century primarily to recover silver; modern leaching practices are essentially improved variations on the older methods. Today the most widely applied leach process is the heap leach method which is generally used for lower grade oxide ores. In instances where a mine has both oxide (generally lower grade) and sulfide ores (generally higher in grade), two or more processes may be used. The low-grade ore is typically processed by heap leaching, the higher grade ore by carbon-in-leach (CIL), carbon-in-pulp (CIP), or other methods. Depending on ore characteristics, cyanidation may be used by itself or in combination with other processes such as gravity and flotation. With hard-to-process ores, other processes such as oxidation, chlorination, and autoclaving may be used in conjunction with cyanide leaching.

### Heap Leaching

Mine-run ore is generally crushed and screened, then hauled by truck to the leach pads where bulldozers are commonly used to level and contour the pile. A cyanide solution is sprayed on the ore and percolated through the heap dissolving metal values in passing. The metal-laden solution ("pregnant solution") is routed through a series of pipes or lined ditches to a pregnant solution pond. From the pond the solution is pumped or flows by gravity to the recovery plant.

In the recovery plant the pregnant solution is passed through a series of tanks containing activated charcoal which adsorbs the gold. Alternatively, in the Merrill-Crowe process, metal values are precipitated from the solution using zinc dust.

When the charcoal becomes saturated, it is treated with a hot caustic solution to dissolve the gold which is then electroplated onto steel wool cathodes. The cathodes are smelted to recover gold and other metallic constituents in bullion form referred to as "dore'."

A flowsheet for a typical heap leach operation is presented in figure B-13. Figure B-14 illustrates a typical heap leach operation. At the toe of the heap (to the left) can be seen the pregnant solution collection ditch and associated piping. To the left of the collection ditch are the pregnant and barren solution ponds.

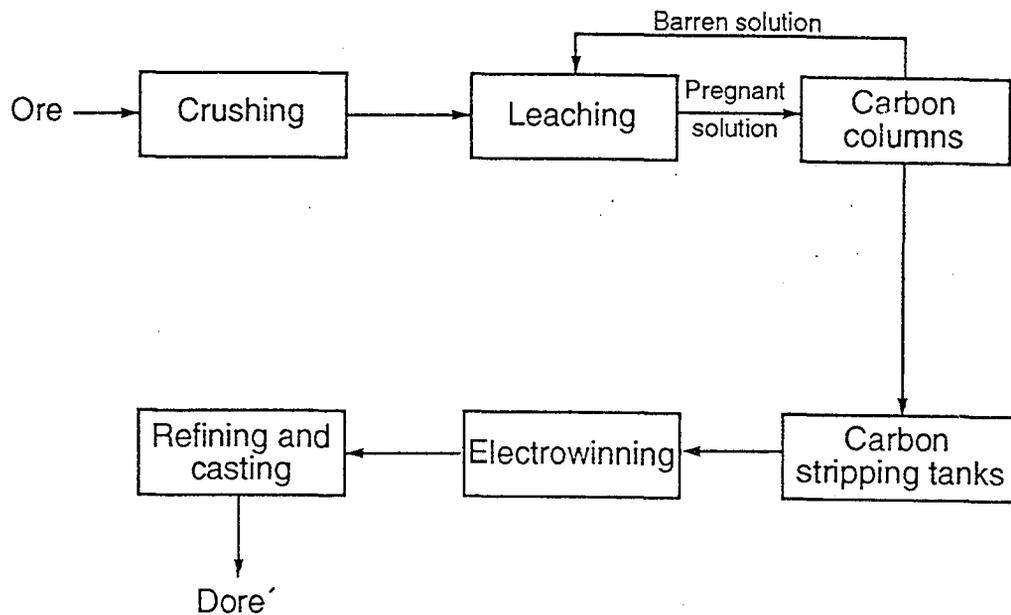
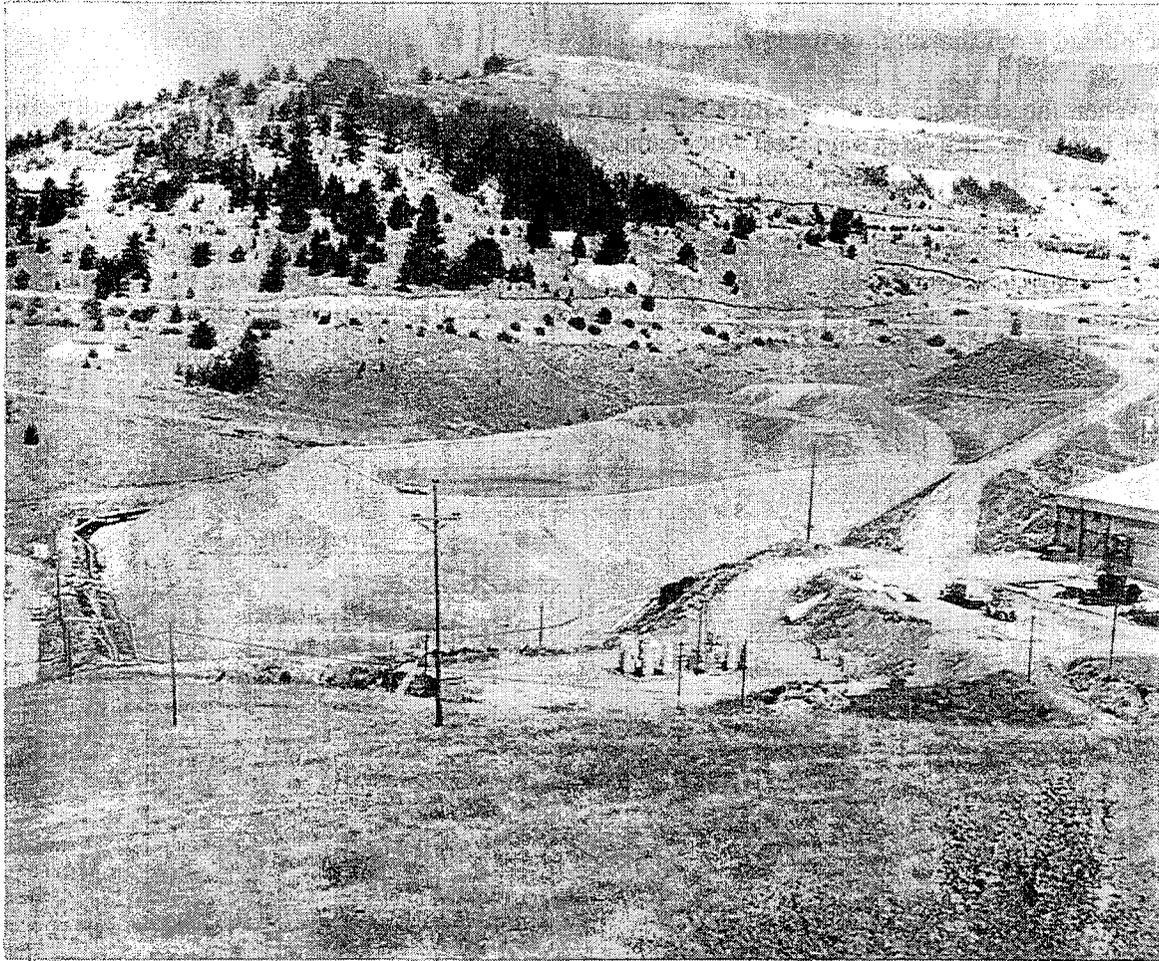


Figure B-13.—Heap leach flowsheet.



**Figure B-14.--Typical heap leach operation.**

### **Vat Leaching**

Vat leaching is very similar to heap leaching except that instead of the ore being leached on a heap, it is leached in a series of vats. The metal recovery method is generally the same as heap leach recovery.

Figure B-15 shows the remains of a vat leach operation; a flowsheet for vat leaching is presented in figure B-16.

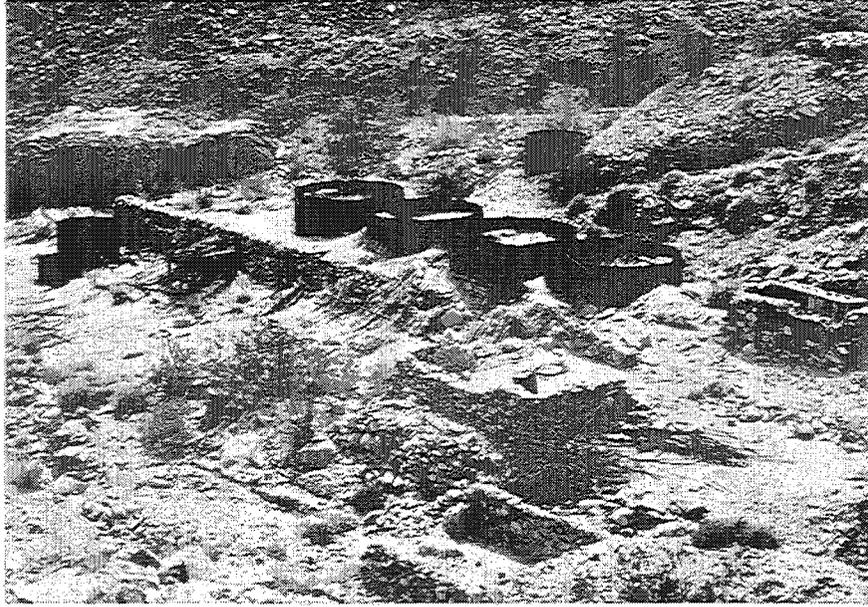


Figure B-15.—Remains of vat leach mill.

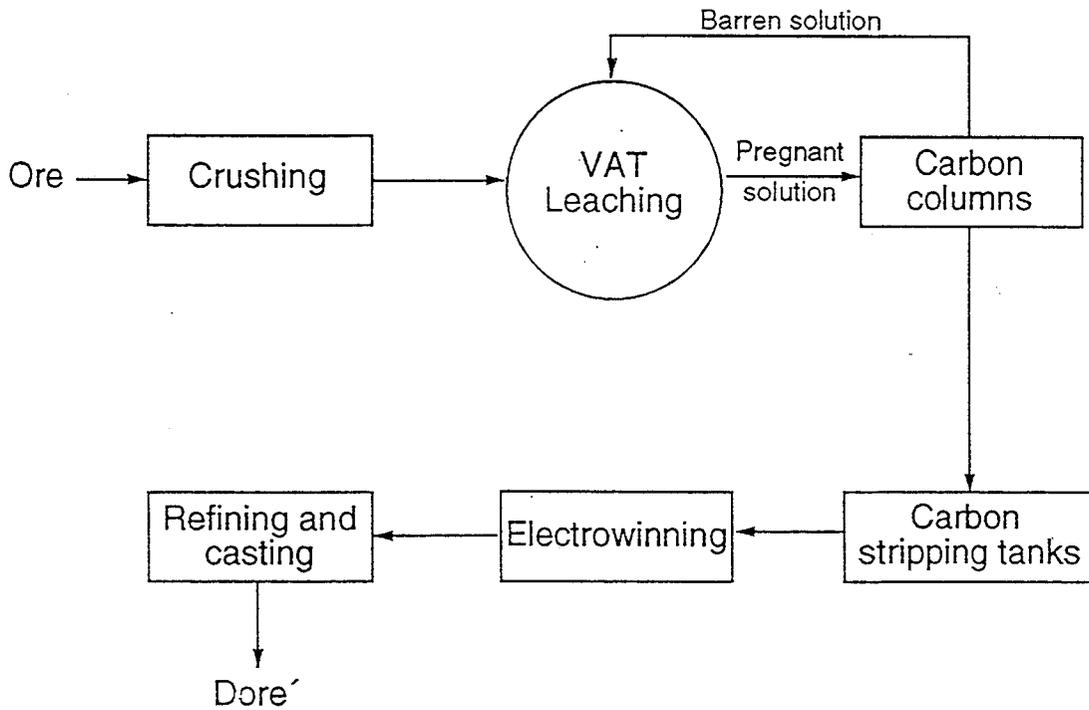


Figure B-16.—Vat leach flowsheet.

Indications of a possible heap/vat leach mill include, but are not limited to, large or small, generally flat-topped mounds or heaps, ditches between the heaps, a level area that may have been a solution pond, large wooden or metal tanks or vats, carbon columns, electrowinning equipment, or smelting-casting furnaces. Markings on barrels, bins, or other containers may indicate their use for cyanide transport or storage.

#### Reference Cited

1. Camm, T. W. Simplified Cost Models for Prefeasibility Mineral Evaluations. BuMines IC 9298, 1991, 35 pp.

# APPENDIX C. --AML INVENTORY AND INVESTIGATION FORM

U. S. Bureau of Mines

**AML INVENTORY FORM**

EVALUATOR

Part I - Pre-Field Data (Side 1)

PAGE  1 OF

SITE NUMBER

DATE OF INVESTIGATION

**1) PROPERTY NAME:**

Alternate Names

MILS Sequence No.  MRDS No.

BOM Mineral Property File No.

State ID No.  EPA ID No.

**2) OWNERSHIP:** What is the current ownership of the site? Check one.

Federal  Indian  State  County  Municipal  Private/Patented

Unknown  Other

If the owner is known, fill in the following information.

Name or Agency

Address

Telephone Number  -  -

Ownership includes Surface only  Minerals only  Both

**3) LOCATION DATA:** Fill in location information as available.

State  County

Township  N S Range  E W Section

Section Subdivision  Meridian

Latitude  Longitude

UTM Zone  Northing  Easting

Elevation  Specify units for elevation. Feet  Meters

Map Name  Map Scale

1:250,000 Quadrangle

Mining District

Approximate area of site  Measured in Square feet  Acres  Hectares

**4) HISTORICAL DATA:** Check all that apply.

**Type of Operation:**

Surface  Underground  Surface-Underground  Mineral Location  Placer

Prospect  Dredge  Processing Plant  Well  Unknown  No Data

**Status of Operation:**

Past Producer  Explored Prospect  Raw Prospect  Unknown

Developed Prospect (greater than 300 meters of workings)

5/93

SITE NUMBER

DATE OF INVESTIGATION

4) HISTORICAL DATA (Continued.)

Check all that apply.

Commodities:

Arsenic  Cadmium  Copper  Lead  Mercury  Zinc

Other (specify)

Commodity Groups:

Metals  Coal  Oil and Gas  Uranium or Geothermal

Industrial Minerals  Sand and Gravel  Non-Energy Leasable

Other (specify)

Acid Producers or Indicator Minerals:

Arsenopyrite  Chalcopyrite  Galena  Marcasite  Sphalerite  Sulfide   
Iron Oxide  Limonite  Pyrite  Pyrrhotite  Stibnite

Size/Production:

Indicate the total amount of ore produced to date in metric tons (mt).

Small (0-10,000 mt)  Small-Medium (10,000mt-250,000mt)  Medium (250,000mt-500,000mt)   
Medium-Large (500,000mt-1,000,000mt)  Large (Over 1,000,000mt)

Mill Method:

Amalgamation  Arrastre  Gravity  Crusher (only)  Heap Leach  Leach   
CIP (Carbon-in-Pulp)  Cyanidation  Stamp  Flotation  Jig Plant  Retort   
No Mill  Unknown

Neutralizing Host Rock:

Carbonate  Dolomite  Limestone  Marble

Workings/history:

Indicate size, number, and type of mine openings, if available.

Years of Operation:

From  To

Annual Precipitation:

Check one.

Less than 25 centimeters  More than 25 centimeters

5) SPECIALTY DATA:

Check all that apply.

Site in a known or suspected floodplain:

None  Annual - 10 years  10 - 100 years  100 - 500 years  Less than once every 500 years

Threatened and Endangered Plants and Animals:

a) Are any threatened and/or endangered plants and/or animals on or near the site? Circle one. YES NO

b) If present, list type(s).

COMMENTS:

INVESTIGATION DATE

PAGE  OF

GPS LOCATION

SITE NUMBER  SITE NAME

EVALUATOR  AGENCY   
ADDRESS  TELEPHONE

1) NEAREST SITE(S) OF HUMAN ACTIVITY (Give distance, circle units, or mark N/A)

Dwelling(s)  km mi School  km mi Workplace  km mi  
Campground  km mi Trail  km mi Road  km mi

2) SENSITIVE ENVIRONMENTS (If any, give name or distance, if known) Circle one per group

a) Threatened and Endangered Species  UNK YES NO  
b) Wetlands  km mi UNK YES NO  
c) Fisheries  km mi UNK YES NO  
d) Other  km mi UNK YES NO

3) WATER Are bodies of water found on or within 2 mi (3.2 km) of the site? Circle one, and check all that apply. YES NO

Stream  River  Pond  Lake  Bay  Other   
Name of nearest water body  Distance  km mi

4) AIRBORNE POLLUTANTS Circle one per group

a) Dust UNK YES NO  
b) Spray UNK YES NO  
c) Vapor UNK YES NO  
d) Other Name  UNK YES NO

5) RADIATION Did pre-field research indicate this area has produced uranium? Circle one. YES NO

If yes, take radiation reading and record value.  Counts per second (cps)

6) EXPLOSIVES Are any explosives or blasting supplies found on the site? Circle one. UNK YES NO

If present, list type and location.

7) OTHER Are any of the following present? Check all that apply, provide comments as necessary below.

Acrid Odor  Drum(s)/Tank(s)  Overhead Wire(s)  Power Substation(s)  Tramway(s)   
Antennas  Fence(s)  Pipe(s)  Scrap Metal  Transformer(s)   
Aviation Hazard(s)  Flume(s)  Pole(s)  Tower(s)  Trestle(s)   
Bag(s)  Headframe(s)  Power Line(s)  Tram Bucket(s)  Wooden Structure(s)   
Chemical(s)  Overhead Cable(s)  Other (specify)

Site appears to have cultural significance or value  (Check if yes)

8) PHOTOGRAPH NUMBERS

9) SKETCH NUMBERS

COMMENTS

INVESTIGATION DATE

PAGE  OF

SITE NUMBER

SITE NAME

**10) FEATURE** Number  Fill out one form per feature. Check appropriate box below.

Adit <input type="checkbox"/>	Decline <input type="checkbox"/>	Machinery <input type="checkbox"/>	Ore Stockpile <input type="checkbox"/>	Quarry <input type="checkbox"/>	Stope <input type="checkbox"/>
Building <input type="checkbox"/>	Glory Hole <input type="checkbox"/>	Mill Building <input type="checkbox"/>	Pit, Large, >3 m <input type="checkbox"/>	Shaft <input type="checkbox"/>	Subsidence <input type="checkbox"/>
Cistern <input type="checkbox"/>	Highwall <input type="checkbox"/>	Mill Tailings <input type="checkbox"/>	Pit, Small, <3 m <input type="checkbox"/>	Solution Mining Well <input type="checkbox"/>	Sump <input type="checkbox"/>
Crosscut <input type="checkbox"/>	Leach Pad <input type="checkbox"/>	Mine Dump <input type="checkbox"/>	Placer Mine <input type="checkbox"/>	Solution Pond <input type="checkbox"/>	Trench <input type="checkbox"/>
Other <input type="text"/>					Tunnel <input type="checkbox"/>

**11) CONDITION** Does the condition of the above identified feature represent a physical hazard? Circle one. YES NO

Check the conditions that best describe the physical character of the above feature.

Breached <input type="checkbox"/>	Collapsed, Partial <input type="checkbox"/>	Empty <input type="checkbox"/>	Foundation <input type="checkbox"/>	Standing <input type="checkbox"/>	Unstable Walls <input type="checkbox"/>
Caved <input type="checkbox"/>	Concealed <input type="checkbox"/>	Eroded <input type="checkbox"/>	Intact <input type="checkbox"/>	Subsided <input type="checkbox"/>	Wind Erosion <input type="checkbox"/>
Caved, Partial <input type="checkbox"/>	Concealed, Partial <input type="checkbox"/>	Eroded, Partial <input type="checkbox"/>	Open to Entry <input type="checkbox"/>	Unconfined <input type="checkbox"/>	
Collapsed <input type="checkbox"/>	Confined <input type="checkbox"/>	Fenced <input type="checkbox"/>	Rotten Cribbing <input type="checkbox"/>	Other <input type="text"/>	

**12) SIZE OF FEATURE** Indicate size of feature and specify units (feet or meters). Measurement

Length <input type="text"/>	Width <input type="text"/>	Depth or Height <input type="text"/>	Actual <input type="checkbox"/>	Feet <input type="text"/>
<input type="text"/> X <input type="text"/> X <input type="text"/>			Estimate <input type="checkbox"/>	Meters <input type="text"/>
Slope (Degrees) <input type="text"/>	Bank Stability: Stable <input type="checkbox"/>	Unstable <input type="checkbox"/>	Marginally Stable <input type="checkbox"/>	

**13) WATER** Is water present at the feature? Circle one. YES NO

Is water emanating from or passing through the feature? Circle one. YES NO

a) If water is present, how does it occur? Check all that apply.

Standing <input type="checkbox"/>	Filled <input type="checkbox"/>	Partly Filled <input type="checkbox"/>	Flowing <input type="checkbox"/>	Intermittent <input type="checkbox"/>
-----------------------------------	---------------------------------	--	----------------------------------	---------------------------------------

b) If present, determine: GPM:  Conductivity:  pH:

c) Observe water bed color. (Check all that apply, or specify other.)

Brown <input type="checkbox"/>	Green <input type="checkbox"/>	Yellow <input type="checkbox"/>	Yellow-orange <input type="checkbox"/>	Orange <input type="checkbox"/>	Gray-black <input type="checkbox"/>	Other (specify) <input type="text"/>
--------------------------------	--------------------------------	---------------------------------	--	---------------------------------	-------------------------------------	--------------------------------------

**14) PLANTS** Are plants present on or around the feature? Circle one. YES NO

If yes, check one.

Healthy <input type="checkbox"/>	Stressed <input type="checkbox"/>	Dead <input type="checkbox"/>	Barren <input type="checkbox"/>	Partial Revegetation <input type="checkbox"/>	Full Revegetation <input type="checkbox"/>	Other (specify) <input type="text"/>
----------------------------------	-----------------------------------	-------------------------------	---------------------------------	---	--	--------------------------------------

**15) STAINING** Stains may indicate spills, oxidation, or alteration. Are non-water-related stains present? YES NO

If stains are present, check appropriate color or specify other. Yellow-orange  Gray-black  Other (specify)

**16) MACHINERY** Is machinery present at this feature? Circle one. YES NO

a) Location of machinery. Check all that apply.

Inside Building <input type="checkbox"/>	No Building <input type="checkbox"/>	Outside Building <input type="checkbox"/>	Other (specify) <input type="text"/>
--	--------------------------------------	---	--------------------------------------

b) Type of machinery. Check all that apply or specify other.

Amalgamation Equipment <input type="checkbox"/>	Crusher(s) <input type="checkbox"/>	Ore Bin(s) <input type="checkbox"/>	Stamp Mill(s) <input type="checkbox"/>	Vat(s) <input type="checkbox"/>
Arrastre <input type="checkbox"/>	Flotation Cell Group <input type="checkbox"/>	Retort(s) <input type="checkbox"/>	Tank(s) <input type="checkbox"/>	
Ball Mill(s) <input type="checkbox"/>	Leach Tank(s) <input type="checkbox"/>	Rod Mill(s) <input type="checkbox"/>	Thickener(s) <input type="checkbox"/>	
Others (specify) <input type="text"/>				

**17) PHOTOGRAPH NUMBERS**

**18) SKETCH NUMBERS**

**COMMENTS**



INVESTIGATION DATE 4-28-93

PAGE 1 OF 3

GPS LOCATION N-527989 E-556613

SITE NUMBER 0160799203 SITE NAME Grizzly Bear

EVALUATOR John DOE AGENCY USBM

ADDRESS E. 360 3<sup>rd</sup> Ave, Spokane, WA TELEPHONE (509) 353-2700

1) NEAREST SITE(S) OF HUMAN ACTIVITY (Give distance, circle units, or mark N/A)

Dwelling(s) 5 km (mi) School N/A km mi Workplace N/A km mi  
Campground N/A km mi Trail N/A km mi Road N/A km mi

2) SENSITIVE ENVIRONMENTS (If any, give name or distance, if known)

Circle one per group

a) Threatened and Endangered Species UNK YES NO  
b) Wetlands      km mi UNK YES NO  
c) Fisheries      km mi UNK YES NO  
d) Other      km mi UNK YES NO

3) WATER Are bodies of water found on or within 2 mi (3.2 km) of the site? Circle one, and check all that apply. YES NO

Stream  River  Pond  Lake  Bay  Other   
Name of nearest water body Gold Creek Distance 0.1 km (mi)

4) AIRBORNE POLLUTANTS

Circle one per group

a) Dust UNK YES NO  
b) Spray UNK YES NO  
c) Vapor UNK YES NO  
d) Other Name      UNK YES NO

5) RADIATION Did pre-field research indicate this area has produced uranium? Circle one.

YES NO

If yes, take radiation reading and record value. 00 Counts per second (cps)

6) EXPLOSIVES Are any explosives or blasting supplies found on the site? Circle one.

UNK YES NO

If present, list type and location. Dynamite in adit near Portal

7) OTHER Are any of the following present? Check all that apply, provide comments as necessary below.

Acrid Odor  Drum(s)/Tank(s)  Overhead Wire(s)  Power Substation(s)  Tramway(s)   
Antennas  Fence(s)  Pipe(s)  Scrap Metal  Transformer(s)   
Aviation Hazard(s)  Flume(s)  Pole(s)  Tower(s)  Trestle(s)   
Bag(s)  Headframe(s)  Power Line(s)  Tram Bucket(s)  Wooden Structure(s)   
Chemical(s)  Overhead Cable(s)  Other (specify) NONE

Site appears to have cultural significance or value  (Check if yes)

8) PHOTOGRAPH NUMBERS 016 0799203-1

9) SKETCH NUMBERS 1, 2

COMMENTS

Mine water flows into nearby creek.

INVESTIGATION DATE 4-28-93

PAGE 2 OF 3

SITE NUMBER 0160 799203

SITE NAME Grizzly Bear

10) FEATURE Number 1 Fill out one form per feature. Check appropriate box below.

Adit <input checked="" type="checkbox"/>	Decline <input type="checkbox"/>	Machinery <input type="checkbox"/>	Ore Stockpile <input type="checkbox"/>	Quarry <input type="checkbox"/>	Slope <input type="checkbox"/>
Building <input type="checkbox"/>	Glory Hole <input type="checkbox"/>	Mill Building <input type="checkbox"/>	Pit, Large, >3 m <input type="checkbox"/>	Shaft <input type="checkbox"/>	Subsidence <input type="checkbox"/>
Cistern <input type="checkbox"/>	Highwall <input type="checkbox"/>	Mill Tailings <input type="checkbox"/>	Pit, Small, <3 m <input type="checkbox"/>	Solution Mining Well <input type="checkbox"/>	Sump <input type="checkbox"/>
Crosscut <input type="checkbox"/>	Leach Pad <input type="checkbox"/>	Mine Dump <input type="checkbox"/>	Placer Mine <input type="checkbox"/>	Solution Pond <input type="checkbox"/>	Trench <input type="checkbox"/>
Other <input type="text"/>					Tunnel <input type="checkbox"/>

11) CONDITION Does the condition of the above identified feature represent a physical hazard? Circle one. **YES** NO

Check the conditions that best describe the physical character of the above feature.

Breached <input type="checkbox"/>	Collapsed, Partial <input type="checkbox"/>	Empty <input type="checkbox"/>	Foundation <input type="checkbox"/>	Standing <input type="checkbox"/>	Unstable Walls <input type="checkbox"/>
Caved <input type="checkbox"/>	Concealed <input type="checkbox"/>	Eroded <input type="checkbox"/>	Intact <input type="checkbox"/>	Subsided <input type="checkbox"/>	Wind Erosion <input type="checkbox"/>
Caved, Partial <input type="checkbox"/>	Concealed, Partial <input type="checkbox"/>	Eroded, Partial <input type="checkbox"/>	Open to Entry <input checked="" type="checkbox"/>	Unconfined <input type="checkbox"/>	
Collapsed <input type="checkbox"/>	Confined <input type="checkbox"/>	Fenced <input type="checkbox"/>	Rotten Cribbing <input type="checkbox"/>	Other <u>Wall Slough</u>	

12) SIZE OF FEATURE Indicate size of feature and specify units (feet or meters). Measurement

Length NA x Width 4 x Depth or Height 7

Slope (Degrees) N/A Bank Stability: Stable  Unstable  Marginally Stable

Actual  Feet   
Estimate  Meters

13) WATER Is water present at the feature? Circle one. **YES** NO

Is water emanating from or passing through the feature? Circle one. **YES** NO

a) If water is present, how does it occur? Check all that apply.

Standing  Filled  Partly Filled  Flowing  Intermittent

b) If present, determine: GPM: 9.35 Conductivity: 300 pH: 6.5

c) Observe water bed color. (Check all that apply, or specify other.)

Brown  Green  Yellow  Yellow-orange  Orange  Gray-black  Other (specify)

14) PLANTS Are plants present on or around the feature? Circle one. **YES** NO

If yes, check one.

Healthy  Stressed  Dead  Barren  Partial Revegetation  Full Revegetation  Other (specify)

15) STAINING Stains may indicate spills, oxidation, or alteration. Are non-water-related stains present? YES NO

If stains are present, check appropriate color or specify other. Yellow-orange  Gray-black  Other (specify)

16) MACHINERY Is machinery present at this feature? Circle one. YES **NO**

a) Location of machinery. Check all that apply.

Inside Building  No Building  Outside Building  Other (specify)

b) Type of machinery. Check all that apply or specify other.

Amalgamation Equipment <input type="checkbox"/>	Crusher(s) <input type="checkbox"/>	Ore Bin(s) <input type="checkbox"/>	Stamp Mill(s) <input type="checkbox"/>	Vat(s) <input type="checkbox"/>
Arrastre <input type="checkbox"/>	Flotation Cell Group <input type="checkbox"/>	Retort(s) <input type="checkbox"/>	Tank(s) <input type="checkbox"/>	
Ball Mill(s) <input type="checkbox"/>	Leach Tank(s) <input type="checkbox"/>	Rod Mill(s) <input type="checkbox"/>	Thickener(s) <input type="checkbox"/>	

Others (specify)

17) PHOTOGRAPH NUMBERS NONE

18) SKETCH NUMBERS NONE

COMMENTS Water bed color represents bed color at portal.

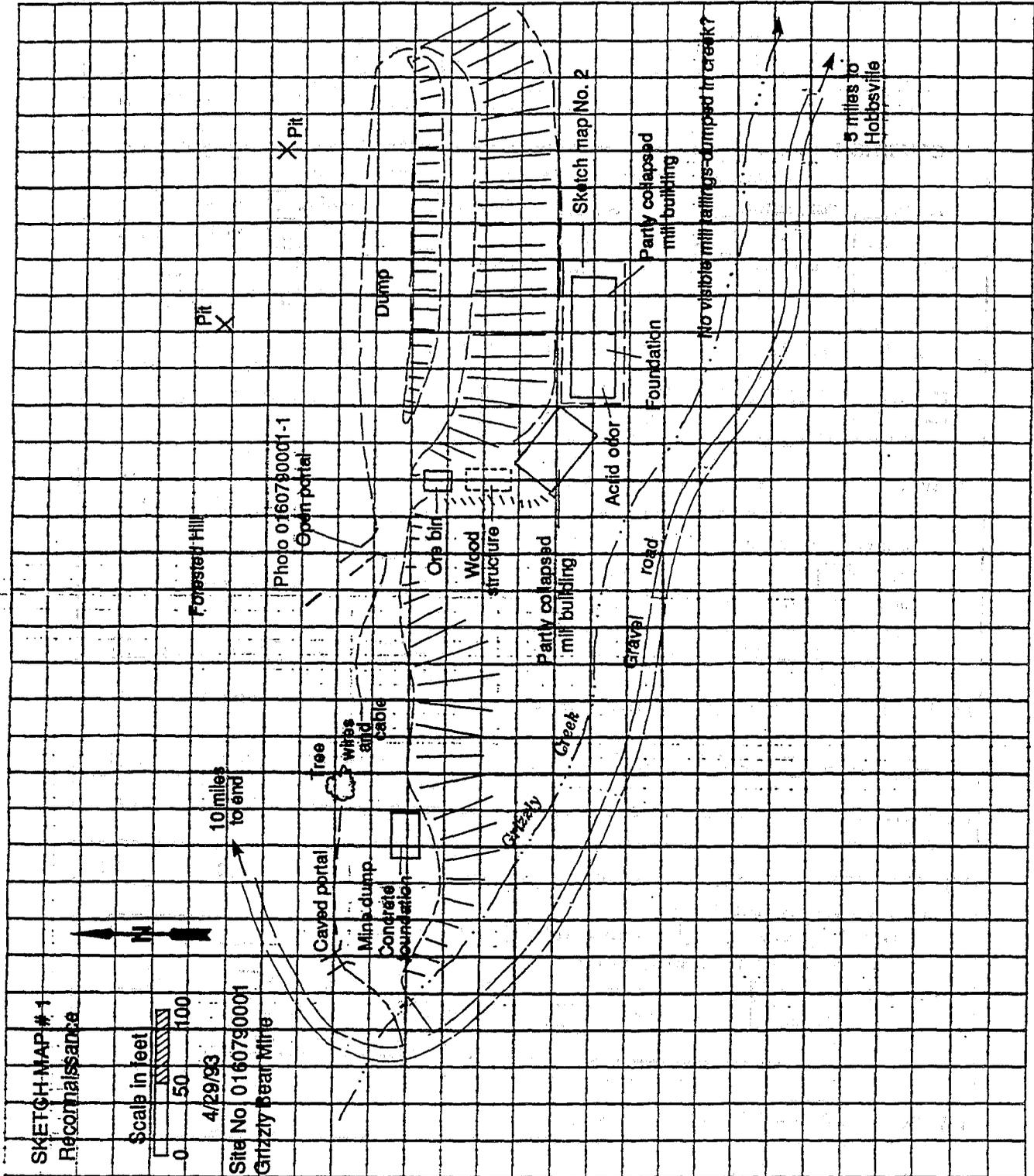
U.S. Bureau of Mines  
**AML INVENTORY FORM**

Part III - Supplemental Data (Notes, Sketches, Photographs, etc.)

PAGE **3** OF **3**

SITE NUMBER **0160799203**

DATE **4-28-93**



NOTE: Be sure to provide a north arrow and the scale on sketch maps.

## APPENDIX D.--TOPOGRAPHIC MAPS

The distinctive feature of topographic maps with respect to other map types is that topographic maps use contour lines to portray the shape and elevation of the land and render the three-dimensional ups and downs of the mapped terrain to a two-dimensional surface. They show and name works of nature including mountains, rivers, lakes, plains, and vegetation, among others. Of prime interest to the AML investigator, works of man, such as buildings, canals, railroads, roads, boundaries, transmission lines, mines, mills, shafts, pits, waste piles, and tailings dumps, also are found on topographic maps.

The amount of detail shown on topographic as well as other maps, is proportionate to the scale of the map; the larger the scale, the more detail shown. Figure D-1a presents, in large-scale to small-scale order, the areal coverage and map-to-ground ratios of the five most commonly used topographic maps; figure D-1b provides general map information and addresses of USGS Map Sales offices. Symbols used on topographic maps are presented in figure D-2.

Following is a discussion of map scales repeated from the USGS pamphlet, "Map Scales."

To be most useful, a map must show locations and distances accurately on a sheet of paper of convenient size. This means that everything included in the map-ground area, distance, rivers, lakes, roads, and so on--must be shown proportionately smaller than it really is. The proportion chosen for a particular map is its scale.

### Large is Small

Simply defined, scale is the relationship between distance on the map and distance on the ground. A map scale might be given in a drawing (a graphic scale), but it usually is given as a fraction or a ratio-- $1/10,000$  or  $1:10,000$ .

These "representative fraction" scales mean that one unit of measurement on the map--1 inch or 1 centimeter--represents 10,000 of the same units on the ground. If the scale were  $1:63,360$ , for instance, then 1 inch on the map would represent 63,360 inches or 1 mile on the ground (63,360 inches divided by 12 inches = 5,280 feet or 1 mile). The first number (map distance) is always 1. The second number (ground distance) is different for each scale; the larger this second number is, the smaller the scale of the map.

"The larger the number, the smaller the scale" sounds confusing, but it is easy to understand. A map of an area 100 miles long by 100 miles wide drawn at a scale of  $1:63,360$  would be more than 8 feet square! To make this map a more convenient size, either the scale used or the amount of area included must be reduced.

If the scale is reduced to  $1:316,800$ , then 1 inch on the map represents 5 miles on the ground, and an area 100 miles square can be mapped on a sheet less than 2 feet square (100 miles at 5 miles/inch equals 20 inches, or 1.66 feet). On the other hand, if the original  $1:63,360$  scale is used but the mapped area is reduced to 20 miles square, the resulting map will also be less than 2 feet square.

Such maps would be much handier. But would they be more useful? In the small-scale map

(1:316,800), there is less room; therefore, everything must be drawn smaller, and some landmarks must be left out altogether. On the other hand, the larger scale map (1:63,360) permits more detail, but it also covers much less ground.

Many areas have been mapped at different scales. When choosing a map—that is, when choosing a scale—the most important consideration is its intended use. A town engineer, for instance, may need a very detailed map in order to precisely locate house lots, power and water lines, and streets and alleys in a community. A commonly used scale for this purpose is 1:600 (1 inch on the map represents 50 feet on the ground). This scale is so large that many features—such as buildings, roads, railroad tracks—that are usually represented on smaller scale maps by symbols can be drawn to scale.

### U.S. Geological Survey Scales

The U.S. Geological Survey publishes maps at various scales. The scale used for most U.S. topographic mapping is 1:24,000. Maps published at this scale cover 7.5 minutes of latitude and 7.5 minutes of longitude; they are commonly called "7.5-minute quadrangle" maps. Map coverage for the United States has been completed at this scale, except for Puerto Rico, which is mapped at 1:20,000 and 1:30,000, and a few States that have been mapped at 1:25,000. Most of Alaska has been mapped at 1:63,360, with some populated areas also mapped at 1:24,000 and 1:25,000.

The 1:24,000 scale is fairly large. A map at this scale provides detailed information about the natural and manmade features of an area, including the locations of important buildings and most campgrounds, caves, ski lifts, watermills, and even drive-in theaters. Footbridges, drawbridges, fence lines, private roads, and changes in the number of lanes in a road are also shown at this scale. They would be omitted, usually, from maps in the 1:50,000 to 1:100,000 scale range; these maps cover more area while retaining a reasonable level of detail. Maps at these scales most often use the 15-minute or 30-by-60 minute quadrangle formats.

Small-scale maps (1:250,000 and smaller) show large areas on a single map sheet, but details are limited to major features—boundaries, State parks, airports, major roads, and railroads.

Figures D-3 and D-4 are examples of topographic maps on which mines and mine-related features are depicted. Figure D-3 shows the southwest corner of the Butte North, MT 15-minute topographic map. As can be seen, the map shows many small "Xs" and other symbols that represent mines and prospects, both surface and underground. Even at the scale of 1:62,500 (about 1 in to the mile), the Berkeley Pit and various mine dumps and tailings disposal areas are clearly shown in the lower right corner. Figure D-4 (Butte North 7.5 minute map) shows a portion of the area displayed in figure D-3 at the scale of 1:24,000 (1 inch represents 2,000 feet). It is readily apparent that the 7.5 minute map is much more detailed than the 15 minute map.

On the surface, it appears that use of 7.5 minute maps is preferable to smaller-scale 15-minute maps for identification of AML sites. However, this is not always the case. For example, the older 15-minute series maps were compiled largely using information collected by field investigators. Working on the ground, the mappers were able to locate and describe features such as small mine workings, old buildings, foundations, and ruins that may be of interest to the AML investigator. On the other hand, the newer 7.5-minute series is based on interpretation of aerial photographs that may not show the more

subtle features noted by ground investigators. In some cases, 15-minute maps may indicate old mine or mill building foundations that have been subsequently overgrown by vegetation and do not appear on the 7.5-minute maps. In view of the forgoing, the AML investigator is encouraged to obtain both 15- and 7.5-minute map coverage of the area of interest.

The following discussion presents some of the advantages and disadvantages of the two map series. It should be noted that the USGS has discontinued publication and distribution of the 15-minute series. However, the Survey maintains file copies which may reproduced for the user.

#### Areal coverage

A 15-minute map covers about 4 times the area of a 7.5 minute map which makes it easier to determine spatial relationships and provides greater continuity with respect to roads, boundaries, watercourses, etc.

#### Detail

The larger scale 7.5-minute maps generally provides more detail than the 15-minute maps.

#### Data coverage

Older 15-minute series maps may show subtle features that were either not included on the 7.5-minute maps or were not apparent on the aerial photographs from which the maps were compiled. However, the 7.5-minute map may include features that were not in existence when the 15-minute maps were compiled.

For more information about topographic maps, the USGS has available a number of booklets, pamphlets, and information sheets at its Map Sales offices that describe the map products available.

## STANDARD SERIES MAPS

*Standard quadrangle maps* cover systematically subdivided areas of latitude and longitude, and are published at various scales depending on the size of the area mapped

*Standard quadrangle formats* range from 7.5x7.5 minutes covering geographic areas of 49 to 71 square miles to 1x2 degrees covering areas of 4580 to 8669 square miles

*Standard quadrangle map scales* range from 1:24 000 (one inch on the map represents 2000 feet on the ground) to 1:250 000 (one inch on the map represents approximately 4 miles on the ground)

*Other quadrangle maps* are published at scales of 1:20 000 (Puerto Rico) to 1:63 360 (Alaska) and 1:1 000 000 (International Map of the World)

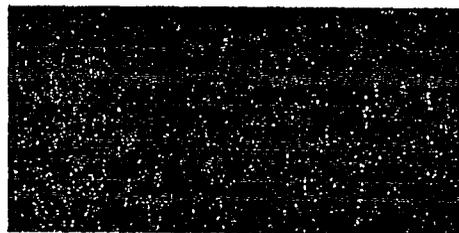
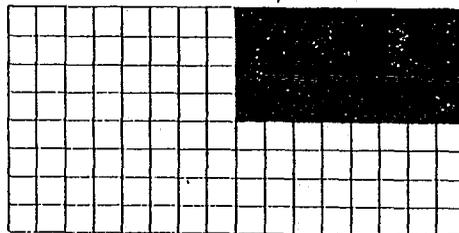
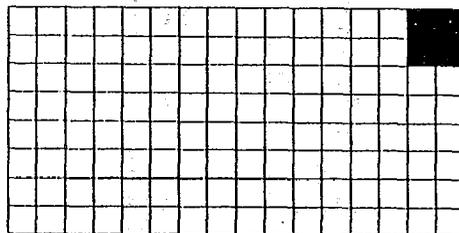
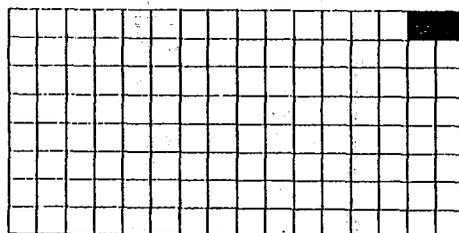
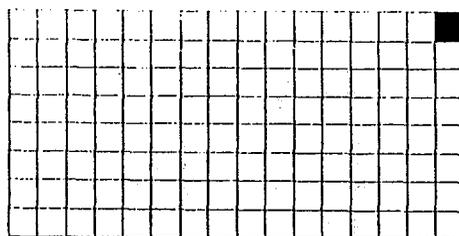
*Special area maps* are published at scales of 1:50 000 and 1:100 000 (County, Regional, and National Park Maps), and 1:500 000 (State Base Maps).

## MAP SERIES COMPARISON

Illustrated opposite is the relative comparison of the size of the area covered by the various map series. Comparatively, the number of maps required to cover an area of 1 degree latitude by 2 degrees longitude is:

- 128—7.5 minute maps
- 64—7.5x15 minute maps
- 32—15 minute maps
- 4—30x60 minute maps
- 1—1x2 degree map

The amount of detail shown on a map is proportionate to the scale of the map; the larger the map scale, the more detail that is shown. For example, individual houses are shown on 1:24 000-scale 7.5-minute maps, whereas only landmark buildings are shown on 1:100 000-scale 30x60-minute maps.



## 7.5 MINUTE SERIES

Map scale<sup>1</sup> ..... 1:24 000  
 Map to ground ratio ..... 1 inch represents 2000 feet  
 Area covered ..... 49–71 square miles  
 Paper size (approx.) ..... 22"x27"  
 Contours and elevations<sup>2</sup> ..... shown in feet

## 7.5 X 15 MINUTE SERIES

Map scale ..... 1:25 000  
 Map to ground ratio ..... 1 inch represents 2083 feet  
 Area covered ..... 100–140 square miles  
 Paper size (approx.) ..... 24"x40"  
 Contours and elevations ..... shown in meters

## 15 MINUTE SERIES

Map scale<sup>3</sup> ..... 1:62 500  
 Map to ground ratio ..... 1 inch represents about 1 mile  
 Area covered ..... 197–282 square miles  
 Paper size (approx.) ..... 18"x22"  
 Contours and elevations<sup>2</sup> ..... shown in feet

## 30 X 60 MINUTE SERIES

Map scale ..... 1:100 000  
 Map to ground ratio ..... 1 inch represents 1.6 miles  
 Area covered ..... 1578–2167 square miles  
 Paper size (approx.) ..... 29"x44"  
 Contours and elevations ..... shown in meters

## 1 X 2 DEGREE SERIES

Map scale ..... 1:250 000  
 Map to ground ratio ..... 1 inch represents about 4 miles  
 Area covered ..... 4580–8669 square miles  
 Paper size (approx.) ..... 22"x32"  
 Contours and elevations<sup>2</sup> ..... shown in feet

<sup>1</sup>1:25 000 scale on selected maps

<sup>2</sup>Shown in meters on selected maps

<sup>3</sup>1:50 000 scale on selected maps

Figure D-1a.—Information regarding five commonly-used topographic maps.

Series	Scale	1 inch represents approximately	1 centimeter represents	Size (latitude x longitude)	Area (square miles)
Puerto Rico 7.5-minute .....	1:20,000	1,667 feet	200 meters	7.5 x 7.5 min.	71
7.5-minute .....	1:24,000	2,000 feet (exact)	240 meters	7.5 x 7.5 min.	49 to 70
7.5-minute .....	1:25,000	2,083 feet	250 meters	7.5 x 7.5 min.	49 to 70
7.5 x 15-minute .....	1:25,000	2,083 feet	250 meters	7.5 x 15 min.	98 to 140
USGS/DMA 15-minute .....	1:50,000	4,166 feet	500 meters	15 x 15 min.	197 to 282
15-minute .....	1:62,500	1 mile	625 meters	15 x 15 min.	197 to 282
Alaska 1:63,360 .....	1:63,360	1 mile (exact)	633.6 meters	15 x 20 to 36 min.	207 to 281
County 1:50,000 .....	1:50,000	4,166 feet	500 meters	County area	Varies
County 1:100,000 .....	1:100,000	1.6 miles	1 kilometer	County area	Varies
30 x 60-minute .....	1:100,000	1.6 miles	1 kilometer	30 x 60 min.	1,568 to 2,240
U. S. 1:250,000 .....	1:250,000	4 miles	2.5 kilometers	1° x 2° or 3°	4,580 to 8,669
State maps .....	1:500,000	8 miles	5 kilometers	State area	Varies
U. S. 1:1,000,000 .....	1:1,000,000	16 miles	10 kilometers	4° x 6°	73,734 to 102,759
U. S. Sectional .....	1:2,000,000	32 miles	20 kilometers	State groups	Varies
Antarctica 1:250,000 .....	1:250,000	4 miles	2.5 kilometers	1° x 3° to 15°	4,089 to 8,336
Antarctica 1:500,000 .....	1:500,000	8 miles	5 kilometers	2° x 7.5°	28,174 to 30,462

### How to order maps and indexes

**Mail orders:** Free indexes may be ordered by State or index name from USGS map sales offices. Maps must be ordered by map name, State, and series/scale. Payment by money order or check payable to the Department of the Interior—USGS must accompany your order. A \$1.00 postage and handling charge is applicable on orders less than \$10.00. Your complete address, including ZIP code, is required. Mail your order and prepayment to:

**USGS MAP SALES**  
**BOX 25286**  
**DENVER, CO 80225**

Residents of Alaska may order Alaska maps or an index for Alaska from:

**USGS MAP SALES—ALASKA**  
**101 12th AVENUE—BOX 12**  
**FAIRBANKS, AK 99701**

**Sales counters:** Maps of the area may be purchased over the counter at the following U.S. Geological Survey offices.

Alaska .....	Anchorage	Room 101, 4230 University Drive E-146 Federal Building, 701 C Street
	Fairbanks	Room 126 New Federal Building, 101 12th Avenue
California .....	Los Angeles	Room 7638 Federal Building, 300 N. Los Angeles Street
	Menlo Park	Room 3128 Building 3, 345 Middlefield Road
	San Francisco	Room 504 Custom House, 555 Battery Street
Colorado .....	Denver	Building 810, Federal Center Room 169 Federal Building, 1961 Stout Street
District of Columbia .....	Washington	Room 2650 Interior Building, 18th & C Street N.W.
Mississippi .....	S.S.C.	Building 3101, Stennis Space Center
Missouri .....	Rolla	1400 Independence Road
Utah .....	Salt Lake City	Room 8105 Federal Building, 125 S. State Street
Virginia .....	Reston	Room 1C-402 National Center, 12201 Sunrise Valley Drive
Washington .....	Spokane	Room 678 U.S. Courthouse, West 920 Riverside Avenue

**Commercial dealers:** Names and addresses of dealers are listed in your local yellow pages. Commercial dealers sell U.S. Geological Survey maps at their own prices.

**Figure D-1b.—General map information and USGS Map Sales offices.**

# Map Symbols

Hard surface, heavy duty road, four or more lanes	
Hard surface, heavy duty road, two or three lanes	
Hard surface, medium duty road, four or more lanes	
Hard surface, medium duty road, two or three lanes	
Improved light duty road	
Unimproved dirt road and trail	
Dual highway, dividing strip 25 feet or less	
Dual highway, dividing strip exceeding 25 feet	
Road under construction	
<hr/>	
Railroad, single track and multiple track	
Railroads in juxtaposition	
Narrow gage, single track and multiple track	
Railroad in street and carline	
Bridge, road and railroad	
Drawbridge, road and railroad	
Footbridge	
Tunnel, road and railroad	
Overpass and underpass	
Important small masonry or earth dam	
Dam with lock	
Dam with road	
Canal with lock	
<hr/>	
Buildings (dwelling, place of employment, etc.)	
School, church, and cemetery	
Buildings (barn, warehouse, etc.)	
Power transmission line	
Telephone line, pipeline, etc. (labeled as to type)	
Wells other than water (labeled as to type)	Oil  Gas
Tanks; oil, water, etc. (labeled as to type)	Water
Located or landmark object; windmill	
Open pit, mine, or quarry; prospect	
Shaft and tunnel entrance	
<hr/>	
Horizontal and vertical control station:	
Tablet, spirit level elevation	BM Δ 5653
Other recoverable mark, spirit level elevation	Δ 5455
Horizontal control station: tablet, vertical angle elevation	VABM Δ 9519
Any recoverable mark, vertical angle or checked elevation	Δ 3775
Vertical control station: tablet, spirit level elevation	BM X 957
Other recoverable mark, spirit level elevation	X 954
Checked spot elevation	X 4675
Unchecked spot elevation and water elevation	X 5657 870

Boundary, national	
State	
County, parish, municipio	
Civil township, precinct, town, barrio	
Incorporated city, village, town, hamlet	
Reservation, national or state	
Small park, cemetery, airport, etc.	
Land grant	
Township or range line, United States land survey	
Township or range line, approximate location	
Section line, United States land survey	
Section line, approximate location	
Township line, not United States land survey	
Section line, not United States land survey	
Section corner, found and indicated	
Boundary monument: land grant and other	
United States mineral or location monument	
<hr/>	
Index contour	
Supplementary contour	
Fill	
Levee	
Mine dump	
Tailings	
Strip mine	
Sand area	
Intermediate contour	
Depression contours	
Cut	
Levee with road	
Wash	
Tailings pond	
Distorted surface	
Gravel beach	
<hr/>	
Perennial streams	
Elevated aqueduct	
Water well and spring	
Small rapids	
Large rapids	
Intermittent lake	
Foreshore flat	
Sounding, depth curve	
Exposed wreck	
Rock, bare or awash; dangerous to navigation	
Intermittent streams	
Aqueduct tunnel	
Disappearing stream	
Small falls	
Large falls	
Dry lake	
Rock or coral reef	
Piling or dolphin	
Sunken wreck	
<hr/>	
Marsh (swamp)	
Inundation area	
Submerged marsh	
Mangrove	

Figure D-2.--Topographic map symbols.



Figure D-3.- Southeast corner of Butte North, MT 7.5-min topographic map.

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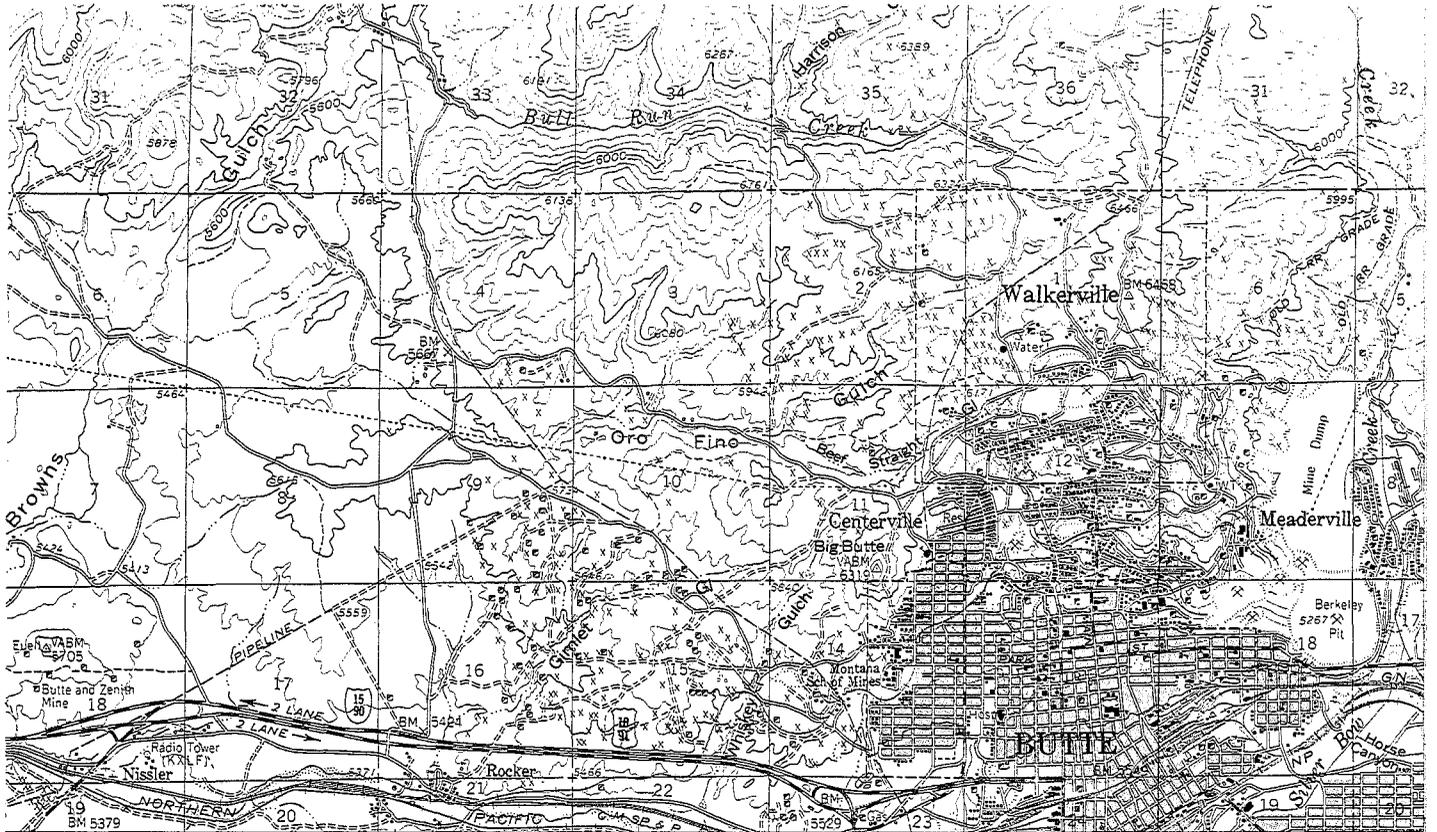


Figure D-4.- Southeast corner of Butte North, MT 15-min topographic map.

## APPENDIX E.--HAZARD RANKING TABLES

Table E-1.--Hazard values for commodities and materials

Commodity	Human	Environmental	Source
Abrasive . . . . .	0	0	USBM <sup>1</sup>
Aluminum . . . . .	4	2	DOD <sup>2</sup>
Antimony . . . . .	7	1	DOD
Arsenic . . . . .	7	4	DOD
Asbestos . . . . .	6	1	DOD
Barium . . . . .	6	1	DOD
Beryllium . . . . .	2	2	USBM
Bismuth . . . . .	2	2	USBM
Boron . . . . .	2	3	DOD
Cadmium . . . . .	8	5	DOD
Calcium . . . . .	0	0	USBM
Cesium . . . . .	4	4	DOD
Chromite . . . . .	2	2	USBM
Chromium . . . . .	2	2	USBM
Cinders . . . . .	0	0	USBM
Clay . . . . .	0	0	USBM
Coal . . . . .	0	0	USBM
Cobalt . . . . .	8	2	DOD
Columbium . . . . .	2	2	USBM
Copper . . . . .	5	5	DOD
Cyanide . . . . .	2	5	DOD
Diatomite . . . . .	0	0	USBM
Feldspar . . . . .	0	0	USBM
Fluorine . . . . .	2	1	DOD
Gallium . . . . .	2	2	USBM
Gemstone . . . . .	0	0	USBM
Geothermal . . . . .	2	2	USBM
Gold . . . . .	2	2	USBM
Graphite . . . . .	0	0	USBM
Gypsum . . . . .	0	0	USBM
Hafnium . . . . .	2	2	USBM
Iridium . . . . .	2	2	USBM
Iron . . . . .	4	2	DOD
Kyanite . . . . .	0	0	USBM
Kyanite Group . . . . .	0	0	USBM
Lead . . . . .	8	5	DOD
Lithium . . . . .	2	2	USBM
Manganese . . . . .	3	3	USBM
Magnesium . . . . .	2	1	DOD
Mercury . . . . .	9	6	DOD
Mica . . . . .	0	0	USBM
Molybdenum . . . . .	2	2	USBM
Nickel . . . . .	7	5	DOD
Niobium . . . . .	2	2	USBM
Olivine . . . . .	0	0	USBM

Table E-1.—Hazard values for commodities and materials—Continued

Commodity	Human	Environmental	Source
Osmium	2	2	USBM
Palladium	2	2	USBM
Peat	0	0	USBM
Perlite	0	0	USBM
Petroleum	2	2	USBM
Phosphate	2	2	USBM
Platinum	2	2	USBM
Platinum Group	2	2	USBM
Pumice	0	0	USBM
Quartz crystal	0	0	USBM
Radium	3	1	DOD
Rare Earth	2	2	USBM
Rhenium	2	2	USBM
Rhodium	2	2	USBM
Ruthenium	2	2	USBM
Sand and gravel	0	0	USBM
Selenium	6	4	DOD
Shale	0	0	USBM
Silica	0	0	USBM
Silicon	0	0	USBM
Silver	5	6	DOD
Sodium	2	2	DOD
Stone	0	0	USBM
Strontium	3	1	DOD
Sulfate	2	2	USBM
Sulfide	2	2	USBM
Sulfur	2	2	USBM
Talc	0	0	USBM
Tantalum	2	2	USBM
Tellurium	2	2	USBM
Thallium	7	3	DOD
Thorium	2	2	USBM
Tin	2	2	USBM
Titanium	2	2	USBM
Tungsten	2	2	USBM
Uranium	4	1	DOD
Vanadium	4	3	DOD
Zeolite	0	0	USBM
Zinc	5	4	DOD
Zirconium	2	2	USBM
(No data)	ERR	ERR	

ERR Suggested for entry into a spreadsheet type software "lookup" to indicate that commodity was either not entered accidentally or commodity is not known.

<sup>1</sup>U.S. Bureau of Mines, WFOC, determined.

<sup>2</sup>U.S. Department of Defense, Priority Model report.

Table E-2.—Status

<u>Code</u>	<u>Factor</u>
Past producer . . . . .	2
Developed deposit . . . . .	1.5
Explored prospect . . . . .	1.2
Raw prospect . . . . .	1
(No data) . . . . .	ERR

ERR Suggested for entry into a spreadsheet type software "lookup" to indicate status is not known.

Table E-3.—Type (Property type)

<u>Code</u>	<u>Factor</u>
Surface . . . . .	1.2
Underground . . . . .	1.2
Surface-underground . . . . .	1.2
Mineral location . . . . .	1
Placer . . . . .	1
Unknown . . . . .	1
Well . . . . .	1
Processing plant . . . . .	1
(No data) <sup>1</sup> . . . . .	1

<sup>1</sup>For no data, suggest default equal factor of "1."

Table E-4.—Size

<u>Production, total mt based on size</u>	<u>Factor</u>
Very small, < 1,000 . . . . .	1
Small, 1,000-10,000 . . . . .	1.2
Small-Medium, > 10,000-250,000 . . . . .	1.4
Medium, > 250,000-500,000 . . . . .	1.6
Medium-Large, > 500,000 to 1 million . . . . .	1:8
Large, > 1 million . . . . .	2
(No data) <sup>1</sup> . . . . .	1

<sup>1</sup>For no data, suggest default equal factor of "1."

**Table E-5.—Mill type**

<u>Code</u>	<u>Factor</u>
Amalgamation .....	2.2
Arrastre .....	1.2
CIP .....	2.2
Crusher (only) .....	1
Cyanidation .....	2.2
Flotation .....	2.2
Gravity .....	1.6
Heap leach .....	2.2
Jig plant .....	1.6
Leach .....	2.2
Retort .....	2.2
Stamp .....	1.6
Unknown/Possible .....	2
(No mill) .....	1

<sup>1</sup>When no indication of the presence of a mill, use default factor value equal to "1."

**Table E-6.—Acid potential**

<u>Code</u>	<u>Factor</u>
Yes .....	1.2
No .....	1

**Table E-7.—Acid producers or indicator minerals**

Arsenopyrite  
Chalcopyrite  
Galena  
Iron oxide  
Limonite  
Marcasite  
Pyrrhotite  
Pyrite<sup>1</sup>  
Sphalerite  
Sulfide  
Sulfur (elemental)

<sup>1</sup>Pyrite is the principal "acid producing" mineral. The other minerals are indicators for possible presence of pyrite.

**Table E-8.--Neutralizing host rocks**

Carbonate  
Dolomite  
Limestone  
Marble

## APPENDIX F.-- HOW AND WHERE TO ACQUIRE MAS/MILS AND OTHER BUREAU OF MINES DATA

MAS/MILS and other Bureau of Mines data may be obtained by contacting the following Bureau Field Operations Centers:

For the State of Alaska: Alaska Field Operations Center, 3301 C Street, Suite 525, Anchorage, AK, 99503-3935, Information No. (907) 271-2455, Facsimile No. (907) 271-3933.

For the States of California, Hawaii, Idaho, Montana, Nevada, Oregon, and Washington: Western Field Operations Center, E. 360 Third Avenue, Spokane, WA, 99204-1413, Information No. (509) 353-2700, Facsimile No. (509) 353-2661.

All other States: Intermountain Field Operations Center, P.O. Box 25086, Building 20, Denver Federal Center, Denver, CO, 80225, Information No. (303) 236-0421, Facsimile No. (303) 236-0238.

A request for MILS data should include the following:

(1) A list of all topographic maps using the exact map name as it appears in the lower right corner of the map.

(2) Next to the name, note the latitude and longitude coordinates of the lower right and upper left corners of the map. For example:

<u>Map Name</u>	<u>Lower lat/lon</u>	<u>Upperlat/lon</u>
Butte North, MT	46°00'/112°30'	46°15'/112°45'

(3) Specify a "Nonconfidential MILS Listing" of all properties within the areas specified.

If the topographic map name is not known, the county name, latitude/longitude boundary and/or mine name(s) can be used to request MAS/MILS data.

The USBM will provide literature reviews, data gathering, hazard ranking, on-site investigations, and site characterization on a reimbursable basis. For more information, contact the Western Field Operations Center, Spokane, WA at (509) 353-2700.

## **APPENDIX G.—SUGGESTED SAFETY TRAINING FOR ABANDONED MINE SITE INVESTIGATORS**

The following is a summary of the training that may be required for site investigators. The actual training requirements will vary and depend on a number of factors, including climate, topography, the remoteness of the site(s), and agency requirements.

### **I. Personal Safety and Survival**

- a. First aid
- b. Adult cardio-pulmonary resuscitation (CPR)
- c. Wild animal safety; habits, methods of avoiding encounters.
- d. Outdoor survival; basics of how to stay healthy while working outdoors and, in an emergency, how to survive until help arrives.
- e. Mine safety training; required for all personnel who work in active mines. The course is taught by instructors who have been trained and certified by the Mine Safety and Health Administration (MSHA), U.S. Department of Labor. Although this course emphasizes active mining, many of the instructors have experience with abandoned mines and might be able to offer helpful advice.

### **II. Transportation**

- a. Helicopter safety; proper methods of approaching, entering, and exiting helicopters. Also, loading equipment inside or outside of helicopter.
- b. Helicopter slinging procedures; proper rigging, slinging, and releasing loads. Also, avoiding electrocution by static electricity.
- c. Defensive and off-road driving; anticipating and avoiding motor vehicle accidents on highway and off.

### **III. Hazardous Materials**

- a. Hazardous materials site worker; Environmental Protection Agency (EPA) approved, 40-h course on identifying hazardous materials, handling them correctly, and using personal protection equipment. This course will provide certification after successful completion. An 8-h refresher course must be taken each year afterward to maintain certification. *This training, while recommended, may not be necessary in all cases or for all workers.*
- b. Hazardous materials operations supervisor; EPA-approved 24-h course on organizing work teams, maintaining safety discipline, and managing decontamination operations. *As above, this training is recommended but may not be necessary in all cases or for all workers.*

- c. **Hazardous materials awareness; general overview of recognizing hazardous materials in the field, maintaining personal safety, and reporting information to authorities.**
- d. **Abandoned explosives; identifying the various types of explosives and related items, maintaining personal safety, and reporting information to authorities.**

#### **IV. Administration**

- a. **Administrative procedures, including contacting the home office regularly, summoning help in an emergency, and notifying proper supervisory personnel in an emergency.**
- b. **Communications; operating personal and base-station radios; knowing operational and emergency frequencies.**
- c. **Camp operations; disseminating information on camp organization, responsibilities, hygiene, and resupply.**

## APPENDIX H.--SUGGESTED EQUIPMENT AND SUPPLIES

The following is a suggested list of safety equipment and supplies for use in conducting AML site investigations. Actual requirements will vary depending on, among others, climate, weather, season, region of operations, and agency policy.

### I. Personal equipment

#### a. Safety equipment

1. Hard hat
2. Safety glasses
3. Ear plugs
4. Steel-toed boots
5. Leather gloves
6. Personal first aid kit
7. Personal survival kit
8. Fireproof shirt (for aircraft use)
9. Fireproof trousers (for aircraft use)
10. Flight helmet (for aircraft use)
11. Fireproof gloves (for aircraft use)
12. Head lamp (if underground operations are considered necessary)
13. Portable radio
14. Firearm if location warrants (.44 magnum pistol or 12-gauge shotgun for bears--primarily in Alaska and Montana)
15. Ammunition (.44 magnum pistol with 300-grain hard lead bullets or 12-gauge sabot shells--primarily in Alaska and Montana)
16. Bear repellent spray--primarily in Alaska and Montana

#### b. Other equipment

1. Completed pre-field forms
2. Field forms
3. Maps
4. Compass
5. Field notebook
6. Pencils, pens, scale, protractor
7. Altimeter
8. Backpack
9. Flashlight with extra batteries
10. Mosquito headnet (primarily in Alaska)
11. Wool shirt
12. Equipment vest
13. Raincoat and trousers
14. Rock hammer
15. Canteen(s) of water
16. Camera with extra film
17. Hiking socks

## II. Other field equipment

- a. Team survival kit containing sleeping bags, small tent, freeze-dried food, water-proof matches, flares, fuel-tablet stove, fuel tablets, and wire
- b. Shovel
- c. Pickax
- d. Tape measure, 30 m (100 ft) long
- e. Plastic flagging of any bright color
- f. Marking pens
- g. Tape measure, 3 m (10 ft) long
- h. Rope, 13-mm- (1/2-in) diam and 30 m (100 ft) long
- i. Rope climbers for above rope
- j. Ranch jack
- k. Gasoline can with spout
- l. Assorted mechanic's tools
- m. Machete
- n. Bow saw
- o. Sampling equipment (sample bags, canvas bags, vials of various capacities, waterproof adhesive tape, sample books, etc.)

## III. Analytical supplies and other equipment

- a. Portable pH meter, or pH indicator (litmus) paper
- b. Geiger counter or scintillometer
- c. Portable conductivity meter
- d. Global positioning system (GPS) receiver

**APPENDIX I.--AML FEATURES, OBSERVATIONS, HAZARDS, AND ACTIONS**

Feature	Observation	Potential hazard	Action
<b><u>Mine Openings</u></b>			
Horizontal tunnel or adit	Open to entry	Physical hazard	Photograph; measure size of opening
	Partly caved	do.	do. <sup>1</sup>
	Fully caved	No hazard	Note condition
	Partly filled with water; yellow-orange stain	AMD, disease, heavy metal transport	Photograph; pH, conductivity, color
	Standing water; yellow-orange stain	do.	do.
	Flowing water; yellow-orange stain; filamentous algae	do.	do.
	Uranium mining area	Radiation	Photograph; note possibility radiation hazard
	Stains (yellow-orange or dark gray to black) on rock or soil	Indicates possible AMD, heavy metals, chemical or petroleum product spill	Photograph, note color and location; sketch map may be appropriate; if water is present, check pH, conductivity
Acrid odor	Heavy metals, chemicals, petroleum	Note presence and approximate location	Note occurrence
	Thin ground over workings	Physical hazard	Photograph; note location
	Animals inhabit workings	Physical hazard, disease	Note occurrence
	Guano (bat manure)	do.	do.

<sup>1</sup>do = ditto, i.e., an exact duplication of the words, phrase, or sentence above.

**APPENDIX I.--AML FEATURES, OBSERVATIONS, HAZARDS,  
AND ACTIONS--Continued**

<b>Feature</b>	<b>Observation</b>	<b>Potential hazard</b>	<b>Action</b>
Vertical or inclined; glory hole	Explosives and/or supplies	Physical hazard	Photograph, note occurrence
	Open to entry	do.	Photograph; measure
	Partly caved	do.	do.
	Caved	do.	Note condition
	Water filled; yellow-orange stain	do.	do.
		AMD, heavy metals	Photograph; pH, conductivity
	Flowing water; yellow-orange stain; presence of filamentous algae	AMD, heavy metal transport	do.
	Uranium mining area	Radiation	Photograph; note possibility of radiation hazard
	Stains (yellow-orange or dark gray to black) on rock or soil	Indicates possible AMD, heavy metals, chemical or petroleum product spill	Photograph, note color and location; sketch map may be appropriate; if water is present, check pH, conductivity
	Acrid odor	Acid development, heavy metal transport, chemical or petroleum spill	Note presence and approximate location, estimate size
Thin ground over workings	Physical hazard	Photograph; note location	
Animals inhabit workings	do.	Note occurrence	

**APPENDIX I.--AML FEATURES, OBSERVATIONS, HAZARDS,  
AND ACTIONS--Continued**

<b>Feature</b>	<b>Observation</b>	<b>Potential hazard</b>	<b>Action</b>
	Guano (bat manure)	Physical hazard, disease	Note occurrence
	Explosives and/or supplies	Physical hazard	do.
Small pit or trench	Open to entry	Minor hazard	Photograph; measure
	Closed to entry	do.	do.
Large pit or quarry	Open to entry	Physical hazard	Photograph; estimate size
	Partly caved, unstable walls	do.	do.
	Water filled (part or all); yellow-orange stain	AMD, heavy metal transport	Photograph; estimate size; pH, conductivity
	Flowing water; yellow-orange stain, filamentous algae	do.	do.
	Stains (orange-yellow to dark gray-black)	Heavy metal contamination; chemical or petroleum spill	Photograph; estimate area affected
	Uranium mining area	Radiation	Photograph; note possibility of radiation hazard
	Cribbed embankments	Physical hazards	Photograph; note presence, approximate size, and location
	Highwalls	do.	do.
	Unstable slopes	do.	do.

**APPENDIX I.--AML FEATURES, OBSERVATIONS, HAZARDS,  
AND ACTIONS--Continued**

<b>Feature</b>	<b>Observation</b>	<b>Potential hazard</b>	<b>Action</b>
	Acrid odor	Acid development, heavy metal transport, chemical or petroleum spill	Note presence and approximate location
	Stains (yellow-orange or dark gray to black) on rock or soil	Indicates possible AMD, heavy metals, chemical or petroleum product spill	Photograph, note color and location; sketch map may be appropriate; if water is present, check pH, conductivity
<b>Solution mining well</b>	<b>Subsidence</b>	<b>Physical hazard</b>	<b>Photograph; measure size</b>
	Stains (orange-yellow to dark gray-black)	Heavy metal contamination; chemical or petroleum spill	Photograph; estimate area affected
	Stains (yellow-orange or dark gray to black) on rock or soil	Indicates possible AMD, heavy metals, chemical or petroleum product spill	Photograph, note color and location; sketch map may be appropriate; if water is present, check pH, conductivity
<b><u>Mine Infrastructure</u></b>			
<b>Buildings</b>	<b>Standing</b>	<b>Physical hazard</b>	<b>Photograph</b>
<b>Machinery</b>	<b>Stained ground</b>	<b>Chemical or petroleum spill</b>	<b>Photograph; note size and location</b>
	<b>Explosives shed</b>	<b>Physical hazard</b>	<b>Photograph; note location</b>
	<b>Outside a building</b>	<b>do.</b>	<b>do.</b>
	<b>Inside a building</b>	<b>do.</b>	<b>Photograph</b>

**APPENDIX I.--AML FEATURES, OBSERVATIONS, HAZARDS,  
AND ACTIONS--Continued**

<b>Feature</b>	<b>Observation</b>	<b>Potential hazard</b>	<b>Action</b>
	Stains (yellow-orange stain, or dark gray to black) on rock or soil	Indicates possible AMD, heavy metals, chemical or petroleum product spill	Photograph, note color and location; sketch map may be appropriate; if water is present, check pH, conductivity
<b>Headframes</b>	Standing	Physical hazard	Photograph
	Collapsed	do.	do.
	Cables	do.	Photograph; note location
<b>Power substations</b>	Transformers	PCB	Photograph; note number and approximate size
	Poles/wires	Physical hazard	Photograph; note location
<b>Sumps and cisterns</b>	Open or partly open tanks	do.	Photograph; note condition and location
<b>Impoundments</b>	Dams used to collect water	do.	do.
<b><u>Mine Dumps</u></b>	Scrap metal	do.	Photograph
	Refuse	Physical hazard, disease	Photograph; note location
		Chemicals	Photograph; note location for further action

**APPENDIX I.--AML FEATURES, OBSERVATIONS, HAZARDS,  
AND ACTIONS--Continued**

Feature	Observation	Potential hazard	Action
	Stains (yellow-orange or dark gray to black) on rock or soil	Indicates possible AMD, heavy metals, chemical or petroleum product spill	Photograph, note color and location; sketch map may be appropriate; if water is present, check pH, conductivity
	General size	Environmental hazard (potential heavy metals)	Data will be needed to determine relative significance
	Slope face erosion and undercutting	Physical hazard	Photograph
		Sedimentation, heavy metal transport	Photograph, note color of exposed portion of dump; note erosion into water
	Stressed plants	Heavy metals, chemicals or petroleum contamination	Photograph; note color, location and size of affected area
	Radical change in vegetation density	do.	do.
	Lack of vegetation	Wind blown dust, acid generation, heavy metals transport	Photograph; estimate size of barren area
	Erosion	Sedimentation, heavy metals transport	Photograph; estimate size of eroded area
	Unstable sides; rotten cribbing	Physical hazard, Sedimentation, potential erosion and heavy metals transport	Photograph; estimate size of affected area
	Standing water	Acid generation, heavy metals	Photograph, note color, check pH, conductivity

**APPENDIX I.—AML FEATURES, OBSERVATIONS, HAZARDS,  
AND ACTIONS--Continued**

Feature	Observation	Potential hazard	Action
	Water running from side or base of dump, filamentous algae	Acid generation, heavy metals transport, erosion and sedimentation	Photograph, note color; check pH, conductivity, note presence of filamentous algae
	Water running along or near base of dump	do.	Photograph; look for signs of erosion especially during periods of high runoff; note filamentous algae, presence of caddis fly cases
	Uranium mining area	Radiation	Photograph; note possibility of radiation hazard
	Stains (yellow-orange or dark gray to black) on rock or soil	Indicates possible AMD, heavy metals, chemical or petroleum product spill	Photograph, note color and location; sketch map may be appropriate; if water is present, check pH, conductivity
	Acrid odor	Heavy metals, chemicals, petroleum	Note presence and approximate location
	Buildings < <see buildings discussed above> >		
<u>Mine Ore Stockpiles</u>	Piles of ore	Acid generation, heavy metals	Photograph; estimate size
	Ore bin-empty	Physical hazard	Photograph; note location
	Ore bin-full or contains some ore	do.	do.

**APPENDIX I.—AML FEATURES, OBSERVATIONS, HAZARDS,  
AND ACTIONS—Continued**

<b>Feature</b>	<b>Observation</b>	<b>Potential hazard</b>	<b>Action</b>
	Ore bin-full or contains some ore	Acid generation, heavy metals	Photograph; note location
	Uranium mining area	Radiation	Photograph; note possibility of radiation hazard
	Stains (yellow-orange stain, or dark gray to black) on rock or soil	Indicates possible AMD, heavy metals, chemical or petroleum product spill	Photograph, note color and location; sketch map may be appropriate; if water is present, check pH, conductivity
	Acrid odor	Heavy metals, chemicals, petroleum	Note presence and approximate location
<b><u>Raised Systems</u></b>			
<b>Flumes</b>	<b>Standing</b>	<b>Physical hazard</b>	<b>Photograph; note location</b>
	Partly standing	do.	do.
	Collapsed	do.	do.
<b>Trestles</b>	<b>Standing</b>	do.	do.
	Partly standing	do.	do.
	Collapsed	do.	do.
<b><u>Mill Infrastructure</u></b>			
<b>Building</b>	<b>Standing</b>	<b>Physical hazard; asbestos, chemicals</b>	<b>Photograph</b>
	Partly collapsed	do.	do.

**APPENDIX I.--AML FEATURES, OBSERVATIONS, HAZARDS,  
AND ACTIONS--Continued**

<b>Feature</b>	<b>Observation</b>	<b>Potential hazard</b>	<b>Action</b>
	Collapsed	Physical hazard; asbestos, chemicals	Photograph
	Stains (yellow-orange or dark gray to black) on rock or soil	Indicates possible AMD, heavy metals, chemical or petroleum product spill	Photograph, note color and location; sketch map may be appropriate; if water is present, check pH, conductivity
	Drums and/or bags	Chemicals	Photograph; note number and location
<b>Machinery</b>	Ball or rod mill	Physical hazard	Photograph
		Mercury, cyanide, other chemicals, heavy metals	Note for future testing for mercury and cyanide
	Flotation cells	Physical hazard	Photograph
		Chemicals	Note for future testing for flotation reagents
	Retort	Mercury	Note for future testing for mercury
	Leach tanks	Cyanide	Note for further testing for chemicals including cyanide
	Stamp Mill	Mercury	Photograph and note for further investigation for chemicals
	Amalgamation equipment	do.	do.
	Arrastre	do.	do.

**APPENDIX I.—AML FEATURES, OBSERVATIONS, HAZARDS,  
AND ACTIONS—Continued**

<b>Feature</b>	<b>Observation</b>	<b>Potential hazard</b>	<b>Action</b>
	Concentrator ore bins	Heavy metals, acid generation	Photograph and note for further investigation for chemicals
	Tanks	Chemicals, residual fuels, cyanide, mercury	do.
	Thickeners	Cyanide, other chemicals	do.
	Vats	do.	Photograph and note for further investigation for chemicals
	Other equipment	Physical hazard	Photograph
	Yellow-orange to dark gray or black stains	Acid generation, heavy metals, chemicals, petroleum spill	Photograph; note size and location of affected area for future testing
	Uranium mining area	Radiation	Photograph; note possibility of radiation hazard
	Stains (yellow-orange or dark gray to black) on rock or soil	Indicates possible AMD, heavy metals, chemical or petroleum product spill	Photograph, note color and location; sketch map may be appropriate; if water is present, check pH, conductivity
	Acrid odor	Heavy metals, chemicals, petroleum	Note presence and approximate location
Power substations	Transformers	Environmental hazard	Photograph; note number and approximate size
	Poles/wires	Physical hazard	Photograph

**APPENDIX I.--AML FEATURES, OBSERVATIONS, HAZARDS,  
AND ACTIONS--Continued**

<b>Feature</b>	<b>Observation</b>	<b>Potential hazard</b>	<b>Action</b>
<b>Impoundments</b>	Dams (usually with dry or nearly dry basins behind them)	Physical hazard	Photograph; note location and size and condition of dam
<b>Mill Tailings (confined or unconfined)</b>	Scrap metal	do.	Photograph
	Refuse	Physical hazard, disease	Photograph; note for further action
		Chemicals	do.
	Yellow-orange to dark gray-black stains	Heavy metals, acid generation, chemical or petroleum spills	Photograph; note color and locations; sketch map may be appropriate
	General size	Heavy metals	Data will be needed to determine relative significance
	Confined or unconfined	Erosion, sedimentation, blowing dust	Photograph; note area and extent
	Dams (presence, integrity)	do.	Photograph; note any problems such as a breach, apparent erosion by a water body
	Slope face erosion and undercutting	Physical hazard	Photograph; measure size
Erosion and sedimentation		Photograph; note color of exposed portion of dump; note erosion into water and area affected	

**APPENDIX I.--AML FEATURES, OBSERVATIONS, HAZARDS,  
AND ACTIONS--Continued**

<b>Feature</b>	<b>Observation</b>	<b>Potential hazard</b>	<b>Action</b>
	Standing water	Possible acid generation, heavy metals	Photograph; note color, check pH, conductivity
	Water running from side or base of tailings; filamentous algae	do.	do.
	Water running along side or base of tailings, filamentous algae	Possible acid generation, heavy metals, possible erosion and sedimentation	do.
	Stressed vegetation	Possible heavy metal or chemical contamination, acid generation	Photograph; estimate size of area affected
	Radical change in vegetation density	Acid generation, heavy metals, chemical or petroleum spill	Note presence, approximate size of affected area
	Lack of vegetation	Windblown dust, acid generation, heavy metal transport	Photograph; estimate size of affected area
	Erosion	Sedimentation, transport of heavy metal-bearing material	do.
	Drums and/or bags	Physical hazard	Photograph; note location
		Chemicals	Photograph; note location, number and labels

**APPENDIX I.--AML FEATURES, OBSERVATIONS, HAZARDS,  
AND ACTIONS--Continued**

<b>Feature</b>	<b>Observation</b>	<b>Potential hazard</b>	<b>Action</b>
	Pipe (part of tailings or chemical distribution system)	Physical hazard  Chemicals	Photograph; note location  do.
	Uranium mining area	Radiation	Photograph; note possibility of radiation hazard
	Stains (yellow-orange or dark gray to black) on rock or soil	Indicates possible AMD, heavy metals, chemical or petroleum product spill	Photograph, note color and location; sketch map may be appropriate; if water is present, check pH, conductivity
	Acrid odor	Heavy metals, chemicals, petroleum	Note presence and approximate location
<u>Leach Pads</u>	General size	Heavy metals, chemicals	Photograph; note location and size
	Pipes and other equipment	Physical hazard  Chemicals	Photograph; note quantity and location  do.
	Drums, bags, etc	do.	Photograph; note location, number and labels
	Standing water	Acid generation, heavy metals	Photograph; note color; check pH, conductivity
	Water flowing from pad; filamentous algae	AMD, heavy metals	do.

**APPENDIX I.--AML FEATURES, OBSERVATIONS, HAZARDS,  
AND ACTIONS--Continued**

<b>Feature</b>	<b>Observation</b>	<b>Potential hazard</b>	<b>Action</b>
	Proximity to bodies of water	AMD, heavy metals, sedimentation	Photograph; note whether water body is or has eroded pile; stains
	Yellow-orange stains	AMD, heavy metals	Photograph; note location and extent
	Uranium mining area	Radiation	Photograph; note possibility of radiation hazard
	Stains (yellow-orange or dark gray to black) on rock or soil	Indicates possible AMD, heavy metals, chemical or petroleum product spill	Photograph, note color and location; sketch map may be appropriate; if water is present, check pH, conductivity
	Acrid odor	Heavy metals, chemicals, petroleum	Note presence and approximate location
<b><u>Solution Ponds</u></b>	Size	Heavy metals, chemicals, blowing dust	Photograph; note location and size
	Pipes and other equipment	Physical hazard	Photograph; note quantity and location
		Chemicals	do.
	Drums, bags, etc	do.	Photograph; note location, number and labels
	Standing water	Acid generation, heavy metals	Photograph; note color; check pH, conductivity
	Water flowing from pad, filamentous algae	AMD, heavy metals, chemicals	do.

**APPENDIX I.--AML FEATURES, OBSERVATIONS, HAZARDS,  
AND ACTIONS--Continued**

<b>Feature</b>	<b>Observation</b>	<b>Potential hazard</b>	<b>Action</b>
	Proximity of bodies of water	AMD, heavy metals, sedimentation	Photograph; note whether water body is or has eroded pile
	Yellow-orange stains	AMD, heavy metals	Photograph; note location and extent
	Uranium mining area	Radiation	Photograph; note possibility of radiation hazard
	Stains (yellow-orange or dark gray to black) on rock or soil	Indicates possible AMD, heavy metals, chemical or petroleum product spill	Photograph, note color and location; sketch map may be appropriate; if water is present, check pH, conductivity
	Acrid odor	Heavy metals, chemicals, petroleum	Note presence and approximate location
<b><u>Suspended Systems</u></b>			
	Antennae (thin wires strung from trees or poles)	Physical hazards	Photograph; note location and prepare a sketch map
	Cables	do.	do.
	Power lines	do.	do.
	Tramways, buckets, and poles	do.	do.
	Wires	do.	do.

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## **APPENDIX K.--LISTING OF PRINCIPAL STATE AML AGENCIES AND AGENCY CONTACTS**

The following listing was repeated from: Colorado Center for Environmental Management and U.S. Bureau of Mines. Inactive and Abandoned Noncoal Mine Inventory and Reclamation: A Status Report on 19 States. V. 1, Nov. 1993.

.....  
State: Alaska

Representing Agency: Department of Natural Resources  
Division of Mining

Agency Contact: Mitch Henning

Address/Phone: 3601 C Street, Suite 200, P.O. Box 107005,  
Anchorage, AK 99510-7005  
(907) 762-2109

.....  
State: Arizona

Representing Agency: State Mine Inspector's Office

Agency Contact: Phil Howard, Assistant SMI

Address/Phone: 1700 West Washington, Suite 403  
Phoenix, AZ 85700  
(602) 542-5971

.....  
State: California

Representing Agency: Department of Conservation  
Office of Mine Reporting and Reclamation Compliance

Agency Contact: Terry Lawler

Address/Phone: 801 K Street, Mail Stop 09-06  
Sacramento, CA 95814-3529  
(916) 324 0681

.....  
State: Colorado

Representing Agency: Department of Natural Resources  
Division of Minerals and Geology

Agency Contact: Dave Bucknam

Address/Phone: 1313 Sherman Street, Room 215  
Denver, CO 80203  
(303) 866-3567

**State:** Florida  
**Representing Agency:** Department of Environmental Protection  
Division of Resource Management  
Bureau of Mine Reclamation  
**Agency Contact:** Steve Windham  
**Address/Phone:** 2051 East Dirac Drive  
Tallahassee, FL 32310  
(904) 488-8217

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**State:** Idaho  
**Representing Agency:** Department of Health and Welfare  
Division of Environmental Quality (DEQ)  
**Agency Contact:** Bruce A. Schuld  
**Address/Phone:** 1420 N. Hilton  
Boise, ID 83720  
(208) 334-0554

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**State:** Minnesota  
**Representing Agency:** Department of Natural Resources  
Minerals Division  
**Agency Contact:** Arlo Knoll  
**Address/Phone:** P.O. Box 567  
Hibbing, MN 55746  
(218) 262-6767

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**State:** Missouri  
**Representing Agency:** Department of Natural Resources  
Division of Environmental Quality  
Abandoned Mines Section  
**Agency Contact:** Larry Cohen  
**Address/Phone:** P.O. Box 176  
Jefferson City, MO 65102  
(314) 751-4041

**State:** Montana  
**Representing Agency:** Department of State Lands  
Abandoned Mine Reclamation Bureau  
**Agency Contact:** Vic Andersen  
**Address/Phone:** 1625 Eleventh Avenue  
Helena, MT 59620  
(406) 444-2074

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**State:** Nevada  
**Representing Agency:** Department of Minerals  
Division of Abandoned Mines  
Abandoned Mines Section  
**Agency Contact:** Doug Driesner  
**Address/Phone:** 400 W. King Street, Suite 106  
Carson City, NV 89710  
(702) 687-5050

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**State:** New Mexico  
**Representing Agency:** Department of Energy, Minerals, and Natural Resources  
Mining and Minerals Division  
**Agency Contact:** Bob Evetts, Program Manager  
**Address/Phone:** 2040 South Pacheco  
Santa Fe, NM 87505  
(505) 827-5970

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**State:** Oregon  
**Representing Agency:** Department of Geology and Minerals Industries  
Mine Land Reclamation Program  
**Agency Contact:** Gary Lynch  
**Address/Phone:** 1536 Queen Avenue S.E.  
Albany, OR 97321  
(503) 967-2039

**State:** South Carolina  
**Representing Agency:** South Carolina Land Resource Conservation Commission  
Mining and Reclamation Division  
**Agency Contact:** Craig Kennedy  
**Address/Phone:** 2221 Devine Street, Suite 222  
Columbia, SC 29205  
(803) 734-9100

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**State:** South Dakota  
**Representing Agency:** Department of Environment and Natural Resources  
Office of Minerals and Mines  
**Agency Contact:** Thomas V. Durkin, Hydrologist  
**Address/Phone:** 523 East Capitol  
Pierre, SD 57501-3181  
(605) 773-4201

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**State:** Texas  
**Representing Agency:** Railroad Commission of Texas  
Surface Mining and Reclamation Division  
**Agency Contact:** Mark Rhodes, Abandoned Mine Land Program  
**Address/Phone:** Capitol Station, P.O. Box 12967  
Austin, TX 78711-2967  
(512) 463-7313

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**State:** Utah  
**Representing Agency:** Department of Natural Resources  
Division of Oil, Gas, and Mining  
**Agency Contact:** Mary Ann Wright  
**Address/Phone:** 355 West North Temple, 3 Triad Center, Suite 350  
Salt Lake City, UT 84180-1203  
(801) 538-5340

**State:** Washington  
**Representing Agency:** State Solid and Hazardous Waste Program  
**Agency Contact:** Vern Meinz  
**Address/Phone:** P.O. Box 47600  
Olympia, WA 98504-7600  
(206) 459-6687

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**State:** Wisconsin  
**Representing Agency:** Department of Natural Resources  
Mine Reclamation Unit  
**Agency Contact:** Lawrence Lynch  
**Address/Phone:** P.O. Box 7291  
Madison, WI 53707  
(608) 267-7553

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**State:** Wyoming  
**Representing Agency:** Department of Environmental Quality  
Abandoned Mine Lands Division  
**Agency Contact:** Gary Beach, Administrator  
**Address/Phone:** 122 West 25th Street, 3rd Floor West  
Cheyenne, WY 82002  
(307) 777-6145

## APPENDIX L.--AERIAL AND SATELLITE PHOTOGRAPHY AND IMAGERY

A variety of AML site information can be gathered from aerial photography and satellite and related imagery. This information includes presence, location, size or relative size, and approximate area of land disturbance; surface area of dumps and tailings; and the presence, location, and approximate size of buildings, access roads, and related features. For satellite imagery, site information is limited to medium or large sites or features. These areas can be identified and marked on maps prior to fieldwork. Imagery is especially useful in semiarid and arid regions with sparse vegetation.

Photographs (or digital images) are usually collected from a vertical rather than oblique perspective, are recorded by an airborne or space based instrument, are recorded at one of a variety of altitudes, and are available at a variety of scales.

Images may be delivered in either hard copy or digital format and may be divided into four general groups: aerial photography, videography, airborne imagery, and satellite imagery. A variety of image or photographic data types or platforms are available. These include low, medium, and high altitude aerial photos (color, black-and-white, infrared, false color infrared); videography (video cameras attached to aircraft); high altitude aircraft (U-2) infrared photography; airborne imaging spectrometers; and satellite imagery. Aerial photos and U-2 photos are available in image positives or negative transparencies. Airborne multi-spectral imagery and videography are available in digital format, and satellite multi-spectral imagery is available in either hard copy or digital format. Aerial photography has the advantage of high resolution, but generally covers relatively small areas. Conversely, satellite imagery has lower resolution, but covers larger areas. Airborne multi-spectral imagery and videography will generally cover areas of small to moderate size, and provide greater detail than commercially available satellite imagery. If aircraft-based photography or imagery is contracted, an associated real-time geo-referencing system is critical to aid in site location.

Aerial photography is available from a variety of domestic sources, including the Department of Agriculture.<sup>1</sup> Scale, and associated resolution, varies with altitude; lower altitude gives higher resolution. Low altitude aerial photography has the capability to show small features including individual mineral prospects.

Airborne multi-spectral imagery is available from a variety of private vendors and a few Federal agencies, namely the National Aeronautics and Space Administration (NASA). Videography is available through some universities, a few federal agencies have in-house systems, and a few private vendors are developing systems for commercial use.

Satellite imagery is available from both domestic<sup>2</sup> and foreign sources<sup>3</sup> in digital or hardcopy

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<sup>1</sup>U.S. Department of Agriculture, Agricultural Stabilization and Conservation Service, Aerial Photography Field Office, 2222 West, 2300 South, P.O. Box 30010, Salt Lake City, UT 84130-0010.

<sup>2</sup>U.S. Department of Interior, U.S. Geological Survey, Eros Data Center, User's Service Section, Sioux Falls, SD 57198; information telephone no.: (605) 594-6151; facsimile telephone no.: (901) 668-0310. (MSS Imagery from LandSat 1, 2, 3, and 4).

EOSAT Corp., Customer Services, 4300 Forbes Blvd., Lanham, MD 20706; information telephone no.: (800) 344-9933; facsimile telephone no. (301) 552-0537. (TM Imagery from LandSat 4, 5, and 6).

<sup>3</sup>SPOT Image Corp., 1897 Preston White Drive, Reston, VA 22091-4368; information telephone no.: (703) 620-2200; facsimile telephone no.: (703) 648-1813.

form, color or black-and-white format, and of varying age and resolution. Earlier American MSS (Multi-Spectral Scanner) imagery has an 80-m resolution, has four data bands, is available in color, and is of limited use for evaluation of objects smaller than 80 m in diameter. More recent American TM (Thematic Mapper) satellite imagery has a 30-m resolution, is available in color, has seven data bands and is of greater use in AML work. The principal current foreign source of satellite imagery is from the French SPOT<sup>5</sup> (Système Probatoire d'Observation de la Terre) satellite which has 20-m resolution and is panchromatic (black-and-white). Russian and Japanese satellite imagery will be available in the near future.

Imagery has a variety of applications, depending upon the needs of the user. For initial phases of an inventory, identification of the presence of mines and prospects is most critical. For a "total" pre-field inventory of all mineral related disturbance, stereoscopic aerial photos are most effective for individual site identification and provide the greatest detail. Specific scale choice depends on various factors including: topography, vegetation density, and average and minimum working size. Various Federal agency experience indicates that in some cases an aerial photo scale of 1:24000 is quite satisfactory; in other cases a scale of 1:3000 to 1:6000 is necessary. Although 1:24000 scale photos are usually cost effective, for large areas, cost may be a limiting factor in using the larger scale (1:3000 to 1:6000) photographs.

However, if identification of the smallest disturbances is not critical, satellite imagery may be as or more cost effective for large areas. In certain environments, where disturbed areas display a significant difference in heat reflectance compared to their surroundings, infrared imagery may be useful.

Airborne multi-spectral imagery is most useful in site characterization work, although it can be helpful in inventory work in areas of complex disturbance patterns. Airborne (as well as satellite) multi-spectral imagery can be used to determine moisture content, forest canopy stress, thermal stress, alteration, etc. Forest canopy stress can be a function of soil heavy metal content, thermal stress can be related to mine fires, and alteration may be related to naturally occurring or man-made deposits of metal sulfides.

Videography is an emerging technology with considerable promise. Depending upon the system used, videography will generally be less expensive than airborne multi-spectral imagery, but may be more expensive than existing aerial photography. Results from several Federal agencies' tests indicate the cost effectiveness of the method depends on several factors including: altitude, system resolution, and total area to be videographed. If, for example, a national park is to be videographed, the cost may be approximately equal to aerial photographs, and the digital format would allow more rapid processing. Conversely, if an entire state is to be evaluated, videography costs would be prohibitively expensive. In this latter case, videography is used only in areas of intense mining activity.

Other types of imaging system data are also available, and may be of use in special cases. These include Return Beam Vidicon (RBV) and Side-Looking Airborne Radar (SLAR). RBV images have improved ground resolution qualities which allows for easier identification of land forms. SLAR imagery may also be useful for geologic analysis, mineral detection, and ground water analysis.

## HANDBOOK COMMENTS FORM

We value the comments and suggestions we receive from the users of this handbook. We will make improvements to it based on those comments. Please give us your comments below, fold the Comments Form, and return it to the U.S. Bureau of Mines, Western Field Operations Center, at the address printed on the reverse side. If you wish to FAX the comments to us, the number is 509-353-2661. Thank you.

Name \_\_\_\_\_

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