AN ASSESSMENT OF ECOLOGICAL AND HUMAN HEALTH IMPACTS OF MERCUTY IN THE BAY-DELTA WATERSHED

CALFED Bay Delta Mercury Project

Task 5C1 ASSESSMENT OF THE FEASIBILITY OF REMEDIATION OF MERCURY MINE SOURCES IN THE CACHE CREEK WATERSHED
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APPENDICES

APPENDIX A. MINE HISTORIES FOR THE SULPHUR CREEK MINING DISTRICT

Abbott Mine

Aliases and Associated Names

Abbott Group, Boggess Mine, Boggess Shaft, Turkey Run Mine, Abbot Mine, Black Dike Claim, Destinelle (Disturnelle) Mine, Excelsior Prospect, Wilbur Springs-Abbott Mine

Introduction

The Abbott Mine is located in Lake County along State Highway 20 about 24 miles west of Williams. The mine was located in 1862 with the first reported production occurring in 1870 (Bradley, 1916b). The mine has been operated intermittently from the 1870s to 1971.

History and Production

The following summary is taken primarily from Wiebelt (1949) and USBM (1965).

The mine was discovered in 1862, and first work of production began in 1870 and continued to 1879. The property was idle from 1879 to 1889 and then continued operating to 1906. The next operating period was from February 1916 to March 1917. Only very limited operations were conducted between 1917 and 1940. Operations were resumed in 1941 and continued through 1946 (Wiebelt, 1949). The Bureau of Mines explored the property by diamond drilling in 1948 and the mine again produced from 1948 through 1963. The final year of production was 1971.

Up to 1940 the mine produced approximately 30,880 flasks of mercury and 6,600 flasks from 1941 to 1946, inclusive, making a total production of about 37,480 flasks of mercury *(through 1946)*. In 1944, the Abbott mine was the most important producer in Lake County and ranked third in the United States (Wiebelt, 1949).

Total production over the life of the mine is estimated to be between 50,000 (U.S.B.M., 1965) and 60,000 flasks of mercury.

Geology

The Abbott mine is located within rocks of the early Cretaceous to late Jurassic Great Valley Sequence (GVS). The GVS consists of marine shales, mudstones, sandstones, and occasional conglomerates. Lenses of detrital serpentinite also occur in some areas, including the Abbott mine area.

Moisseeff (1966) describes the structural setting of the Abbott mine as follows:

> "The deposits of the Abbott group are mainly concentrated along the upper contact of a thick "dike" of detrital serpentine (Main dike), orientated southeast-northwest, and located in the southern part of the district. The lower contact of the Main dike varies in dip from 45° to the southwest at the surface to nearly vertical at depth. The dip along the upper contact is 60° to the southwest near the surface and 80° at the 300-foot level. Small dikes of an often-silicified serpentine gouge, which do not exceed 100 feet in thickness, run in the hanging wall parallel to the upper contact of the Main dike."

The ore at the Abbott mine consisted of cinnabar, and rarely metacinnabar, which occurred as fracture fillings in silicified and altered serpentine breccia (sometimes referred to as "tuffoid") and rarely in the shale within a few feet of the silicified serpentine breccia (Wiebelt, 1949). Ore occurred in dikes and sills of the altered serpentinite and also in tabular, pipelike, or podlike ore bodies along contacts, faults, and fault intersections (USBM, 1965).

Mineralogy

The principal ore mineral at the Abbott Mine was cinnabar (HgS). Metacinnabar (HgS) was also reported to occur in minor amounts in the upper levels of the mine (Moisseeff, 1966). Watts (1893b) reported the occurrence of a small amount of sulpho-selenide of mercury [tiemannite (HgSe)]. No native mercury was reported to occur. Other reported sulfide minerals were marcasite and pyrite, which were apparently fairly common. Native sulfur and minor gold (associated with marcasite) were also reported.

The host rock of the Abbott mine ore deposits is a silica-rich variety of silica carbonate rock made up of opal, chalcedony, quartz, magnesite and a few veinlets of calcite (Moisseeff, 1966). The occurrence of a post mining efflorescence of silky epsomite ($MgSO_4 \cdot 7H_2O$) was mentioned in Watts (1893b).

The occurrence of hydrocarbons was apparently fairly common in some parts of the mine. Moisseeff (1966) reports that "A noteworthy feature of the Ansel ore shoot was the presence of considerable amounts of solid and liquid hydrocarbons." and also "The amounts of gaseous hydrocarbons were also large enough to be considered a fire hazard and required strong ventilation."

Mine Workings

Extensive underground workings are present at the Abbott mine and they connect with the underground workings at the Turkey Run Mine. Moisseeff (1966) reports, "The early workings consisted of a series of shallow shafts, tunnels, and "glory holes," all located in the Main dike."

Wiebelt (1949) included a plan view and longitudinal section of the Abbott mine workings based on existing company maps in his report but noted that the map omitted many of the older, caved, and inaccessible workings.

The following, from USBM (1965), describes the workings of the Abbott mine in the early to mid 1960s:

> "Production is entirely from underground operations, as the character of the ore bodies precludes open-pit mining. Operations are from the 200 and 300 levels of the vertical main shaft, and from the Glory Hole, Ventilation, and Turkey Run adits. Mine workings extend for about 3,000 feet laterally and to a maximum depth of about 500 feet. Mineralized areas have been explored extensively by diamond drilling and underground openings."

In the 1890s, the expense of timbering was reduced by backfilling stopes with waste materials (Crawford, 1894 and 1896) but it is not known how long this practice continued.

Processing Facilities

The processing facilities at the Abbott mine have varied over its history and have included a 6-10 ton Knox & Osborne furnace and a 6-10 ton Hughes furnace (1890s), a 48 ton Scott furnace (1913), a 45 ton rotary furnace and 2 "D" retorts (1948), and two 45 ton rotary furnaces and 2 "D" retorts (1965). There is no indication in the literature that the ore was concentrated by mechanical methods before processing. The descriptions of the various processing facilities from the literature are as follows:

Watts, 1893b

> "The furnaces consist of one Knox & Osborne furnace of 6 tons capacity, for coarse ore, and a Hughes furnace, of similar capacity, for the fine ore. The dimensions of the Knox & Osborne furnace are approximately 14 by 20 by 31. The doors of this furnace, one of which is situated at either end, are about 15 feet below the charging floor, and the discharge for the roasted ore being about 15 feet below the firing doors. This furnace consumes only half a cord of wood in twenty-four hours, the heat being maintained to a great extent by the roasting ore. The vapors from this furnace pass into an iron-lined, brick condensing chamber, wherein a large amount of soot accumulates, and thence into six iron and two wooden condensers, cooled by water. Most of the quicksilver is caught in the first three condensers.

In the Hughes furnace the fine ore descends an incline of about 45°. The flame from a fireplace at each end of the furnace passes over the surface of the ore. The roasted ore is discharged from a chute in the side of the furnace between the fire doors. This furnace consumes about one and three quarters cords of wood per day, and it is not considered satisfactory. The vapor passes into an iron-lined dust chamber, where the soot principally collects, and thence into four iron, and two wooden condensers, cooled by water. Most of the quicksilver is collected in the first four condensers.

A Root suction blower, running slowly, draws the vapors of both furnaces from the condensers into a 50-foot wooden flue, the escape pipe of which extends about 60 yards down hill at an angle of about 60°. The soot, some 60 percent of which is finely divided quicksilver, is worked with caustic lime, which causes the tiny globules to collect. The residue is returned to the furnace."

Crawford, 1894

"There is a Knox & Osborne coarse-ore furnace of 10 tons capacity, with 6 small-sized iron condensers, and a blower run by a 20 ft. overshot wheel, which takes water from the mine. The lime used is burnt on the ground."

Crawford, 1896

"The plant consists of a Knox & Osborne 10-ton coarse-ore furnace; 6 small iron water-jacketed condensers; a blower run by a 20 foot overshot wheel; commodius ore-sheds; etc. The fine ore is made into "adobies," and treated as coarse ore."

Bradley, 1916b

"The reduction equipment consists of a 48-ton Scott furnace, with an ore dryer located between the crusher and furnace."

Wiebelt, 1949

"Complete rotary furnace, 45-ton capacity, including jaw crusher and motor, 4X50-ft. rotary kiln with feeder, dust collector, fans. New condensory system, compressor, 2 "D" retorts and all necessary equipment to operate plant."

USBM, 1965

"The reduction plant includes a jaw crusher, two 4- by 50- foot, 45-ton-capacity oil-fired rotary furnaces, cyclone dust collector, fan, two banks of vertical pipe condensers, and wooden flue and exhaust stacks. Soot is treated in a mechanical hoeing machine; the residue is burned in two oil-fired D retorts. Calcines drop to a concrete bin and are hauled by mine car to the waste dump.

Power is provided by diesel electric generators. Production rate is 50 to 60 tons daily.; grade of the ore averages 10 to 15 pounds of mercury per ton."

Springs

The extensive workings of the Abbott mine intersected at least one thermal spring. In the 1890s water from the mine was used to power a blower run by a 20 foot overshot wheel requiring 1 ½ miners inches of water to operate (Crawford, 1894 and 1896). This translates to a minimum flow rate of 2.25 cu ft / min (about 16.8 gpm) out of the mine. White and others (1963) indicated that in the 1950s the average discharge was about 25 gpm and note the following:

"Drainage from the Reardon Tunnel, 200-foot level, pumped from the bottom of the main shaft at 300-ft level. Average discharge is about 25 gpm; temperature of 26°C measured at portal of tunnel; temperature at source probably about 33°C (White, 1955a, p.131). Ore and thermal water accompanied by some combustible gas are controlled by fractures and breccia zones in serpentine and Upper Jurassic Knoxville sandstone and shale."

The Central and Empire Group

Aliases and Associated Names

Central and Empire group, Empire, Central, Dewey, Little Giant, Mercury Queen, Mercury King, Hidden Treasure, the Mercury mine, the Sulphur Creek mine.

Introduction

The Central and Empire mines are located in Colusa County near the Wilbur Springs resort about 24 miles southwest of Williams. The Central mine lies to the north of Sulphur Creek and is made up of the Central, Dewey, and Little Giant locations. The Empire mine lies to the south of Sulphur Creek and is made up of the Empire, Mercury Queen, Mercury King, and Hidden Treasure locations. Over the years there has been some confusion in reports and maps between these two mines and the mines were later consolidated and referred to as the Central and Empire Group or sometimes as the Central mine.

History and Production (1870s, 1890s, 1926, 1942)

The Empire mine was located in the 1870s and the Central mine was located in 1891. In 1873, sixty-three flasks of mercury were produced from the Empire mine (processed at the Buckeye (Wide Awake) mine – Watts, 1893a). Sometime between the 1890s and the early 1900s the Central and Empire group was operated in conjunction with the Abbott mine (Bradley, 1918) and it is possible that ore mined during that time was processed at the Abbott mine facilities. According to USBM (1965) no significant production was made from the Central Group until 1926 when $10,000 worth of mercury (about 107 flasks) was produced. After that the mine was idle until a small production was reported in 1942. No information was found on any operations after 1942. Total production was approximately 170 flasks.

Geology

The Central and Empire group is located within rocks of the early Cretaceous to late Jurassic Great Valley Sequence (GVS). The GVS consists of shales, mudstones, sandstones, and occasional conglomerates. Lenses of detrital serpentinite also occur in some areas, including the area of the Central and Empire group.

Cinnabar occurs erratically in narrow seams and stringers in silicified and brecciated serpentine near a serpentine-shale contact. The mineralized zone was reported to be 25 to 30 feet wide and to extend to a depth of 50 feet (USBM, 1965).

Mineralogy

The only ore mineral reported at the Central and Empire group is cinnabar (HgS). The cinnabar occurred in leached silica carbonate rocks along "white clayey seams" (Moisseeff, 1966). Zeolites were also reported to occur at the Empire mine (Moisseeff, 1966).

Mine Workings

USBM (1965) reported that the mine workings of the Central and Empire group, now caved, include of several hundred feet of drifts and crosscuts. Moisseeff (1966) described the historical workings as follows:

> "A 150-foot tunnel was dug at what is today called the southwestern-most vein of the Central mine. This tunnel remained in "vein matter." On the northeastern-most vein a 40-foot-long tunnel, included in the Mercury mine, was dug at the level of Sulfur Creek; and another tunnel 85 feet long was dug along the same vein "at a higher level" and was described as the Sulfur Creek mine. Both "mines" were in silica carbonate rocks.
>
> The workings of the Empire mine consisted of four short tunnels, "the highest 600 feet above Sulfur Creek." (Actually, the highest tunnel is only 400 feet above Sulfur Creek.) Two tunnels penetrated into "unaltered serpentine," while the other two remained in "altered serpentine" and the ore was found in "loose altered rocks," probably leached silica carbonate rocks."

The 1991 provisional edition of the Wilbur Springs 7.5 minute quadrangle also shows a shaft symbol labeled as the Empire mine.

Processing Facilities

In 1873 enough ore was mined from the Empire mine to obtain sixty-three flasks of quicksilver which was reduced in a small retort belonging to the Buckeye mine *(later called the Wide Awake mine)* (Watts, 1893a). In the 1890s it is likely that the Central and Empire group were operated in conjunction with the Abbott mine and that ore would have been processed at the Abbott facilities (Bradley, 1918). It is possible that production during this time was reported with the Abbott mine production. In 1926, a small rotary furnace was installed on the Central claims but was not successful and all of the ore mined was processed in pipe retorts (Ransome and Kellogg, 1939).

Currently a small retort is located at the Empire mine and the remains of the small rotary furnace and a retort are located at the Central mine.

In the early days of the Central mine, ore was concentrated by sluicing, which may have resulted in the loss of cinnabar to Sulphur Creek.

The Manzanita Mine Group (including the Cherry Hill and West End Mine Sites)

Aliases and Associated Names

Manzanita mine, West End Mine, North Star, Monticello, Oak Tree, Cerise, Cherry Hill Mine, Hughes mill site,

Introduction

The Manzanita mine is located in Colusa County about one mile west of Wilbur Springs and about 27 miles southwest of Williams in the Sulfur Creek mining district. The Manzanita mine has been operated for both gold and mercury over its history. The Cherry Hill gold mine is located southwest of the Manzanita mine and on the south side of Sulphur Creek. The West End gold mine is located on the north side of Sulphur Creek west of the Manzanita mine.

History and Production

The Manzanita property was discovered in 1863 and operated as a gold mine for many years (up to 1891). Cinnabar was recovered as a byproduct. The site produced mercury from 1902 to 1942 and intermittent operations by various companies and lessees yielded over 2,500 flasks of mercury (USBM, 1965). The mine may have been operated in conjunction with the Cherry Hill mine on the south side of Sulphur Creek in the 1920s. No records separating mercury and gold production are available prior to 1900 (Ransome and Kellogg, 1939).

Geology

The Manzanita mine is located within an area of thinly bedded shales, sandstones, and conglomerates of the early Cretaceous to late Jurassic Great Valley Sequence (GVS). In the Manzanita mine area these rocks have been faulted, fractured, and hydrothermally altered. An irregularly trending silicified zone carrying gold and cinnabar crosses the sedimentary rocks of the GVS in the mine area (USBM, 1965).

Mineralogy

Both gold and mercury were mined at the Manzanita mine. Gold occurs as specks and sheets in leached zones, probably liberated by the destruction of iron sulfides (pyrite and marcasite) (Moisseeff, 1966). Pearcy and Petrersen (1990) report the occurrence of natural amalgam (an alloy of gold and mercury) containing up to 15% mercury at the Manzanita mine.

The main ore of mercury at the Manzanita mine is cinnabar (HgS) but metacinnabar (HgS) was also reported to occur. It is reported that cinnabar could be panned from the soil in several places on the higher portion of the mountain (Watts, 1893a). While no native mercury occurs at the Manzanita mine, natural amalgam, as described above, has been reported. In addition, pan amalgamation was used to recover gold and some elemental mercury or amalgam from this process may be present in the tailings.

Other sulfide minerals reported to occur include pyrite, marcasite, and stibnite. Native sulfur was abundant in some parts of the mine. Moisseeff, 1966, reports the occurrence of the zeolite minerals epistilbite and chabazite. Gangue minerals include quartz and calcite. The presence of bitumen is also reported and apparently created a problem in gold recovery during some periods of mine operation.

Mine Workings

The Manzanita mine has been worked by numerous tunnels and shafts, most of which are caved and inaccessible. Much work was also done by glory hole and open cut methods.

Processing Facilities

Processing facilities have varied depending on whether gold, gold and mercury, or mercury were being produced (see below) . Ores of both gold and mercury were typically concentrated by mechanical means prior to metal recovery. Because of this, the amount of tailings from the pan amalgamation (gold) or the retorting process (mercury) may have been significantly less than would be indicated based solely on average grade and tonnage estimates.

Irelan, 1888 (gold)

> "From the mine ore is trammed to a ten-stamp mill, where it is crushed through No. 8 screens. The stamps weigh nine hundred and fifty pounds each and make one hundred drops per minute. The pulp passes over blanket sluices for the purpose of concentration. The concentrates are worked in two combination pans, sodium amalgam and bluestone being used with the charges."

Watts, 1893a (gold and mercury)

> "This mine, which has been worked at intervals for nearly thirty years, was reopened in 1885 by the Manzanita Gold mining company organized in New York. They erected a mill and commenced work on the southern end of the claim. Their plant consists of three 5-foot Huntington mills, seven Victor concentrators, three 5-foot amalgamating pans, two 8-foot settlers, a No. 1 Gates crusher, and a sixty-five horse power engine and boiler….
>
> …As is well known, the Manzanita was first located as a quicksilver mine, and subsequently the gold value so exceeded that of the quicksilver that the mine was worked entirely for the gold. Under the present management an effort is being made to recover both metals. The ore from the part of the mine yielding the quicksilver is worked by the following method: it is first pulverized in the Huntington mill, then sized by a gravity sizer, designed by G.V. Northey, manager of the works, and then concentrated. Two concentrators work the coarse ore, two the medium, and one the slime. The concentrates average a gold value of from $100 to $200 per ton, and assay about 20 percent quicksilver. The concentrates, which are being stored at the time of the writer's visit, will be retorted and the residues amalgamated…"

Bradley, 1916a

> "The total quicksilver production of the mine approximates 2000 flasks, most of which was obtained by means of concentration during the eight years up to 1912…….G.V. Northy, owner and operator during this period, states (Engineering and Mining Journal, V. 96, p. 783) that the mill treated from two to five tons per hour, the concentrates averaging 35% to 40% quicksilver (often as high as 68%), "while the tailings for several months' milling averaged from 5 to 10 cents per ton."

> "The dried concentrates, mixed with 10% to 25% lime, were retorted…..The average value of the ore was $5 per ton, or about 0.5% quicksilver."

Averill, 1943

> "A pilot plant to process mercury ore from near the top of the hill above the old workings of the Manzanita mine was built on the Wide Awake property ½ mile to the south. The concentrate from a Wilfley table (approximately 12.5% mercury) was treated in a 15-foot rotary furnace with an outside diameter of 30" and an inside diameter of 20". Heat was from butane and the capacity was 4 TPD. Ordinary sheet steel was used for the condensing system with a final 4' square and 12' high redwood tank. A little ore was produced from the Wide Awake at a contact between serpentine and a sedimentary series consisting of sandstone and shale."

The Wide Awake Mine Group

Aliases and Associated Names

Wide Awake mine, Wide Awake Consolidated, Buckeye, Buckeye Quicksilver mine, Jefferson

Introduction

The Wide Awake mine is located in Colusa County, about 1 mile southwest of the Wilbur Springs resort and about 26 miles southwest of Williams. The mine was located in the 1870s and was operated intermittently at least into the 1940s.

History and Production

The mine was discovered in the 1870s and was originally known as the Buckeye mine, a name it retained until the 1890s, at which time it was renamed the Wide Awake mine.

The mine was worked extensively for several years in the 1870s with a reported output of approximately 1,800 flasks of mercury. Early production was from comparatively shallow workings along a serpentine-shale contact. Later (still in the 1870s), a 470- to 500-foot vertical shaft with levels at 190, 290, and 390 feet was sunk which cut off a nearby hot spring (Blank Spring). Efforts were made to drain the shaft by driving a drainage tunnel but operations ceased shortly thereafter. Some ore from the Empire mine was probably processed at the Wide Awake (Buckeye) mine during this period.

In the late 1890s and early 1900s, an effort was made to rehabilitate the vertical shaft and extensive surface facilities (24-ton Scott furnace, enclosed hoist house, bunkhouses, etc.) were constructed. A small production was made but operations terminated in 1900 or 1901.

Some work was done in 1932 and 1943, and a moderate production was reported. The production in 1943 may have been in conjunction with mining and processing of ore from the Manzanita mine to the north at a facility that was constructed on the Wide Awake property for that purpose by the operators of the Manzanita mine.

Total production was probably not much greater than 1,800 flasks, most of which was produced in the 1870s.

Geology

The Wide Awake mine is located within rocks of the early Cretaceous to late Jurassic Great Valley Sequence (GVS). The GVS consists of shales, mudstones, sandstones, and occasional conglomerates. Lenses of detrital serpentinite also occur in some areas, including the area of the Wide Awake mine.

According to USBM (1965), cinnabar occurs in opalized and altered serpentine breccia along a serpentine-shale contact. The mineralized zone strikes northwest, dips to the southwest, and is traceable on the surface for about a mile. The minable vein on the 190-foot level was reported to be 5 feet wide, with a zone of lower grade material extending to a width of 16 feet.

Mineralogy

The primary ore mineral at the Wide Awake mine is cinnabar (HgS). Moisseeff (1966) also reports that one sample of almost pure metacinnabar (HgS) was found on a dump at the Wide Awake mine during his study.

Mine Workings

Early production was from tunnels and shallow surface workings. Later, a 470- to 500-foot vertical shaft with levels at 190, 290, and 390 feet was sunk which cut off a hot spring at approximately 250 feet (Moisseeff, 1966). There are also references to a drainage tunnel being driven to de-water the shaft. In the 1940s, some ore was produced at a contact between serpentine and sandstone and shale in conjunction with the processing of ore from the Manzanita mine.

Processing Facilities

Mining and Scientific Press, 1875b

> "…Superintendent Caswell who has worked the mine up with flasks for retorts, to small retorts and then to a Knox & Osborne ten ton furnace, with all necessary improvements…"

Forstner, 1903

> "The mine is equipped with a very fine reduction plant consisting of a 24-ton fine ore furnace, which has however, been scarcely used."

There are numerous references in the early 1900s to the 24-ton Scott fine ore furnace.

Averill, 1943

> "A pilot plant to process mercury ore from near the top of the hill above the old workings of the Manzanita mine was built on the Wide Awake property ½ mile to the south. The concentrate from a Wilfley table (approximately 12.5% mercury) was treated in a 15-foot rotary furnace with an outside diameter of 30" and an inside diameter of 20". Heat was from butane and the capacity was 4 TPD. Ordinary sheet steel was used for the condensing system with a final 4' square and 12' high redwood tank. A little ore was produced from the Wide Awake at a contact between serpentine and a sedimentary series consisting of sandstone and shale."

Springs

Bradley, 1916a

> "Blank's Sulphur Spring. The spring is now *(in 1916)* included in the wide Awake mining property. It is on the south side of Sulphur Creek. When the Wide Awake shaft (down 500 feet), which is a few hundred feet distant, was sunk it cut off this spring. As long as the shaft was kept open the spring was dry. Now that the shaft is filled with water to within 56 feet of the collar, the spring is again flowing, but its temperature is 103°F instead of 108°F as formerly."

Note that Blanks Sulphur Spring has also called Blank Spring or Blanck Spring. In addition, Blank Spring is no longer part of the Wide Awake mine property but is now on Bureau of Land Management property.

The Elgin Mine

Aliases and Associated Names

Elgin, Elgin prospect, New Elgin

Introduction

The Elgin mine is located in Colusa County about 3 miles northwest of Wilbur Springs near the head of Sulphur Creek. The mine was discovered in 1875

History and Production

The Elgin mine was first located in the 1870s. Reportedly, at least 52 flasks of mercury were produced in 1875 (Mining and Scientific Press, 1875a). Some development work and a small production occurred in 1892-1893. Limited production also occurred in 1905 and 1916 (Ransome and Kellogg, 1939). Several unsuccessful attempts to produce sulfur were also made over the years at the Elgin mine.

Geology

The country rocks in the Elgin mine area are hydrothermally altered serpentine and shale. The serpentine body trends northwest-southeast and the ore deposit occurs in a silicified body of serpentine along the upper contact of the serpentine and shale. The ore is concentrated along the intersections of small faults which cut the serpentine body (USBM, 1965; Moisseeff, 1966)

Mineralogy

The only mercury mineral reported from the Elgin mine is cinnabar (HgS). The only other sulfide reported is pyrite which occurred in crystals up to ¼ inch in size (Moisseeff, 1966). Native sulfur was so abundant at the Elgin mine that some attempts were made to operate the mine for sulfur rather than mercury.

The host rock of the mercury ore at the Elgin mine is a leached, silicified serpentine containing opal, aragonite, magnesite, native sulfur, and bituminous material. The zeolite mineral chabazite is also reported by Moisseeff (1966).

Mine Workings

USBM (1965) states, "mine workings included numerous surface cuts and about 500 feet of underground openings, now inaccessible. High rock temperatures, hot water, and gases made underground mining difficult."

Watts (1893a) indicates that, in the early 1890s, there were two tunnels, one at about 400 feet above the creek (180 feet in length) and one about 470 feet above the creek (110 feet in length).

Processing Facilities

Mining and Scientific Press, 1875a

> "On the Colusa County side of the hill is the Elgin mine, which is about four miles from the present Wilbur Springs. The mine is under the management of J.O. Smith. They have one retort of about 800 pounds capacity per 24 hours. Mr. Smith started up the retort on the 20th of August, and has produced 52 tanks of quicksilver."

Forstner, 1903

> "…some quicksilver was however, made in a 10-pipe retort furnace belonging to the property."

Bradley, 1916a

> "The mine is equipped with a retort furnace, and when last operated used a Griffin mill and Colorado bumping tables for concentrating the cinnabar."

Huguenin, 1917

> "Reduction – 1 Fitzgerald furnace (retort) 1 TPD; 1 mill, partially dismantled, crusher and tables…Many of the old dumps are said to go 0.3 to 0.4 percent Hg. Ore worked so far has averaged about 1.8 percent. Concentration tried in 1908-09 but not successful."

Springs

There are numerous springs in the Elgin mine area and the mine intersected at least one of these springs making underground mining difficult due to the presence of hot water and gases.

Bradley, 1916a

> "…From the "lower" tunnel, which is 500 feet above the bottom of the canyon, a stream of hot salino-sulphur water flows over 40,000 gallons per twenty-four hours. Its temperature is 138°F, and the odors of both sulphuretted hydrogen and ammonia are noticeable. It is strongly saline and is said to carry about 2000 grains of mineral matter per gallon. There is a considerable deposit of flour sulphur along the edges of the stream… Higher up near the top of the ridge there is another similar spring, temperature 152°F, which also has a strong flow…"

Watts, 1893a

> "About 300 feet below the upper tunnel, and probably 2,000 feet to the southeast therefrom, there is a gas spring, which the writer was informed had been burning more than twelve months. The outcropping rocks near the spring are sandstone and shale, but the gas seems to come from siliceous vein matter, similar to that observed in the Elgin mine. The gas issued from a hole about 3 feet deep, and burned with a flame about 3 feet in height. Immediately about the gas spring, between croppings of sandstone, is decomposed shale, which emits a fetid odor and inflammable gas when disturbed. "

The Clyde Mine

Aliases and Associated Names

Clyde, Keely Claim

Introduction

The Clyde gold mine is located in Colusa County about 3 miles northwest of Wilbur Springs near the head of Sulphur Creek. The mine was discovered in 1860s or early 1870s. The Keely claim is located about 100 yards southeast of the Clyde mine.

History and Production

The Clyde mine was probably discovered in the 1860s and first worked in 1886 or 1887 and was worked sporadically into the 1890s. In the 1970s, someone set up a trommel type gold recovery system and may have reprocessed older mined materials on site and in the creek. This activity apparently generated the current tailings pile and three small ponds present on the site (Charles Whitcomb - BLM, personal communication, 2003).

The Clyde mine is a gold mine and no reports of mercury production were found.

Geology

The country rocks in the Clyde mine area are serpentinite and a soft slate or shale. Serpentinite is present to the North, East, and South of the mine area and shale occurs to the West. The body trends northwest-southeast and the ore deposit occurs in a silicified body of serpentine along the upper contact of the serpentine and shale. Gold ore was reported to occur in decomposed slate.

Mineralogy

Native gold and pyrite are reported to occur at the Clyde mine.

Mine Workings

Prior to 1892, there are references to at least two shafts and two tunnels at the Clyde mine, and a third shaft on the Keely claim located about 100 yards to the southeast (Watts, 1892). The upper adit was driven sometime in the 1970s or 1980s (Charles Whitcomb - BLM, personal communication, 2003). Currently there are three adits, one at the creek level and two higher up the hill. No shafts are visible, however there is an area of subsidence that could be related to these older workings.

Processing Facilities

In the 1880s, gold ore from the Clyde mine was worked in a 31/2-foot Huntington mill. In the 1890s, a 5-foot Huntington mill was built just below the Clyde mine to process ore from the Keely claim. In the 1970s a trommel type placer gold recovery system was brought in, possibly to reprocess the older mined material on the site. It is likely that the current tailings pile and the three small ponds present on the site are a result of this activity.

The Rathburn Mine Group
(Rathburn, Rathburn-Petray (Middle Pit), Petray South, and Petray North)

Aliases and Associated Names

Rathburn Mine, Rathburn Group, Old Kentucky Claim, Kentucky Mine, Last Resort Claim, May Day Claim, Juniper Claim, Juniper Mine, Juniper Mercury Mine, Laurel Claim, Ukiah, Petray, Petray Prospect, Farris Claim,

Introduction

The Rathburn group is in Colusa county about 4 miles north of Wilbur Springs and originally consisted of the May Day, Last Resort, Old Kentucky, Juniper, and Laurel claims.

History and Production

The Rathburn mine was worked intermittently prior to 1892. Greatest activity was during 1892-1893 when over 100 flasks of mercury was produced. The mine was abandoned in 1915 and was relocated in 1956 (USBM, 1965). Production from the Rathburn group area (including the Rathburn, Rathburn-Petray, (Middle Pit), Petray South, and Petray North mine sites) continued into the late 1960s or early 1970s. Total production was at least 300-400 flasks. Some of the ore from the Rathburn group area may have been processed at the Abbott mine and the production may have been reported as coming from the Abbott mine.

Geology

The Rathburn group occurs in a large body of serpentinite and the ore occurs in silicified fractures in the serpentinite.

Mineralogy

The only mercury mineral occurring at the Rathburn group is cinnabar (HgS), which occurs in silicified fractures in serpentine.

Mine Workings

The mine was worked in the early days by numerous shafts and tunnels that are now caved. In the 1950s and 1960s some trenching was done on the property. Between the 1950s and the early 1970s open pit and surface mining operations occurred at the Rathburn, Rathburn-Petray (Middle Pit), Petray South, and Petray North sites.

Processing Facilities

In the early days of operation, ore was processed in small retorts. A furnace was constructed and an attempt was made to process the ore on a large scale but was not successful (Watts, 1893a).

It is not known what on-site processing facilities were used in the 1960s. Field examination has identified one site near the Rathburn with bricks and other debris that may indicate the location of one of the small retorts mentioned by Watts. A June 1973 State Water Resources Control Board document titled Mercury in California contains an entry in Table 13, p. 57, indicating ore from the Petray mine was treated by Rotary Furnace at the Abbott mine during 1971. This table also indicated that the mine open pit was only active during June and July of that year and that the mine status in July 1972 was "closed." The table lists this mine as "production class 3" which equals 10 to 100 flasks. It is unclear if this means total mine production or only production for 1971.

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APPENDIX B. THERMAL SPRINGS IN THE SULPHUR CREEK MINING DISTRICT (Flow Rates, Temperature, pH and Selected Chemical Analyses of Thermal Spring Waters; Data compiled from Goff and others, 2001; Rytuba, 2000; and Thompson, 1993)

Spring	Flow L/min	Temp deg C	pH	Cl mg/L	HCO_3 mg/L	SO_4 mg/L	B mg/L	Reference
Blank	12-14	43-44	7.5	8510-8765	5850-5970	292-333	191-196	Goff and others, 2001
Blank		44	7-7.9	8200-9360	6100-7090	10-27	173-257	Thompson, 1993
Elbow	0.5	70-74	8-8.5	12530-13390	6160-7465	56-455	315-355	Goff and others, 2001
Elbow		59-62	8-8.1	12800 182	8600, 370	10-7382	294	Thompson, 1993;
Jones	0-20	55-58	8-8.2	10920-11860	3265-8250	152-220	265-328	Goff and others, 2001
Jones		56-62	7.7-8.5	10720-11430	7200-8250	10-336	269-340	Thompson, 1993;
Wilbur Main Spring	20	54-57	7.0-7.8	8810-11100	6030-7375	72-187	228-295	Goff and others, 2001
Wilbur Main Spring	80	52-58	7.1-8.4	9930-11150	6690-7375	10-157	259-312	Thompson, 1993;
Wilbur Spring—Don White's	5	54-58	7.2-8	9720-11080	4690-6135	141-420	255-285	Goff and others, 2001
Elgin	20-26	67-70	7.7-8.3	10770-11390	6265-6540	104-221	196-223	Goff and others, 2001
Elgin—Orange Tub Spring	42	63	8.2	11480	5960	262	223	Goff and others, 2001
Elgin	100+	67	7.4-8.2	11000-11300	7200-8270	10-90	216-220	Thompson, 1993
Elgin			8.1			90		Rytuba, 2000
Turkey Run Mine		22	7.6	1150	2300	2390	35	Thompson, 1993
Turkey Run Mine	50-57	28-29	6.5 (F); 7.3-7.7 (L)	1020-1145	1715-2330	1930-5310	33-40	Goff and others, 2001 (F)=Field, (L)=Lab
Turkey Run Mine			6.6			1760-2020		Rytuba, 2000

Compared to composition of sea water, as reported by Hem (1985), the thermal springs along Sulphur Creek are about half the salinity, are depleted in Mg, Ca, and SO_4, and are enriched in HCO_3, Li, I, and SiO_2 (Thompson, 1993). The Sulphur Creek thermal spring waters are also unusually high in dissolved H_2S, NH_3, and B (Thompson, 1993). The most likely source for these elevated components are the Great Valley sequence marine sediments (Thompson, 1993). From the above table it can be seen that the thermal springs along Sulphur Creek and at Elgin differ in chemistry from thermal water at the Turkey Run mine, which issues from a collapsed mine adit. The increase in SO_4 and decrease in most other components in Turkey Run thermal water may relate to complex mixing between deep connate water and shallow ground waters that dissolve sulfates from alteration minerals in the extensive underground mine workings interconnecting the Abbott and Turkey Run mines (Goff and Janik, 1993, pp. 242). The SO_4 content of Turkey Run thermal water is one to two orders of magnitude higher than all other thermal spring waters in the Clear Lake region (Goff and Janik, 1993).

APPENDIX C. LIST OF DATA, ASSUMPTIONS AND TONNAGE ESTIMATES FOR MINE SITE MATERIAL PILES

Mine Site	Feature	Cu. Yds.	Density (tons/cu.yd.)	Tons	Hg (ppm)	Hg Content (kg)	Notes
Abbott	Lg. Calcine Pile	165,000	1.35	220,000	60 (20-220)	12,000	Large calcined tailings pile, toe is eroding to Harley Gulch tributary
	Area SE of brick furnace	6,700	1.35	9,000	60 (10-270)	500	Area of calcined tailings, eroding to Harley Gulch tributary
	Flat west of lg. Calcine pile	1,000	1.35	1,400	30	38	Area of calcined tailings pad, eroding to Harley Gulch tributary
	Sm. Pile #1	19	1.35	26	50	1	
	Sm. Pile #2	53	1.35	72	60	9	
	Roads (Abbott and Turkey Run)	<14,000	1.35	<19,000	30 (20-40)	<500	Assume 1-foot thick calcine tails on roads (not all roads "paved")
Abbott Total		**≤187,000**		**≤ 250,000**		**≤ 13,000**	
Turkey Run	Ore Bin Pile	3,200	1.35	4,300	1,380	5,000	Tonnage and mercury content may be less if ore is a veneer on waste rock, pile eroding to Turkey Run Creek (thermal water)
	Road Pile	1,000	1.35	1,400	160	200	Waste rock eroding to Turkey Run Creek (thermal water)
	Pad/Road area-lower site	8700	1.35	11,700	10 (2-20)	107	[Assume 0.9 ac and 6 feet deep]
	Sm. Pile #1	19	1.35	27	1,720	93	Small yellow colored pile
	Sm. Pile #2	4	1.35	5	290	1	Small reddish colored pile
	Sm. Pile #3	7	1.35	9	80	1	Thin gray colored slope covering
	Sm. Pile #4	3	1.35	4	870	3	Small pile of crushed material
Turkey Run Total		**12,900**		**17,400**		**5,400**	
Combined Abbott-Turkey Run		**200,000**		**≤ 265,500**		**≤ 18,400**	

Mine Site	Feature	Cu. Yds.	Density (tons/cu.yd.)	Tons	Hg (ppm)	Hg Content (kg)	Notes
Wide Awake	Mixed Calcine/Waste Pile	8,000	1.35	11,000	40 (10-60)	400	Estimated pile volume is very approximate
	Small Pile	7	1.35	9	5	0.04	Small pink-gray pile at WA-6
Wide Awake Total		**8,000**		**11,000**		**400**	Excluding grassy area pile
West End	Waste Pile	**3,600**	1.35	**5,000**	300	**1,400**	Waste rock pile along Sulphur Creek
Cherry Hill	Small Pile	13	1.35	18	220	4	
	Small Pile	18	1.35	24	47	1	
	Waste Pile along Creek	**578**	1.35	**780**	280	**198**	Relatively small thistle covered waste pile of uncertain origin along bank of Sulphur Creek
Cherry Hill Total		**609**		**822**		**203**	
Empire	Large Waste Pile	5,600 (3,800-7,200)	1.35	8,000	100 (56-150)	700	Grass and thistle covered waste rock
	Small Waste Pile	73 (50-100)	1.35	100	100	9	
Empire Total		**5,700**		**8,100**		**700**	
Manzanita							No significant piles. Site contains bare cuts, benches and slope rubble. Mine waste is incorporated into stream bank sediments along Sulphur Creek
Central	Calcine Pile	**78**	1.35	**110**	30	**3**	Small calcined tailings pile (upper mine area waste rock not measured, to be addressed in Task 5C2)
Elgin	Slope Waste	900-4,000	1.35	1,200-5,400	290	320 –1,400	Volume highly uncertain
	Small Pile	76	1.35	100	20	2	

Mine Site	Feature	Cu. Yds.	Density (tons/cu.yd.)	Tons	Hg (ppm)	Hg Content (kg)	Notes
Elgin Total		**1000-4100**		**1,300-5,500**		**320-1,400**	High uncertainty
Clyde	Tailings Pile	15,500	1.35	21,000	6.7	130	Tailings pile eroding to creek, not calcined tailings
Clyde	Trench 1 Pile	600	1.35	800	5	4	
	Trench 2 Pile	450	1.35	600	5	3	Used Hg analysis from trench 1
	Trench 3 Pile	400	1.35	500	5	2	Used Hg analysis from trench 1
Clyde Total		**17,000**		**2,300**		**140**	
Rathburn	Waste Piles	**Approx. 6,500**	1.35	**9,000**	42.7	**770**	0.4 ac—need to confirm with additional information, very approximate
Rathburn-Central Pit	Eastern Waste Pile	80,000	1.35	100,000	125	11,300	3.3 acres area from air photo—need to confirm with additional information--very approximate
	Pit Berm Pile	**Approx.** 15,000	1.35	20,000	910-too high?	16,500 too high?	0.8 ac area from air photo; Hg result possibly high/not representative of the berm pile?
Rathburn-Central Pit total		**95,000**		**120,000**		**28,570**	Amounts are lower limits, numerous small waste dumps to the west are not included
Petray South	Small Pile 1	70	1.35	100	270 est. = pile 2 value	24	Estimate very approximate
	Small Pile 2	300	1.35	400	270	98	Estimate very approximate
	Small Pile 3	17	1.35	23	170	8	Estimate very approximate
Petray South	Small Pile at crusher site	7	1.35	9	1,070	9	Estimate very approximate
	Crusher site dump	7,000	1.35	9,000	26.6	220	Estimate very approximate.
Petray South total		**7,400**		**9,500**		**360**	Estimate very approximate -- may not have identified all small piles; limited volume and mercury analysis data
Petray North	Waste rock into ravine	**1,400-4,300**	1.35	**1,900-5,800**	280	**480-1,500**	0.3 ac 13,000 sq.ft.—should confirm during Task 5C2; vol assuming 3-9 feet thick

Mine Site	Feature	Cu. Yds.	Density (tons/cu.yd.)	Tons	Hg (ppm)	Hg Content (kg)	Notes
Total All Rathburn and Petray areas		**213,000**		**287,000**		**29,410-30,400**	
Total All Mine Sites		**449,000-458,000**		**581,000-593,000**		**51,000-53,000**	These totals represent material in discrete piles only.

APPENDIX D. ESTIMATES OF AREAS DISTURBED BY MINING

Mine Site	Area	Notes
Abbott-Turkey Run	67 acres	Represents total of the higher elevation areas at both the Turkey Run and the Abbott
Wilbur Springs Mines including the Wide Awake	120 acres	This is the area of enriched mercury bedrock from Pearcy (1989) and represents a maximum estimate of the area disturbed by mining activities.
Elgin	5 acres	This area represents the whole upper mine area
Clyde	15 acres	Includes the areas with prospecting trenches
Rathburn-Petray (all areas)	93 acres	Represents both north and south areas of mining disturbance
Total	300 acres	

APPENDIX E. SAMPLING PROCEEDURE AND ANALYTICAL METHODS FOR TOTAL MERCURY

Sampling

Sampling of material for total mercury analyses was done as follows. The sample collector, wearing gloves, used a disposable plastic spoon to collect approximately 200 to 400 grams of sample. The sample was placed in a precleaned (to US EPA specifications for contaminant-free sample containers, < 0.2 ug/l Hg) glass screw top 9 oz. jar with a Teflon-lined lid. The jar and lid were labeled with the sample number in permanent ink and an adhesive label with additional information was attached to the jar. The jar was then placed inside a clean plastic bag, the bag closed with a twist tie and the bag labeled with permanent ink. Gloves and spoons were utilized to collect single samples and discarded, except that field-duplicate samples were collected with the same gloves and spoon as the original sample. After sample collection, the sample number and related site location and sample characteristics information were then recorded in a field notebook and one or more photographs were taken of the sample location.

Typically the uppermost inch of soil or mine site material was removed prior to sample collection to obtain a more representative sample. Spoonfuls of material were then collected from over a several square foot area and up to several inches deep. Sample material mostly contained particle sizes in the sand to clay size ranges but some material up to ¼ inch was usually present. Fragments larger than ¼ inch were generally avoided to minimize sample heterogeneity problems and so that the sample would be more representative of material size fractions more readily subject to offsite transport. At sample locations covered with vegetation, typically grass, forbs or moss, the vegetation was scraped away from the sample location with a rock hammer prior to sample collection. An attempt to minimize plant matter in the sample was made during sample collection. At locations where material was too coherent to be collected with a plastic spoon, the pick-end of a rock hammer was used to loosen the material for sampling. The hammer was always run through material immediately adjacent to the sample location before the sample was collected.

ANALYTICAL METHODS

Sample preparation and analysis for total mercury was done by ALS Chemex Labs, Inc. in Vancouver, BC. Sample preparation consisted of drying samples below 100 deg F, if needed, followed by pulverization in a zirconia mill. Clean quartz sand was run between every sample during pulverization to minimize carryover. A zirconia mill was used for pulverization to minimize metallic element contamination of the samples to allow their use for whole rock major and trace element analyses in the future, if needed.

Because of the wide range of mercury contents of sampled materials, from 10s of ppb to thousands of ppm, two Chemex mercury analytical methods were utilized, Chemex Method 20 “Geochemical Mercury” and Chemex Method 344 “Mercury Assay”

Method 344 Assay Procedure for Mercury—Acid Chlorate Digestion/Atomic Absorption Spectroscopy—detection limit 0.001%, upper limit 100% [10 ppm to 1,000,000 ppm].

A prepared sample (0.2 to 1.0 g) is digested with concentrated nitric acid and potassium chlorate in a 55 deg C water bath. Hydrochloric acid is added for further digestion. The sample is transferred to a volumetric flask (250 ml), topped to volume, and mixed. A portion of the sample is treated with stannous chloride to reduce the mercury. The resulting mercury is volatized by argon-purging and measured by atomic absorption spectrometry.

Method 20 Geochemical Procedure for Mercury— Nitric Aqua Regia Digestion/Atomic Absorption Spectroscopy—detection limit 10 ppb, upper limit 100,000 ppb [0.01 ppm to 100 ppm].

A prepared sample (1.00 gram) is digested with concentrated nitric acid for at least one hour. After cooling, hydrochloric acid is added to produce aqua regia and the mixture is then digested for an additional hour and a half. The resulting solution is diluted to 25 ml with demineralized water and mixed. A portion of the sample is treated with stannous chloride to reduce the mercury. The resulting mercury is volatized by argon-purging and measured by atomic absorption spectrometry**.**

APPENDIX F. QUALITY ASSURANCE AND CONTROL FOR TOTAL MERCURY

Introduction

Quality assurance and control for mine-site mercury analyses consisted of collection and submission of field-duplicate samples, blank and standard samples along with project field samples. About 20 percent of all total-mercury analyses were for quality assurance and control purposes. Additionally, ALS Chemex ran certified standards for mercury with each batch of samples submitted. Finally, five samples were submitted to U.C. Davis for mercury analyses for inter-laboratory comparison.

Quality Assurance and Control Results for Total Mercury

Twelve pairs of field-duplicate samples were submitted for mercury analysis during this project (Table E1). Variability of the analytical results for field duplicate samples typically ranged between 0 and 20% for samples by both the mercury assay (> or = 10 ppm) and geochemical mercury methods (0.01 to 100 ppm). Apparent variabilities of 25 or 50 percent were obtained for duplicate assay analyses in the low 10s of ppm levels. However, these variabilities are exaggerated because data reporting for the mercury assay method is only to the nearest 10 ppm (0.001%).

Reruns of some low and intermediate mercury samples were made as a check on sample variability. The results are listed in Tables E2 and E3. Percent differences between repeat analyses at the 0.1 ppm level were 20 percent or less with one exception. Percent differences at the 40 ppm level were less than 11 percent.

Ten blank samples were submitted for mercury project. The blank material consisted of crushed quartz washed in distilled water. Previous mercury analyses of this material by ALS Chemex were below the geochemical mercury method detection limit of 0.01ppm. Analysis of the blank samples indicates mercury carryover between samples ranged from less than 0.01 percent to 2.5 percent and averaged about 0.5 percent (Table E4). The blanks ranged in mercury content from below the detection limit (<0.01 ppm) to 1.79 ppm. The maximum observed carryover, 1.79 ppm, was for a blank following a 14,270 ppm ore sample. These results indicate that typical carryover between mine-site material samples is about 0.1 ppm Hg. This carryover amount is inconsequential, as the mercury content of most mine-site material samples is 2-3 orders of magnitude above this amount. However, this amount of mercury carryover is the same order of magnitude as regional background mercury levels, so regional background samples were submitted for analysis separately from mine site samples.

To check the accuracy of analyses for total mercury, eight USGS Geochemical Exploration Standards were submitted blind with project samples. ALS Chemex ran in-house and certified standards with each batch of project samples submitted. ALS Chemex used two CANMET Certified Standards, PD-1 (run eight times), and SO-2 (run one time). In combination, the USGS and CANMET standards represent a range of total mercury contents between 0.068 and 389 ppm. The ALS Chemex analyses and the USGS and CANMET data for these standards are provided in Tables E5 and E6. The ALS Chemex analyses are generally in good agreement with the mercury contents reported for these standards, but results for GXR-6 exceed the reported mercury mean for this standard by about 0.05 ppm. USGS GXR-2 and CANMET PD-1 were run sufficient times for statistical comparisons between the Chemex results and their reported mercury contents. No statistically significant difference was found between the Chemex data and the reported mercury data for these standards (by difference of means t-test at 95 percent confidence).

Five samples were run at both ALS Chemex and U.C. Davis as an inter-laboratory comparison. Results for this comparison are provided in Table E7. The three USGS Geochemical Exploration standards generally compare well between the two labs. Samples X-4 and X-5 are project samples and mercury analyses by the two labs are similar in magnitude. Because these relatively high mercury samples are not standards sample inhomogeneity may explain differences between results from the two labs. However, Chemex uses a

different procedure than UC Davis on samples exceeding 100 ppm mercury. The higher mercury results from Chemex and the lower from UC Davis suggest that the Chemex procedure may be more efficient at dissolving mercury sulfide minerals in high mercury samples (see Table F7 footnote).

Table-F1 (Comparison of Samples and Field Duplicates)

Samples	Analysis (ppm)	Difference (ppm)**	Percent Difference*	Comments
A-10, A-11	40, 40	<10	<25	Calcined Tailings
A-19, A-20	20, 30	10	50	Calcined Tailings
Tr-1, Tr-1A	390, 350	40	10.3	Local Background Soil
Tr-2, Tr-2A	0.14, 0.12	0.02	14.3	Local Background Soil
Tr-5, Tr-6	290, 290	<10	<3.4	Small Pile
Tr-10, Tr-11	1370, 1390	20	1.4	Ore
WA-7, WA-8	10, 20	10	50	Calcined Tailings
MAN-10, MAN-11	130, 130	<10	<7.7	Local Background Soil
CEN-2, CEN-3	30, 30	<10	<33	Calcined Tailings
R-3, R-4	43.20, 41.7	1.50	3.5	Local Background Soil
R-3 rerun, R-4 rerun	43.74, 38.64	5.10	11.7	
P-10, P-11	110, 130	20	15.4	Waste Rock
BG-10, BG-11	0.12, 0.11	0.01	8.3	Regional Background Soil

* [(High-Low)/(High)] X 100

**Results for samples analyzed by ALS Chemex mercury assay method are only reported to the nearest 10 ppm. Results for samples analyzed by ALS Chemex geochemical mercury method are reported to the nearest 0.01 ppm.

Table F2 (Geochemical Method Reruns of Regional Background Samples—reproducibility at lowest detectable mercury levels)

Sample	Analysis 1 (ppm)	Analysis 2 (ppm)	Difference (ppm)	Percent Difference*
BG-06	0.10	0.12	0.02	20
BG-07	0.19	0.12	0.07	58
BG-08	0.13	0.12	0.01	8
BG-09	0.23	0.21	0.02	10
BG-10	0.12	0.12	0.00	<8
BG-11	0.12	0.11	0.01	9
BG-12 (USGS GXR-6)	0.11	0.12	0.01	9
BG-13 (Blank)	<0.01	0.01	<0.01	--

* [(High-Low)/(High)] X 100

Table F3 (Reproducibility at Intermediate Mercury Levels)**

Sample	Analysis 1 (ppm)	Analysis 2 (ppm)	Difference (ppm)	Percent Difference*
R-2	42.30	43.74	1.44	3.4
R-3	42.30	46.74	4.44	10.5
R-4	41.70	38.64	3.06	7.9

*Percent difference equals [(high-low)/(high)] X 100
**Using ALS Chemex Geochemical Mercury Method

Table F4 Total Mercury Analytical Results for Sample Blanks (clean crushed quartz)

Sample	Hg Analysis (ppm) = Carryover	Previous sample (ppm)	% Carryover from previous sample
TR-15	0.11, 0.11	10	1.1
WR-17	0.13	1040	0.125
CH-7	0.02	0.79	2.5
MAN-13	<0.01	260	None detected
CEN-5	0.03, 0.06	4.15	1.4
EL-10	0.33, 0.22	3030	0.01
R-6	0.27, 0.06	990	0.01
R-30	<10 by assay; 0.07 by geochemical	50	0.14
P-12	1.79	14,270	0.01
BG-13	<0.01, 0.01	0.11	None detected

Table F5 Total Mercury Analytical Results for USGS Geochemical Exploration Standards

Standard	Hg (ppm)	Mean (ppm)	SD (ppm)	USGS Mean Hg (ppm)	USGS SD (ppm)	% Difference Between Means*	Comments
GXR-2	2.41 2.94 3.03 3.38 3.67	3.09	0.48	2.90	0.7	6	Analysis by ALS CHEMEX Geochemical Mercury Method
GXR-3	0.17 0.30 0.33 0.33	0.28	0.08	0.33	0.04	15	
GXR-5	0.16			0.158	0.017		
GXR-6	0.10 0.10 0.10 0.11 0.12	0.11	0.01	0.068	0.014	36**	

*(High-Low)/High X 100
** UCD Mean +/- SD = 0.12+/-0.01 ppm for five GXR-6 analyses

Table F6 Total Mercury Analyses for CANMET Certified Standards PD-1 and SO-2 by ALS Chemex for QA/QC

Standard	Total Hg (ppm)	Mean (ppm)	SD (ppm)	CANMET Mean (ppm)	CANMET SD (ppm)	Comments
PD-1	410, 420, 420, 400, 380, 400, 360, 340	391	29	389	18	Analysis by CHEMEX Mercury Assay Method
SO-2	0.06			0.082	0.009	Analysis by Geochemical Mercury Method

Table F7 Inter-laboratory Comparison of Five Samples UC Davis and ALS Chemex

Sample No.	Sample	ALS Chemex (ppm)	ALS Chemex Mean +/- SD (ppm)	UCD (ppm)	UCD Mean +/- SD (ppm)	% difference of mean Hg contents*
X-1	USGS GXR-6	0.10 0.10 0.10 0.11 0.12	0.11+/-0.01	0.11 0.12 0.12 0.12 0.13	0.12+/-0.01	4
X-2	USGS GXR-3	0.17 0.30 0.33 0.33	0.28+/-0.08	0.38 0.38 0.39 0.39 0.39	0.39+/-0.01	23
X-3	USGS GXR-2	2.41 2.94 3.03 3.38 3.67	3.09+/-0.48	3.24 3.30 3.26 3.32 3.22	3.27+/-0.04	5
X-4	MAN-10/11 Mine site soil	150 150 160 160 190	160+/-20	71.6 101.4 82.0 98.0 69.8	84.6+/-14.6	47
X-5	TR-10 Ore fines -149 um	3720 3850 3910 3920 4090	3900+/-130	1298 1786 1874 1969 1973	1780+/-280	54

*(High-Low)/High X 100

Comment: Samples below 100-ppm total mercury were run at ALS Chemex using their Geochemical Mercury procedure: Nitric acid-Aqua Regia Digestion; Mercury Reduction with Stannous Chloride;

Mercury Volitization by Argon Purge and Atomic Absorption Spectrometry. Samples above 100-ppm total mercury were run at ALS Chemex using their Mercury Assay procedure: Concentrated Nitric Acid-Potassium Chlorate Digestion+Hydrochloric Acid; Mercury Reduction with Stannous Chloride; Mercury Volitization by Argon Purge and Atomic Absorption Spectrometry. A possible explanation for the difference between ALS Chemex and UCD analytical results on the high mercury samples is that the UCD procedure is not dissolving all of the mercury sulfide minerals in these samples.

APPENDIX G. GPS LOCATION DATA FOR SAMPLES

Sample #	Latitude	Longitude	Sample #	Latitude	Longitude
A-01	39.01836	122.4435	CEN-19D	39.0387	122.43
A-02	39.01848	122.44324	CEN-19F	39.0376	122.4281
A-03	39.01889	122.44355	CEN-20C	39.03659	122.42769
A-04	39.01917	122.44366	CH-01	39.03343	122.43175
A-05	39.01978	122.44438	CH-02	39.03318	122.43113
A-06	39.01976	122.44431	CH-03	39.03327	122.4309
A-07	39.01917	122.44415	CH-04	39.03349	122.43061
A-08	39.01994	122.44509	CH-05	39.03366	122.43045
A-09	39.01957	122.44478	CH-06	39.034	122.43081
A-10	39.01941	122.44466	CH-22A	39.03307	122.43101
A-11	39.01941	122.44466	EL-01	39.05857	122.47363
A-12	39.01922	122.44479	EL-02	39.05778	122.47221
A-13	39.01922	122.44479	EL-03	39.05778	122.47221
A-14	39.01908	122.44476	EL-04	39.05889	122.47473
A-15	39.01908	122.44476	EL-05	39.05893	122.47465
A-16	39.01863	122.44369	EL-06	39.05972	122.47237
A-17	39.01869	122.44396	EL-07	39.05808	122.46884
A-18	39.01876	122.44425	EL-08	39.05807	122.46843
A-19	39.01887	122.44455	EL-09	39.05808	122.46843
A-20	39.01887	122.44455	EL-17A	39.05826	122.47163
A-21	39.02075	122.44199	EMP-01	39.03395	122.42556
A-22	39.02051	122.44201	EMP-02	39.03395	122.42556
A-23	39.02069	122.44372	EMP-03	39.03395	122.42556
A-24	39.02098	122.44677	MAN-01	39.03393	122.42907
A-25	39.02088	122.4466	MAN-02	39.03402	122.42906
A-26	39.02067	122.44653	MAN-03	39.03387	122.4287
A-27	39.02075	122.44626	MAN-04	39.03377	122.42859
A-28	39.02147	122.44624	MAN-05	39.03355	122.4288
A-29	39.02049	122.44607	MAN-06	39.03355	122.4288
BC-1	39.01569	122.43941	MAN-07	39.03381	122.42848
BG-01	39.08651	122.48261	MAN-08	39.03466	122.42842
BG-02	39.08373	122.48105	MAN-09	39.03415	122.42814
BG-03	39.07907	122.47871	MAN-10	39.03478	122.42738
BG-04	39.06769	122.48053	MAN-11	39.03478	122.42738
BG-05	NA	NA	MAN-12	39.03451	122.42738
BG-06	39.04469	122.46497	MAN-22B	39.03424	122.42684
BG-07	39.02828	122.4518	P-01	39.08632	122.45026
BG-08	39.00912	122.41355	P-02	39.08574	122.45034
BG-09	39.01174	122.40906	P-03	39.08528	122.45043
BG-10	39.04247	122.40795	P-04	39.08634	122.45299
BG-11	39.04247	122.40795	P-05	39.08642	122.45289
C-01	39.0712	122.47841	P-06	39.08913	122.45136
C-02	39.07178	122.47778	P-07	39.08878	122.45128
C-17A	39.07109	122.4777	P-08	39.08879	122.4514
CEN-01	39.03652	122.42742	P-09	39.08884	122.45015
CEN-02	39.03663	122.42767	P-10	39.08621	122.45013
CEN-03	39.03663	122.42767	R-01	39.07635	122.44723
CEN-04	39.03789	122.4284	R-02	39.07664	122.44727
CEN-19A	39.0379	122.4311	R-03	39.0815	122.44826

Sample #	Latitude	Longitude	Sample #	Latitude	Longitude
R-04	39.0815	122.44826	WA-01	39.02873	122.42315
R-05	39.08306	122.44744	WA-02	39.02882	122.42691
R-07	39.08332	122.44665	WA-03	39.02976	122.42895
R-08	39.08307	122.44645	WA-04	39.02958	122.42895
R-09	39.08307	122.44645	WA-05	39.0303	122.42916
R-10	39.0832	122.44445	WA-06	39.03012	122.42928
R-11	39.08633	122.44473	WA-07	39.02965	122.4291
R-20B	39.0763	122.44758	WA-08	39.02965	122.4291
TR-01	39.01765	122.4365	WA-09	39.02951	122.42908
TR-02	39.01991	122.4364	WA-10	39.02933	122.42918
TR-03	39.01626	122.44027	WA-11	39.029	122.42903
TR-04	39.0175	122.43987	WA-12	39.02894	122.42819
TR-05	39.01738	122.43976	WA-13	39.02856	122.42845
TR-06	39.01738	122.43976	WA-14	39.02844	122.42762
TR-07	39.01745	122.43939	WA-15	39.02852	122.42733
TR-08	39.01726	122.43935	WA-18C	39.02793	122.42772
TR-09	39.01675	122.43922	WA-18E	39.02856	122.42893
TR-10	39.01702	122.43879	WA-19G	39.02901	122.42883
TR-11	39.01702	122.43879	WE-01	39.03478	122.43397
TR-12	39.01742	122.43847	WE-02	39.03489	122.43412
TR-13	39.01742	122.43847	WE-03	39.03529	122.43191
TR-14	39.01742	122.43847			

APPENDIX H. MINE SITE FEATURES AND SAMPLE LOCATIONS

Figure H1 Abbott-Turkey Run Mine Site Features

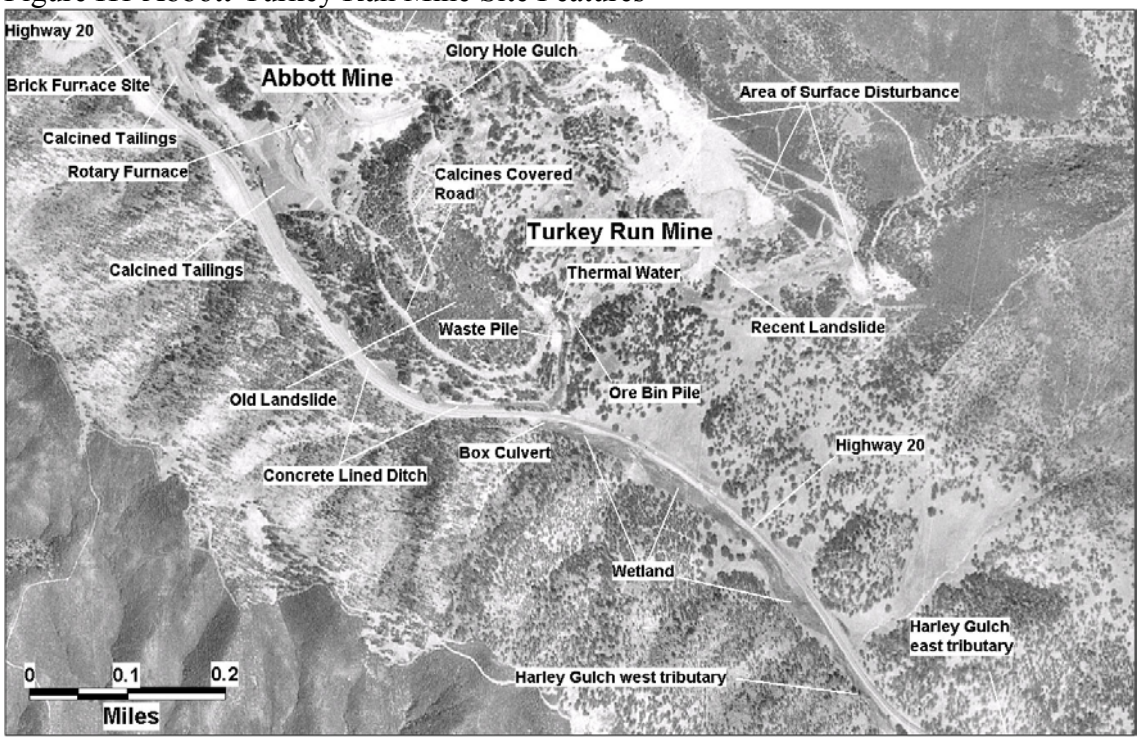
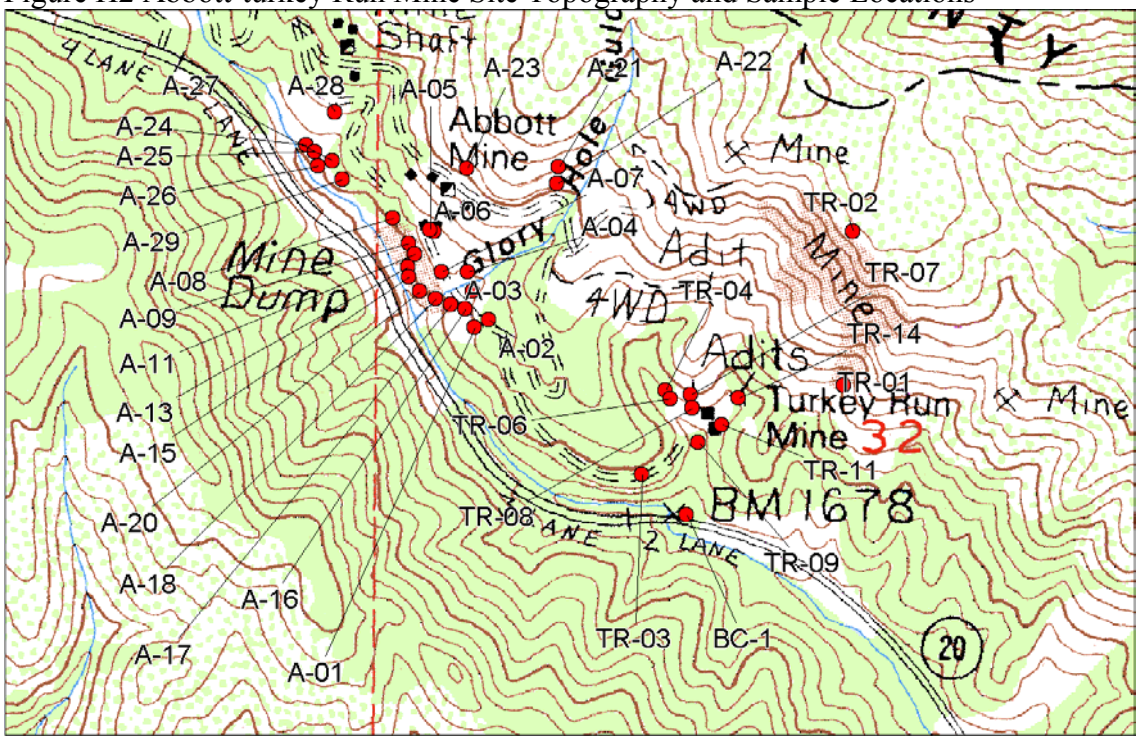


Figure H2 Abbott-turkey Run Mine Site Topography and Sample Locations



Contour Interval 40 Feet

Figure H3 Wilbur Springs Area Mine Sites and Features

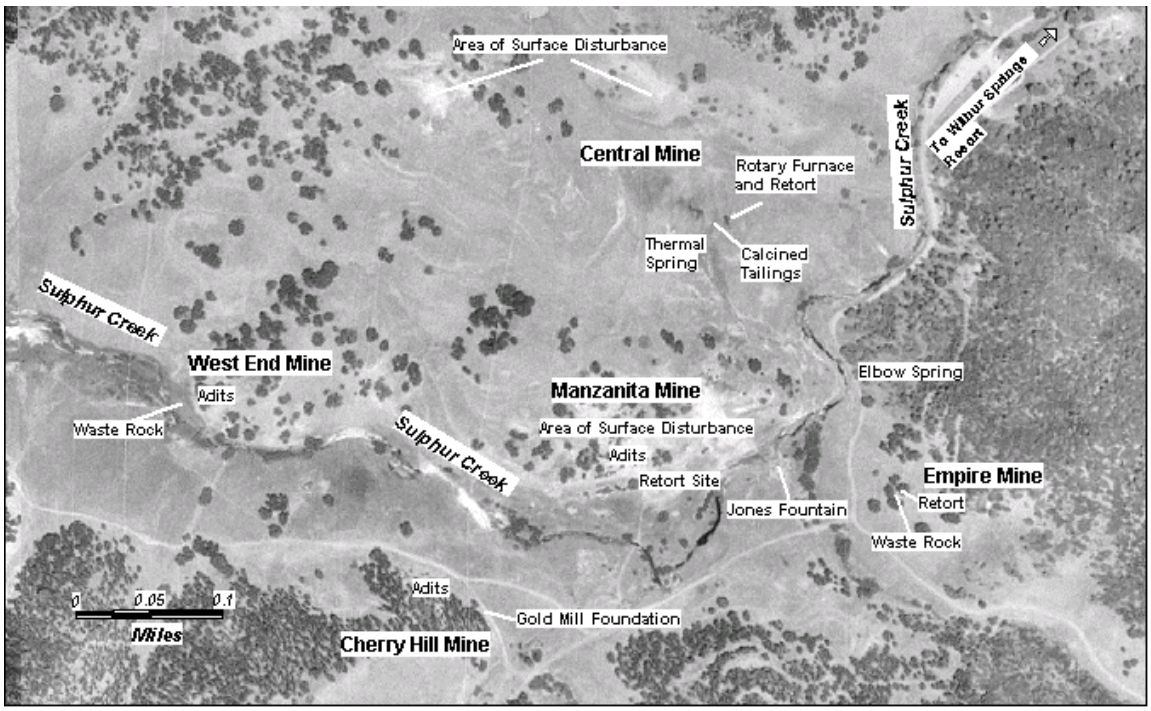
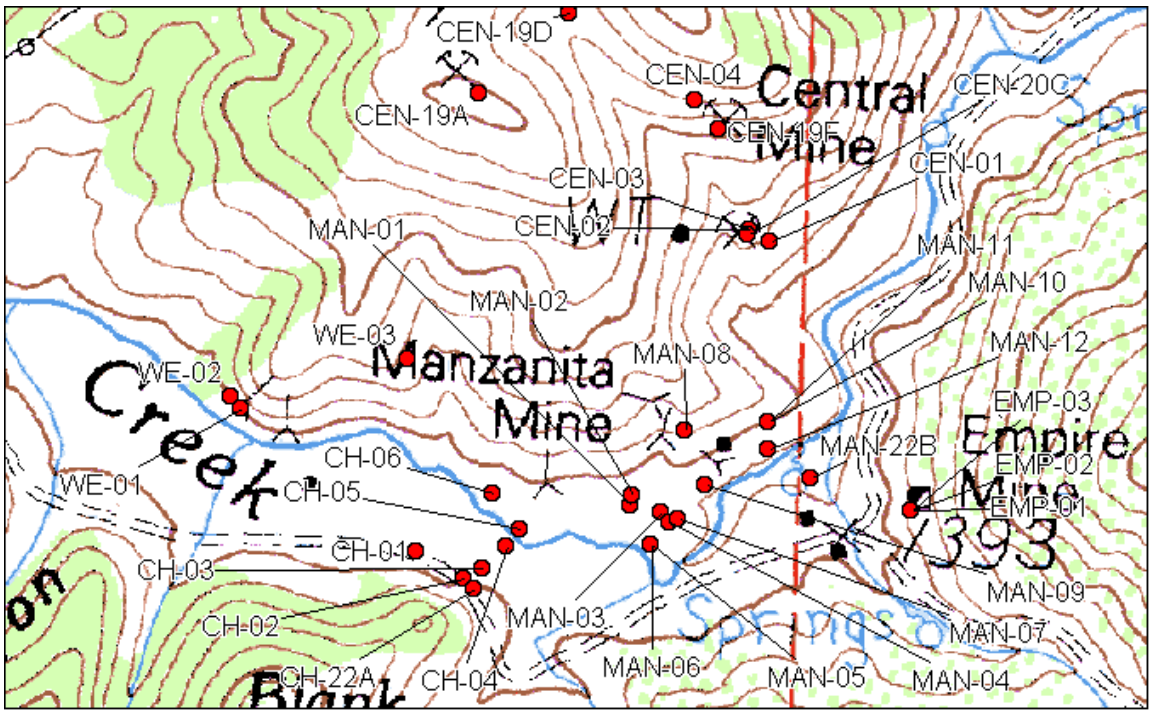


Figure H4 Wilbur Springs Area Mine Sites Topography and Sample Locations



Contour Interval 40 Feet

Figure H5 Wide Awake Mine Site and Blank Spring Area Features

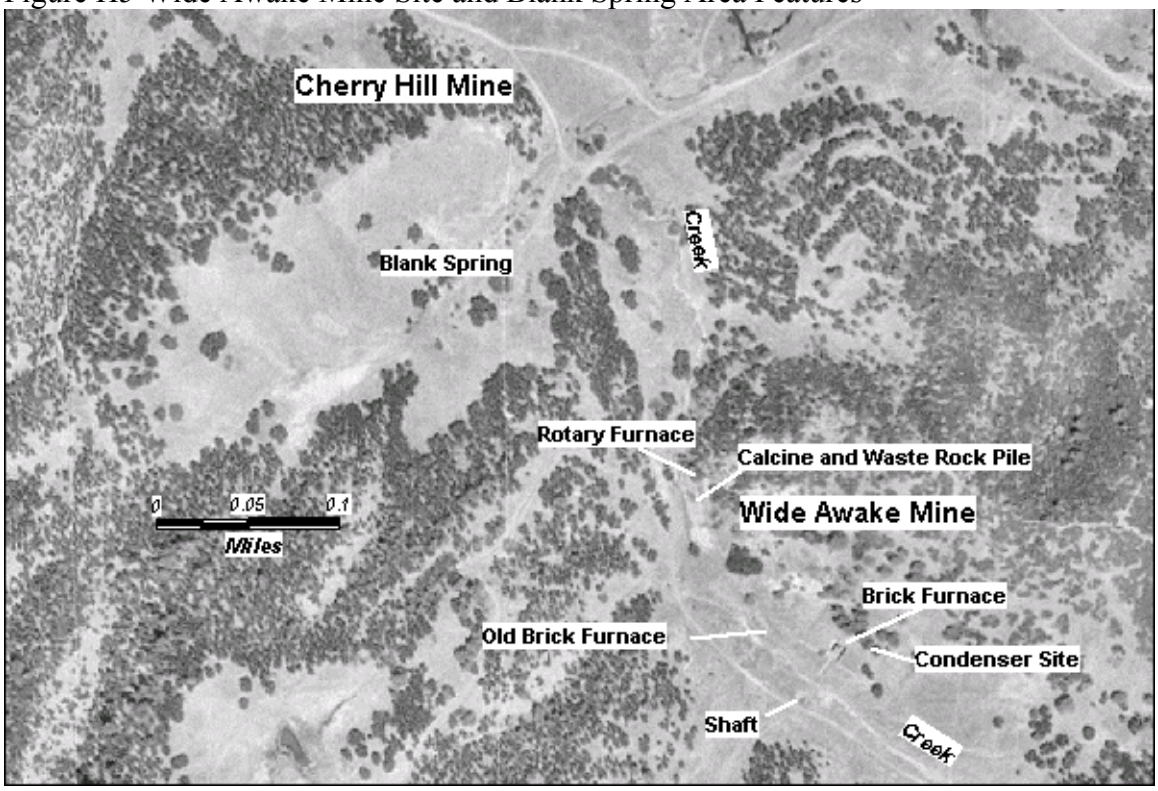


Figure H6 Wide Awake Mine Site and Blank Spring Area Topography and Sample Locations. Contour Interval 40 Feet

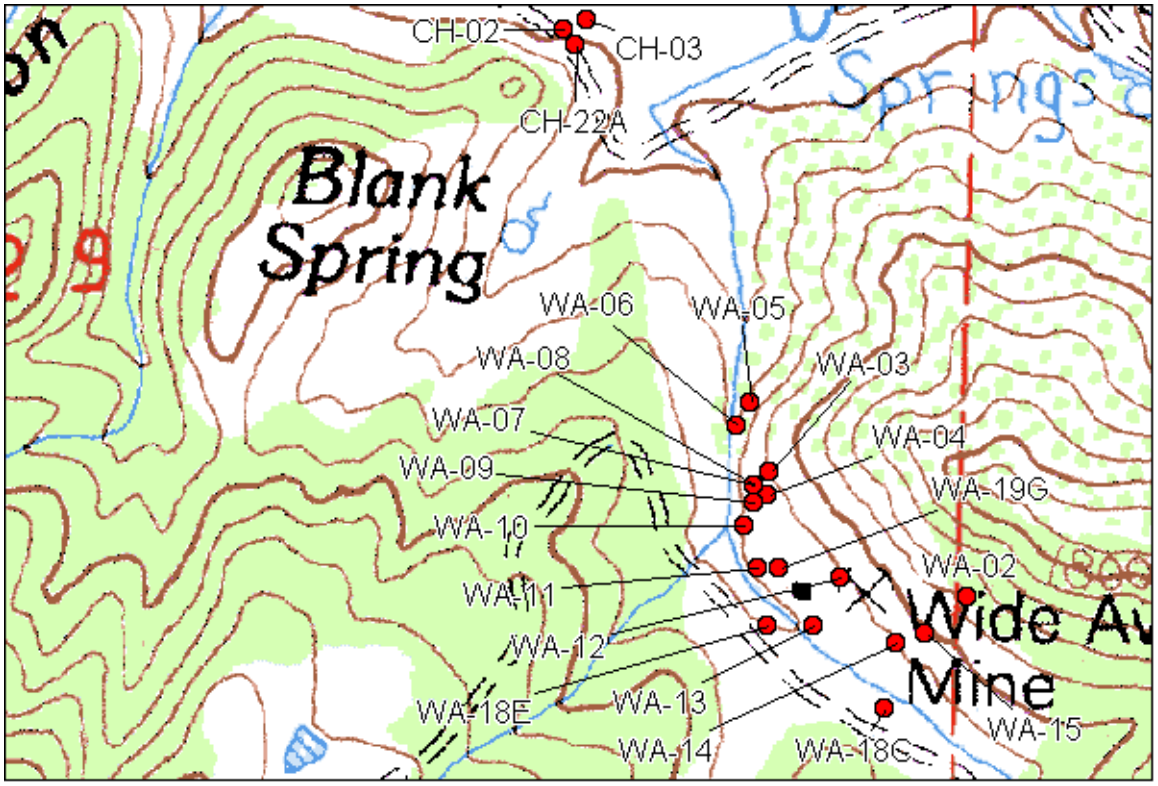


Figure H7 Elgin Mine Site Features

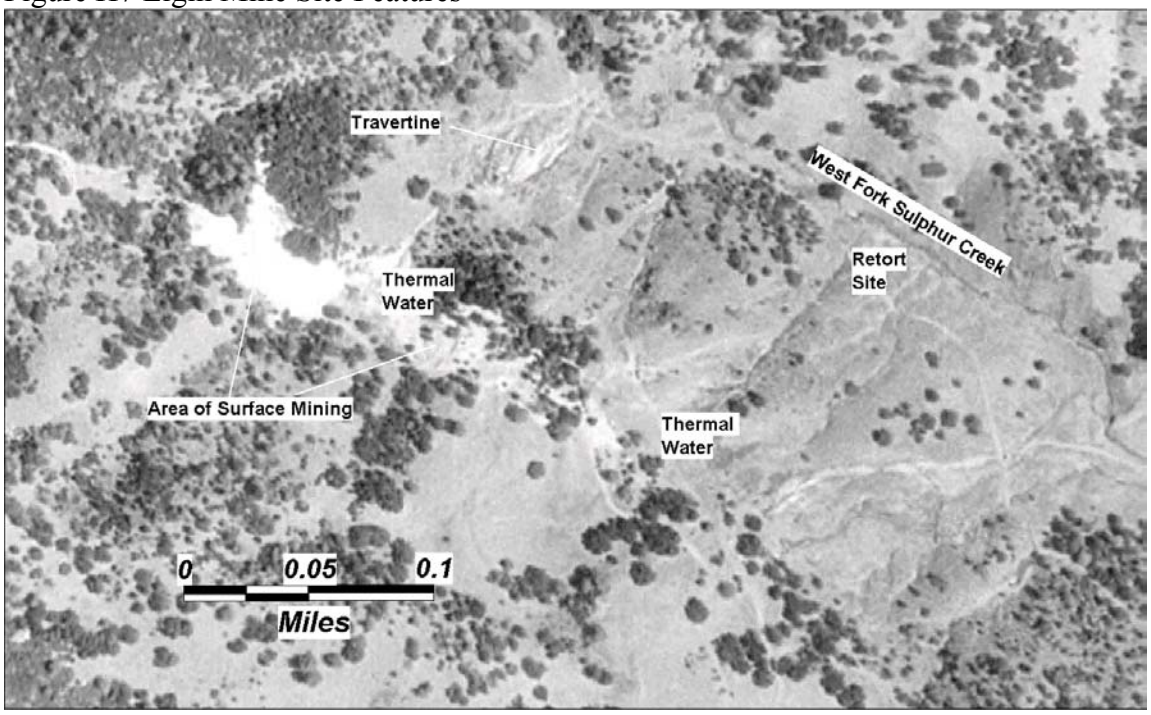
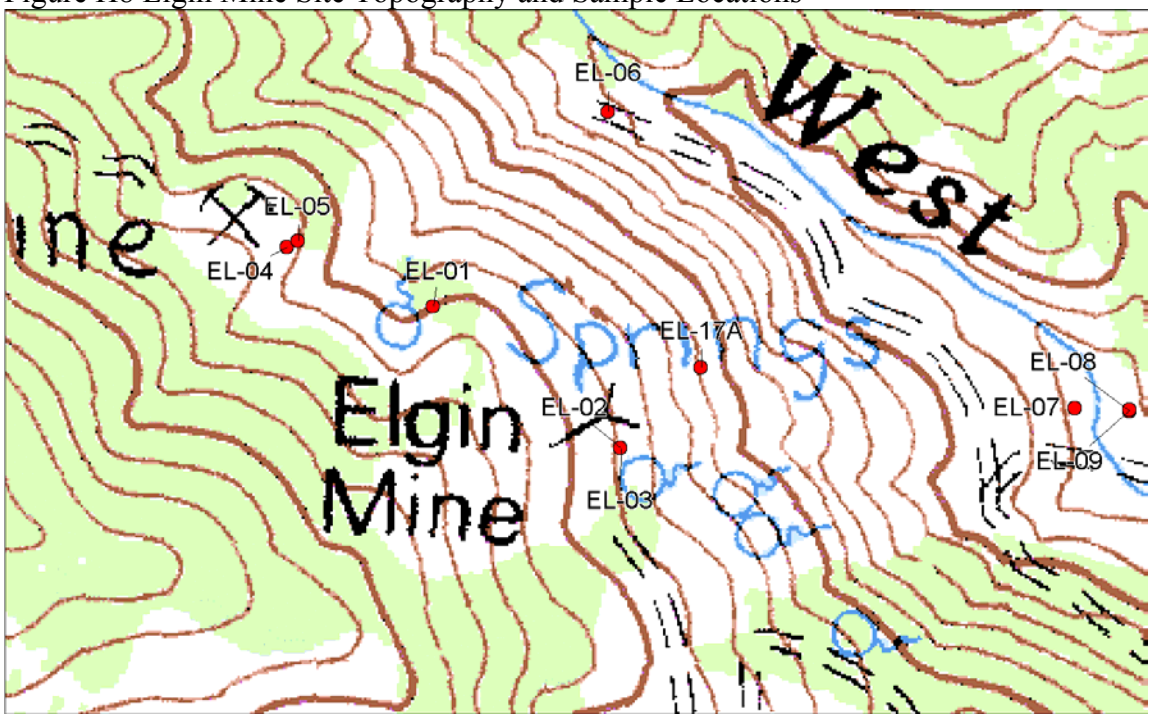


Figure H8 Elgin Mine Site Topography and Sample Locations



Contour Interval 40 Feet

Figure H9 Clyde Mine Site Features

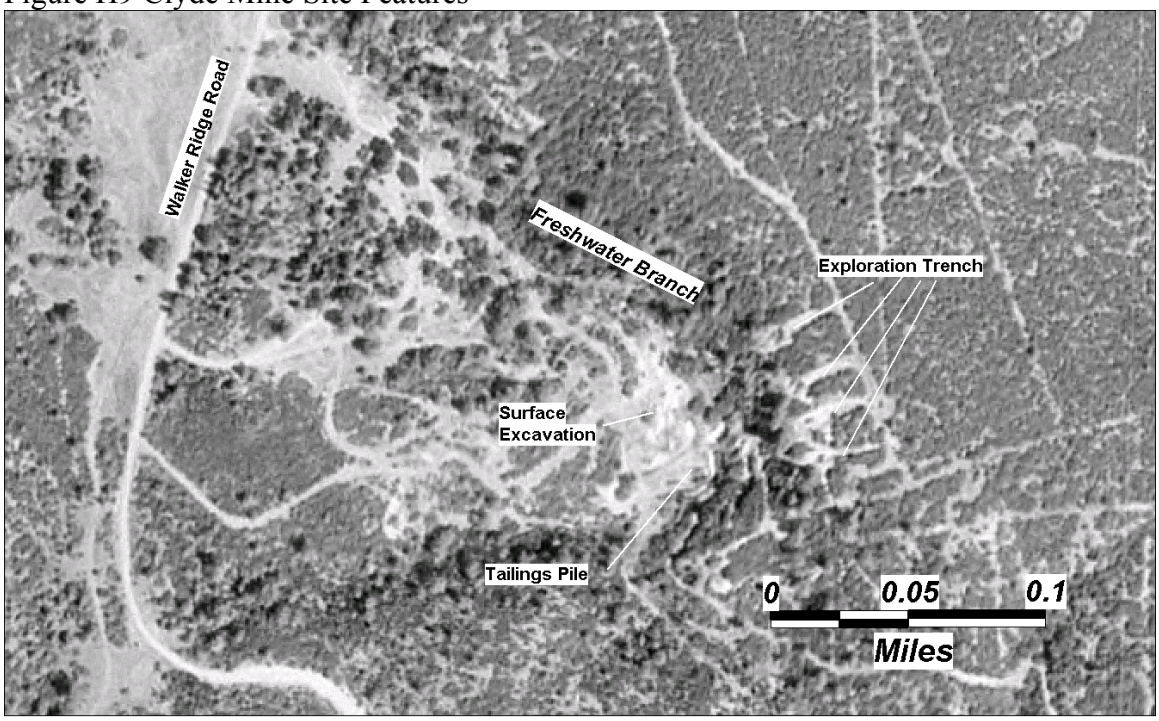
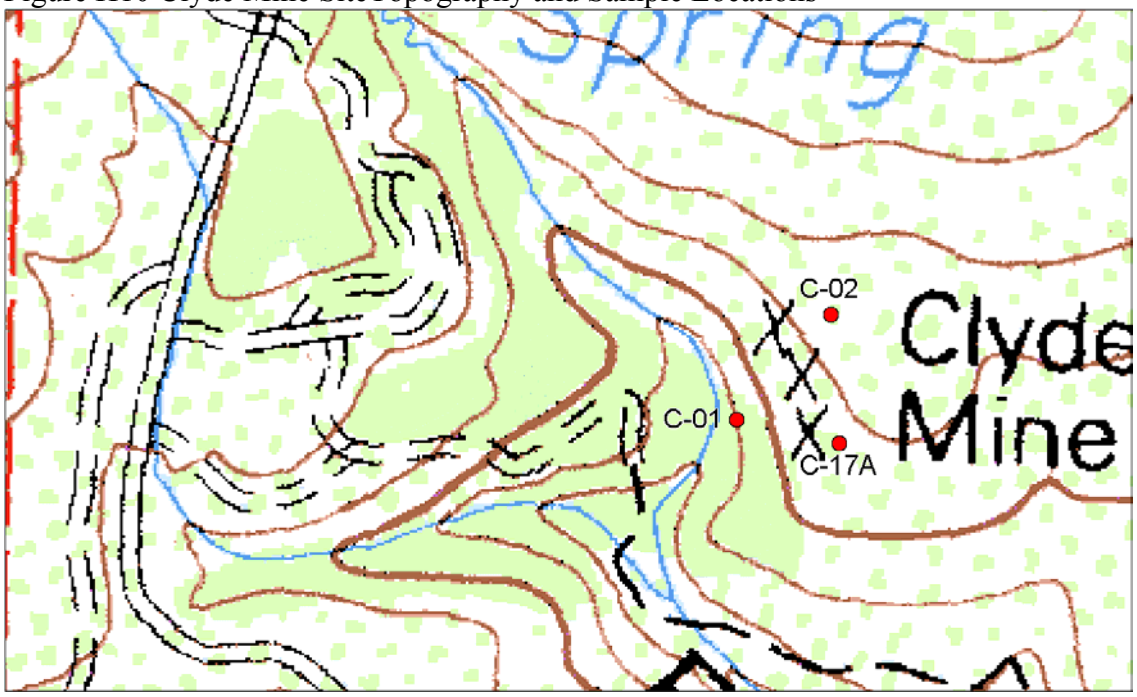


Figure H10 Clyde Mine SiteTopography and Sample Locations



Contour Interval 40 Feet

Figure H11 Rathburn and “Central Pit” Site Features

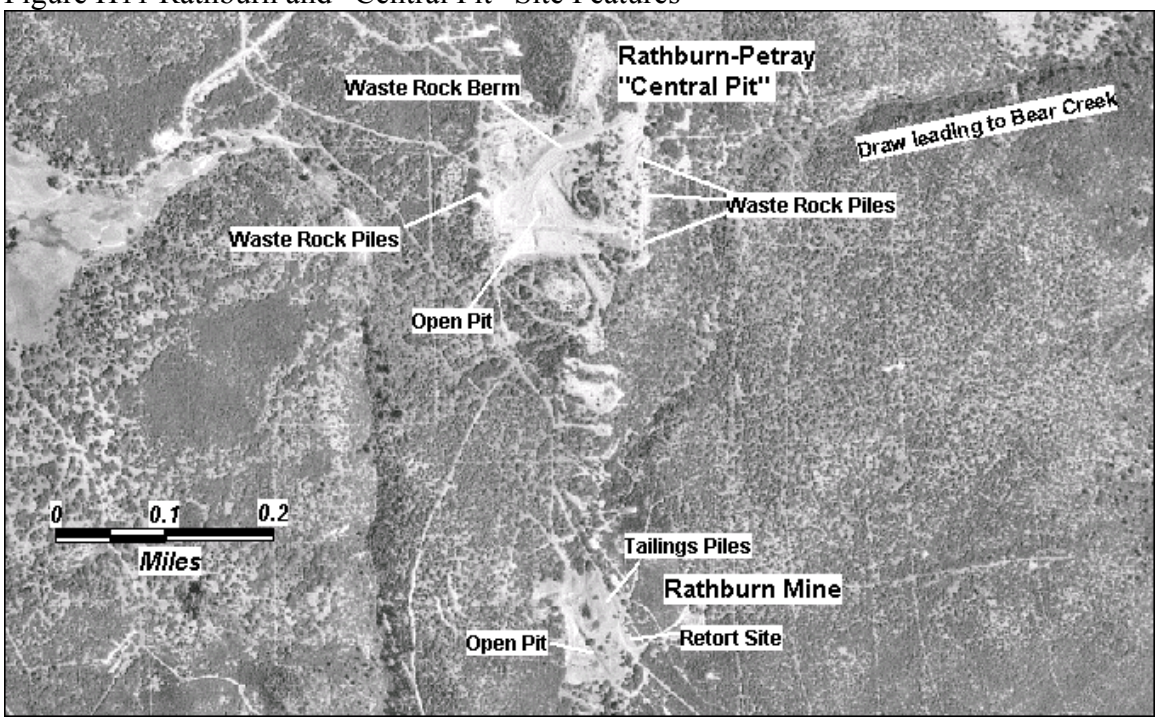
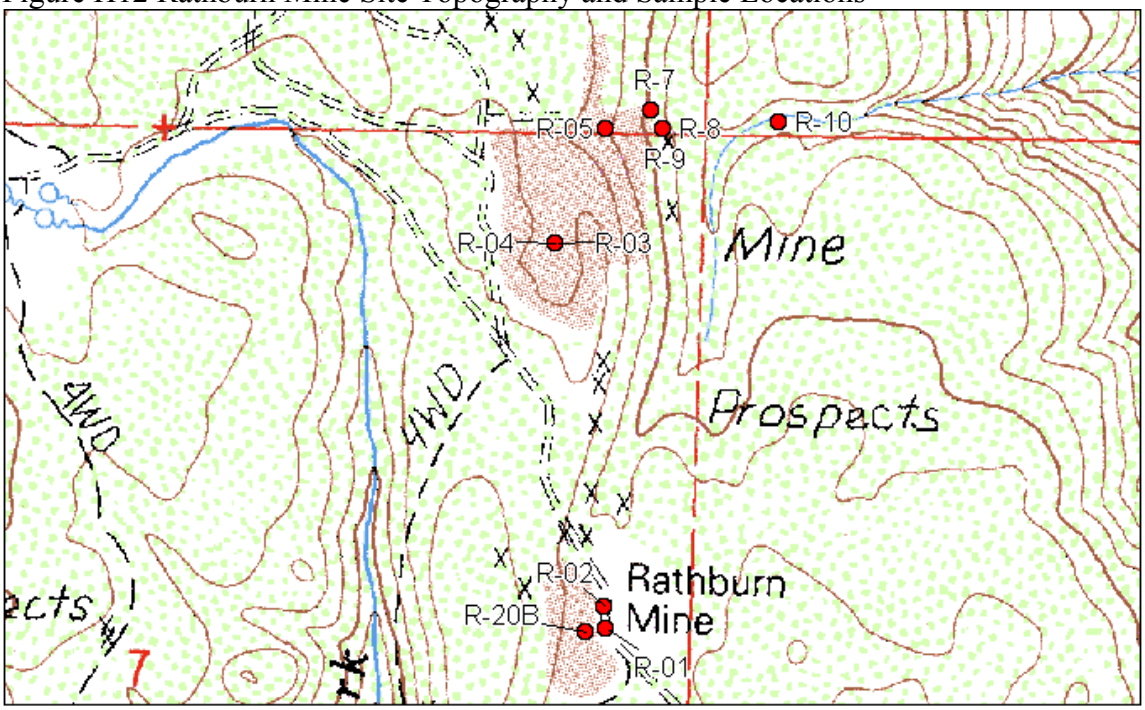


Figure H12 Rathburn Mine Site Topography and Sample Locations



Contour Interval 40 Feet

Figure H13 Petray Mine Site Features

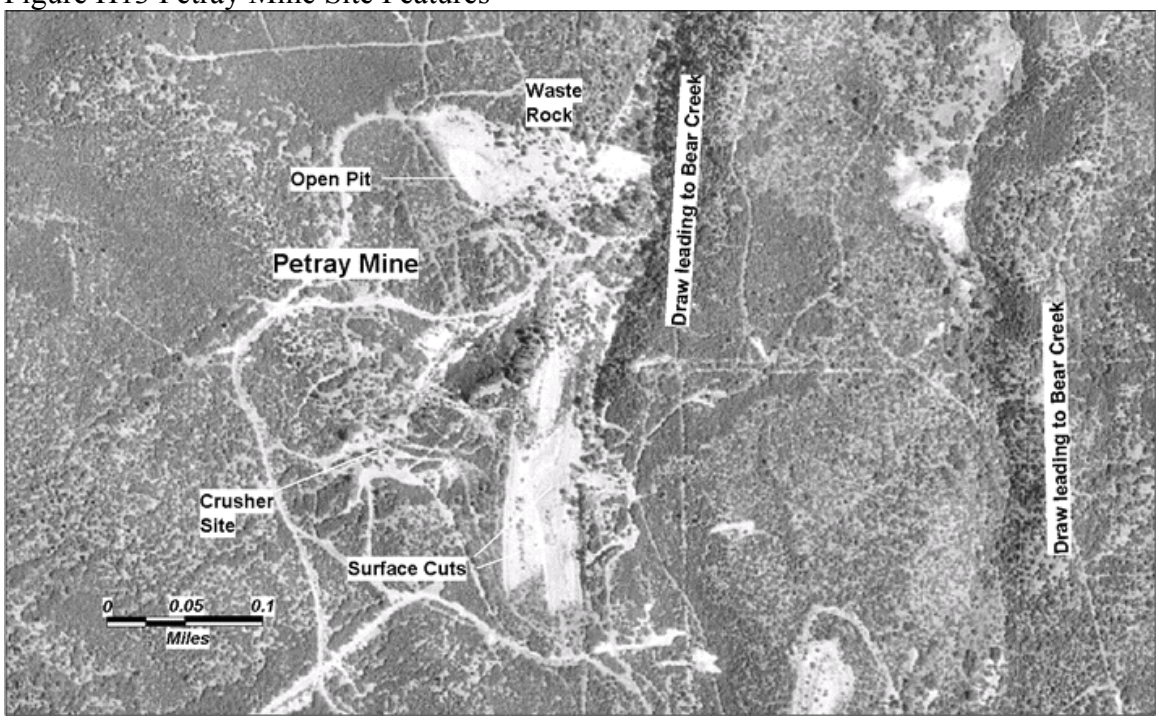
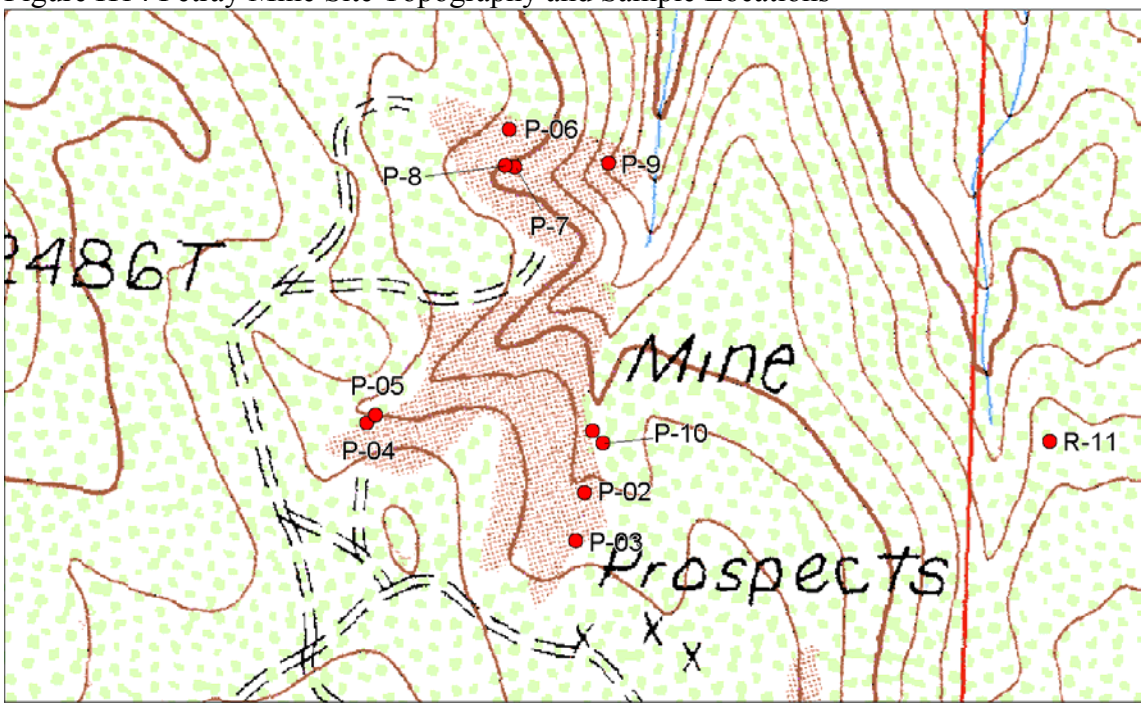


Figure H14 Petray Mine Site Topography and Sample Locations



Contour Interval 40 Feet

APPENDIX I. MERCURY ANALYSES

Site	Sample	Total Mercury by Assay Method*	Total Mercury by Geochemistry Method**	Comments
Abbott	A-1	50		Small Pile-near second rotary furnace site
	A-2	60		Small Pile—second pile near A-1 l, at NE corner of foundation
	A-3	40		Calcined Tailings—East upper part of large tailings pile
	A-4	220		Calcined Tailings—West upper part of large tailings pile
	A-5	100	>100	Furnace Site—bench just below caved road between old processing area and existing rotary furnace
	A-6	490		Furnace Site—just to south of rotary furnace
	A-7	60		Calcined Tailings—in dugout road area going down through large calcined tailings pile
	A-7A	140		Calcined Tailings—Sieved sample: +100-mesh fraction, Field Duplicate sample of A-7 collected in plastic bag.
	A-7B	150		Calcined Tailings—Sieved sample: -100-mesh fraction, Field Duplicate sample of A-7 collected in plastic bag.
	A-8	50		Calcined Tailings—lower west edge of large pile
	A-9	40		Calcined Tailings
	A-10	40		Calcined tailings—between coarse material pile on north and fine material pile on south
	A-11	40		Field duplicate of A-10—Calcined Tailings
	A-12	290	>100	Local background?/ calcined tailings—soil and rock from under tailings
	A-13	1530		Calcined Tailings—coarse tailings 6 feet south of A-12
	A-14	<10	2.00	Local background—Gray colored lower portion of soil and rock, below a 6 inch-1 foot thick yellow transition zone under 30 inches of calcined tailings

Site	Sample	Total Mercury by Assay Method*	Total Mercury by Geochemistry Method**	Comments
	A-15	50		Calcined Tailings—coarse red tailings—vertical channel sample beginning about 14 inches above A-14 and extending about 18 inches vertically
	A-16	40		Calcined Tailings—southeast edge of large tailings pile
	A-17	20		Calcined Tailings—south edge of large pile in area with white colored surface material
	A-18	150		Calcined Tailings—southeast toe of pile
	A-19	20		Calcined Tailings—corner of tailings pile
	A-20	30		Field Duplicate of A-19—Calcined tailings
	A-21	260	>100	Local Background—soil at NE top edge of the "Glory Hole"
	A-22	120	>100	Local background—sediment in the bottom of the "Glory Hole" cut
	A-23	520	>100	Local background—loose soil moving down road cut on north side of road just west of shaft and rotary furnace
	A-24	10		Calcined Tailings—mixed tailings and land slide material along creek bank south of old brick furnace site
	A-25	30		Calcined Tailings—top of tailings along creek, 45 feet east of A-24
	A-26	20		Calcined Tailings—top of tailings along creek bank east of A-25, material deep red in color
	A-27	270		Calcined Tailings—coarse material across road to the north from creek and previous samples, along small tributary gulch—fines sampled
	A-28	670		Furnace Site-Grass and thistle covered rocky soil 10-feet south of brick furnace, sample contains brick fragments and much plant matter
	A-29		0.48	Local Background soil and rock in a road cut to the east of the brick furnace—on siltstone and shale

Site	Sample	Total Mercury by Assay Method*	Total Mercury by Geochemistry Method**	Comments
Turkey Run	TR-1	390	>100	Local Background—sediment and rock in middle of landslide, upper Turkey Run
	TR-1A	350		Rerun TR-1 field duplicate—Local Background
	TR-2		0.14	Local Background—sediment and debris from a cut containing siliceous material with a "gray froth" appearance, upper Turkey Run
	TR-2A		0.12	Rerun TR-2 field duplicate—Local Background
	TR-3	40		Calcined Tailings—road surface
	TR-4	1720		Small Pile—small yellow pile with no vegetation immediately next to seasonal drainage feature, lower Turkey Run
	TR-5	290		Small Pile—small red pile about 5 feet from seasonal drainage feature, lower Turkey Run
	TR-6	290		Field duplicate of TR-5—Small Pile
	TR-7	80		Small Pile—thin gray colored fine-grained material on slope just below railroad ties, lower Turkey Run
	TR-8	870		Small Pile—near TR-7
	TR-9	160	>100	Waste Rock—Mine waste pile on west side of main drainage, lower Turkey Run
	TR-9A	310		TR-9 field duplicate—sieved sample: +100 mesh portion of TR-9 Field Duplicate sample
	TR-9B	400		TR-9 field duplicate—sieved sample: -100 mesh portion of TR-9 Field Duplicate sample
	TR-10	1370	>100	Ore—Ore bin pile southwest side
	TR-11	1390	>100	TR-10 –Field Duplicate--Ore
	TR-11A	990		TR-10 Field Duplicate sieved sample: -100 mesh portion of TR-10 Field Duplicate sample
	TR-11B	3510		TR-10 Field Duplicate sieved sample: -100 mesh portion of TR-11 Field Duplicate sample
	TR-12		*2.26,* 1.49	Local Background/Waste Rock—1st of 3 vertical samples from small erosion "gully" on east side of lower Turkey Run, buff colored sediment, 0-3 feet from the bottom

Site	Sample	Total Mercury by Assay Method*	Total Mercury by Geochemistry Method**	Comments
	TR-13	20		Calcined Tailings—2nd of 3 vertical samples from small erosion gully on east side of lower Turkey Run, red calcined tailings interbedded with buff colored sediments overlying TR-12, 18-30 inches thick
	TR-14		10.22, 9.95	Local Background/Waste Rock—3rd of 3 vertical samples from small erosion gully on east side of lower Turkey Run, buff colored sediments overlying TR-13, 12-28 inches thick
	TR-15		0.11, 0.11	Quartz Blank
Wide Awake	WA-1		2.37	Local Background—Detrital serpentinite on ridge SE of Wide Awake
	WA-2		5.03	Waste Rock—small dump in front of small surface cut, east of large brick furnace
	WA-3	60		Waste Rock—green waste rock from large mixed waste pile
	WA-4	30		Calcined Tailings—red calcined tailings from large mixed waste pile
	WA-5	120	>100	Furnace Site—soil under oak north of small rotary furnace
	WA-6	<10		Furnace Site—small gray-pink, fine grained, semi-cemented pile
	WA-7	10		Calcined Tailings—red calcined tailings from large mixed waste pile
	WA-8	20		Field Duplicate of WA-7
	WA-9	40		Calcined Tailings—red calcined tailings from large mixed waste pile
	WA-10	90		Waste Rock/Local Background—bank material along creek
	WA-11	90		Waste Rock/Local Background? Flat grass-covered pile
	WA-12	220		Waste Rock?—limonitic soil area on slope
	WA-13	30		Furnace Site—soil at very old brick furnace
	WA-14	440		Furnace Site—soil with brick fragments at Scott furnace
	WA-15	1040		Furnace Site—soil from under site of condenser building
	WA-17		0.13	Quartz Blank
	WA-18		*2.41*	*USGS STD GXR-2, 2.9 ppm Hg*

Site	Sample	Total Mercury by Assay Method*	Total Mercury by Geochemistry Method**	Comments
West End	WE-1	290	>100	Waste Rock—fines from toe of coarse fragment siliceous waste pile along Sulphur Creek
	WE-2	300	>100	Waste Pile—areas with higher percentage of fines than WE-1, 40-50 feet west
	WE-3		4.91	Local Background—Small cut along old road NE of West End
Cherry Hill	CH-1	220	>100	Small Pile—thistle and grass covered, 15 feet south of the road on west side of site
	CH-2		47.20	Small Pile—between concrete structures (gold mill) on south side of road
	CH-3		5.97	Local Background—soil from 15 feet north of the road opposite the front of the large concrete structure, geothermal exploration well area
	CH-4		57.00	Local Background—soil sample 75 feet north of CH-3, toward Sulphur Creek, geothermal exploration well area
	CH-5	280	>100	Local Background/ alluvium—sediment from 8 foot high north facing bank, about 15 feet from Sulphur Creek, geothermal exploration well area
	CH-6		*1.72,* 0.79	Local Background/ alluvium—sediment from 7 foot high bank on north side of Sulphur Creek
	CH-7		0.020	Quartz Blank
Manzanita	MAN-1	100	>100	Local Background—soil sample at west end of lower terrace
	MAN-2		67.00	Local Background—pale colored bank sediment/ soil about 30 feet north of MAN-1
	MAN-3		85.90	Retort Site/local background—thistle and grass covered soil from approximate site of road adjacent to retort
	MAN-4		5.93	Local Background/Retort Site—thistle and grass covered soil from direction most likely for material from retort to have moved
	MAN-5		25.60	Local Background/ Alluvium—sample of bank sediment consisting of cobbles and a small amount of fines, 0-18 inches up from base, about 4 feet from Sulphur Creek

Site	Sample	Total Mercury by Assay Method*	Total Mercury by Geochemistry Method**	Comments
	MAN-6		77.80	Local Background/ Alluvium—sample of 12 inch interval of bank sediment directly above Man-5, more fines and less cobbles than Man-5
	MAN-7	560	>100	Retort Site—soil sample in small bare area just east of brush pile with old equipment
	MAN-8	290	>100	Retort Site—soil sample in bare area at base of ramp to first bench, very near retort site
	MAN-9		62.6	Small Pile—east of the retort area, possibly where concentration tables were located
	MAN-10	130	>100	Local Background—sediment at cut face of first bench (previously sampled and analyzed at >100 ppm)
	MAN-11	130		Field duplicate of MAN-10
	MAN-12	260	>100	Retort Site—soil from lower most flat/terrace area where a former building may have been located
	MAN-13		<0.01	Quartz Blank
	MAN-14		*0.31, 0.16*	*USGS std GXR-5 = 0.158 ppm*
Empire	EMP-1	150	>100	Retort Site/Waste Rock —grass covered soil 25 feet west of small retort
	EMP-2	150	>100	Field duplicate of EMP-1 —Retort Site
	EMP-3		56.4	Retort/Waste Rock—Fine grained gray colored material 5 feet north of EMP-1
	EMP-4		*0.25, 0.12*	*USGS STD GXR-6 = 0.068 ppm Hg*
Central	CEN-1	420		Retort Site—Soil 3 feet east of retort.
	CEN-2	30		Calcined Tailings/ Furnace Site—tailings below small rotary furnace
	CEN-3	30		Field duplicate of CEN-2 —Calcined Tailings
	CEN-4		*2.42;* 4.15	Waste Rock—Fine sediment at base of south face of cut in the upper Central mine; sample analyzed twice
	CEN-5		*0.03,* 0.06	Quartz Blank; sample analyzed twice
	CEN-19A	60		Waste Rock—OMR collected sample—dump material

Site	Sample	Total Mercury by Assay Method*	Total Mercury by Geochemistry Method**	Comments
	CEN-19D	<10	5.49	Waste Rock—OMR collected sample—settling pond sediment, upper Central Mine
	CEN-19F	10		Waste Rock—OMR collected sample—mine dump
Elgin	EL-1	90		Waste Rock/Thermal Water—mud sample on south side of hot-springs pool
	EL-2	330	>100	Local Background--<1/2 inch gray soil and rock fragments from altered outcrop
	EL-3	120	>100	Local Background—Reddish soil adjacent to EL-2
	EL-4	330	>100	Local Background—sediment/soil washing down road cut, south side of road, upper western portion of mine site
	EL-5	240	>100	Local Background—gray colored sediment from bare area north side of road, upper western portion of mine site
	EL-6	290		Waste Rock—waste rock and soil along base of travertine deposit in contact with flowing cooled thermal spring water
	EL-7	3030		Retort Site—processing area on east side of pile above rock wall, approximately 40 yards from stream
	EL-8	20		Retort Site—soil from along concrete and brick foundation
	EL-9	20		Waste rock/tailings?—pile with –1 inch rock fragments and soil on creek bank
	EL-10		*0.33,* 0.22	Quartz Blank
	EL-11		*3.38, 2.94*	*USGS std GXR-2 , 2.90 ppm Hg*
Clyde	C-1		6.67	Waste Rock—Tailings (not calcined)
	C-2		4.98	Local Background—dozer cut
	C-17A		40	Waste Rock—OMR collected sample
Rathburn	R-1	470	>100	Retort Site—soil from area with bricks
	R-2		42.70	Tailings--not calcined? from ore crushing and concentration operation??
	R-3		43.20; 46.74	Local Background—brown fine grained sediment near center of upper bench at the "Middle" Pit

Site	Sample	Total Mercury by Assay Method*	Total Mercury by Geochemistry Method**	Comments
	R-4		41.70, 38.64	Field Duplicate of R-3—Local Background
	R-5	990	>100	Waste Rock—fines and serpentinite rock fragments from Middle Pit berm
	R-6		*0.27,* 0.06	Quartz Blank
	R-7		*0.67, 0.30*	*USGS std GXR-3, 0.33 ppm Hg*
	R-7A	80		Waste Rock—Large dump east of Middle Pit
	R-8	170		Waste Rock—Large dump east of Middle Pit
	R-9	140		Waste Rock—Large dump east of Middle Pit
	R-10	90		Waste Rock/Local Background—Fines in shallow drainage east of Large Dump at Middle Pit
	R-11		0.18	Regional Background—serpentinite
	R-20B	50		Waste Rock—Pond sediment, OMR collected sample
	R-30	<0.001	0.070	Quartz Blank
	R-40	*<0.001*	*3.67*	*USGS std GXR-2, 2.90 ppm Hg*
Petray	P-1	230	>100	Small Pile with boulder in Petray south pit
	P-2	270	>100	Small Pile—East side of Petray south pit
	P-3	170	>100	Small Pile—In serpentinite, Petray south pit
	P-4	1070	>100	Small Pile—on waste rock near possible crusher site
	P-5		26.60	Waste Rock—at possible crusher site
	P-6		2.98	Local Background—loose sediment in cut at north top of open pit
	P-7	30		Local Background—loose sediment from the floor of the open pit
	P-8	14270		In-place Ore—Fine-grained ore along vertical fracture
	P-9	280		Waste Rock/Local Background-sediment from the eastern part of the northern open pit eroding to the gully to the east
	P-10	110		Waste Rock/Local Background—fine sediments in small gully exiting the Petray south site
	P-11	130		Field Duplicate of P-10
	P-12		1.79	Quartz Blank
	P-13		*4.42*	*USGS Std. GXR-2, 2.9 ppm Hg*

Site	Sample	Total Mercury by Assay Method*	Total Mercury by Geochemistry Method**	Comments
Box Culvert Sediment	BC-1		31.1	Sediment from just outside the box culvert (north side) on HWY 20, 4/30/01
Box Culvert Sediment	BC-1a		56.1	Sediment from just inside the box culvert (north side) on HWY 20, 10/27/01
Blank Spring Mud	BKS	10		Blank Spring sediment, 10 feet downstream of spring orifice 11/20/01
Regional Background Samples	BG-01		0.24	Franciscan Formation: argillitic rocks (map unit KJf_1)
	BG-02		0.23	Franciscan Formation: metasandstone and argilite (map unit KJF_2)
	BG-03		0.31	Serpentinite (Map unit Jsp)
	BG-04		0.07	Serpentinite (Map unit Jsp)
	BG-05		*0.26*	*USGS std GXR-3 = 0.33 ppm Hg*
	BG-06		0.10	Stony Creek Formation (Map unit KJg)
	BG-07		0.19	Detrital serpentinite (Map unit KJgs)
	BG-08		0.13	Stony Creek Formation (Map unit KJg)
	BG-09		0.23	Detrital serpentinite (Map unit KJgs)
	BG-10		0.12	Stony Creek Formation (Map unit KJg)
	BG-11		0.11	Field duplicate of BG-10--Stony Creek Formation (Map unit KJg)
	BG-12		*0.11*	*USGS std GXR-6 = 0.068 ppm Hg*
	BG-13		<0.01	Quartz Blank
	R-11		0.18	Serpentinite (map unit Jsp)

*Data originally reported by ALS Chemex in weight percent to 0.001. Reported here in ppm for ease of comparison with geochemical mercury method data.

**Data originally reported by ALS Chemex in ppb to the nearest 10 ppb. Reported here in ppm for ease of comparison with assay method data.

APPENDIX J. HOT HYDROXYLAMINE HYDROCHLORIDE SELECTIVE LEACH PROCEDURE

ALS Chemex Method G986 Hot-Strong Hydroxylamine Leach

One gram of sample is placed in 20 milliliters of 0.25 M $NH_2OH.HCl$ in 0.25 M HCl for 30 minutes at 60° C. The resulting leachate is analyzed by ICP-MS.

The method extracts both amorphous iron and manganese oxides but virtually no crystalline iron oxides (less than one percent crystalline iron oxides are leached).

APPENDIX K. GOLD ANALYSES

Site	Sample	Assay g/t	Oz/t	Comments
Abbott	A-4	0.325	0.010	Calcined Tailings—West upper part of large tailings pile
	A-7	0.680	0.022	Calcined Tailings—in dugout road area going down through large calcined tailings pile
	A-8	0.015	0.0003	Calcined Tailings—lower west edge of large pile
	A-9	0.095	0.003	Calcined Tailings
	A-10	0.185	0.006	Calcined tailings—between coarse material pile on north and fine material pile on south
	A-11	0.190	0.006	Field duplicate of A-10
	A-13	0.130	0.004	Calcined Tailings—coarse tailings 6 feet south of A-12
	A-15	0.085	0.003	Calcined Tailings—coarse red tailings—vertical channel sample beginning about 14 inches above A-14 and extending about 18 inches vertically
	A-16	0.445	0.014	Calcined Tailings—southeast edge of large tailings pile
	A-17	0.150	0.005	Calcined Tailings—south edge of large pile in area with white colored surface material
	A-18	0.380	0.012	Calcined Tailings—southeast toe of pile
	A-19	0.880	0.028	Calcined Tailings—corner of tailings pile
	A-20	0.565	0.018	Field Duplicate of A-19—Calcined tailings
	A-25	0.080	0.003	Calcined Tailings—top of tailings along creek, 45 feet east of A-24
	A-26	0.100	0.003	Calcined Tailings—top of tailings along creek bank east of A-25, material deep red in color
	A-27	0.185	0.006	Calcined Tailings—coarse material across road to the north from creek and previous samples, along small tributary gulch—fines sampled
Average gold in Abbott Calcined Tailings			*0.009 SD = 0.007*	@ $300/oz = $2.70/ton
Turkey Run	TR-10	0.150	0.005	Ore—Ore bin pile southwest side
Wide Awake	WA-3	0.675	0.022	Waste Rock—green waste rock from large mixed waste pile
	WA-4	1.875	0.060	Calcined Tailings—red calcined tailings from large mixed waste pile
	WA-7	0.865	0.028	Calcined Tailings—red calcined tailings from large mixed waste pile
	WA-8	1.015	0.033	Field Duplicate of WA-7
	WA-9	1.900	0.061	Calcined Tailings—red calcined tailings from large mixed waste pile

Site	Sample	Assay g/t	Oz/t	Comments
Average gold in Calcined Tailings + Waste Rock Pile at Wide Awake			*0.044* *SD = 0.02*	@ $300/oz = $13.20/ton
West End	WE-1	>10, 22.74 (rerun by Fire Assay)	0.731	Waste Rock—fines from toe of coarse fragment siliceous waste pile along Sulphur Creek
Cherry Hill				Not assayed for gold
Manzanita				Not assayed for gold
Empire				Not assayed for gold
Central	CEN-2	0.020	0.0006	Calcined Tailings/ Furnace Site—tailings below small rotary furnace
Elgin	EL-1	1.035	0.033	Waste Rock/Thermal Water—mud sample on south side of hot-springs pool
	EL-6	1.325	0.043	Waste Rock—waste rock and soil along base of travertine deposit in contact with flowing cooled thermal spring water
	EL-7	0.565	0.018	Retort Site—processing area on east side of pile above rock wall, approximately 40 yards from stream
	EL-8	0.045	0.001	Retort Site—soil from along concrete and brick foundation
	EL-9	0.025	0.0008	Waste rock/tailings?—pile with –1 inch rock fragments and soil on creek bank
Clyde				Not assayed for gold
Rathburn	R-2	0.005	0.0002	Tailings--not calcined? from ore crushing and concentration operation?
	R-5	<0.005	<0.0002	Waste Rock—fines and serpentinite rock fragments from Middle Pit berm
Petray	P-5	0.005	0.0002	Waste Rock—at possible crusher site

APPENDIX L. ADDITIONAL INFORMATION ABOUT RUSLE

The RUSLE model is a set of mathematical equations designed to predict the long-term (average annual) soil loss by rill and interrill erosion resulting from raindrop splash and runoff. It is based on more than 10,000 plot years of data from natural rainfall soil plots, and numerous rainfall simulation plots. U.S. Department of Agriculture (USDA) soil scientists developed this empirical model over a period of 70 years. Detailed information about the RUSLE model can be found in Renard and others (1977). Although developed by USDA soil scientists for agricultural use, this soil erosion model has been previously applied in nonagricultural settings such as construction and mine sites (Renard and others, 1977). The model incorporates factors for temperature, rainfall, slope steepness and length, soil type, and vegetative cover.

RUSLE calculations for this study used temperature and rainfall data for Lakeport, California (located about 24 miles west of the project area at an elevation of 1330 feet above mean sea level, a Standard Erosivity Index of 141, and slope length and steepness specific to particular mine site features. Slope steepness and length were determined from a scanned raster image of the USGS Wilbur Springs, CA 7.5-minuet topographic quadrangle and digital air photos, using GIS methods. "Soil type" categories for mine site materials such as calcined tailings, ore and waste rock are not available as options in RUSLE2 program software. As a result, these materials were modeled as sand and silt (with various percentages of rock cover). Where mine site soil erosion was modeled, RUSLE2 soil types were used with characteristics similar to the soil types identified at the mine sites in the Colusa and Lake county soil reports by the Natural Resource Conservation Service (NRCS, 2001). Data for plant cover specific to the plant varieties present at the mine sites in the study area were not available, so bare soil, bare soil with various percentages of rock cover, and the "dense grass" (similar to lawn or golf-course rough) categories were used to bracket mine site erosion rates between high and low limits. The parameters for each mine site scenario and the resulting calculated erosion rates are listed in Appendix M

APPENDIX M. RUSLE2 ESTIMATED EROSION RATES AND MINE FEATURE ASSUMPTIONS

Site and Feature	Soil Type	Steepness (percent)	Horizontal Length of Slope (ft)	Cover	Slope Detachment (t\ac\yr)	Slope Delivery (t\ac\yr)	Notes
Abbott Calcine Pile	Sand-rock cover 30 percent	1) 78	1) 100	1) Bare	13	13	Model 1.1: Pile = sand + 30 % rock cover; erosion down pile face directly to drainage
Abbott Calcine Pile	Sand-rock cover 40 percent	1) 78	1) 100	1) Bare	10	10	Model 1.2: Pile = sand + 40 % rock cover; erosion path down pile face directly to drainage;
Abbott Calcine Pile	1) Sand-rock cover 30 percent 2) Clay loam (low-mod OM)	1) 78 2) 32	1) 80 2) 20	1) Bare 2) Dense Grass	9.3	0.19	Model 2.1: Pile = sand + 30 % rock cover; erosion path down pile face to lower slope of local soil with dense grass cover
Abbott Calcine Pile	1) Sand-rock cover 10 percent 2) Clay loam (low-mod OM)	1) 71 2) 25	1) 140 2) 30	1) Bare 2) Dense Grass	22	0.19	Model 2.2: Pile = sand + 10 % rock cover; erosion path down pile face to lower slope of local soil with dense grass cover; longer slope, less steepness than Model 1;

Site and Feature	Soil Type	Steepness (percent)	Horizontal Length of Slope (ft)	Cover	Slope Detachment (t\ac\yr)	Slope Delivery (t\ac\yr)	Notes
Abbott Calcine Pile	1) Sand-rock cover 40 percent 2) Clay loam (low-mod OM)	1) 71 2) 25	1) 140 2) 30	1) Bare 2) Dense grass	10	0.21	Model 2.3: Pile = sand + 30 % rock cover; erosion path down pile face to lower slope of local soil with dense grass cover;
Summary Abbott Calcine Pile						**Range 0.2 to 13**	Note: low slope dense grass strip at base of pile appears effectively reduce transport of eroded material away from pile. Upper range limit may be too high, compare with Homestake Mine Tailings erosion rate of 1.8 t/ac/yr
Turkey Run Ore Bin Pile (low grade mercury ore)	Silty Clay loam (low-mod OM)-30 percent rock cover	1) 71	1) 25	1) Bare	21	21	Model 1.1: Pile = silty clay loam with 30 % rock cover, bare, with erosion directly to drainage
Turkey Run Ore Bin Pile (low grade mercury ore)	Silty clay loam (low-mod OM)-40 percent rock cover	1) 71	1) 25	1) Bare	15	15	Model 1.2: Pile has more rock cover than Model 1.1

Site and Feature	Soil Type	Steepness (percent)	Horizontal Length of Slope (ft)	Cover	Slope Detachment (t\ac\yr)	Slope Delivery (t\ac\yr)	Notes
Turkey Run Ore Bin Pile (low grade mercury ore)	Sand-rock cover 40 percent	1) 71	1) 25	1) Bare	3.0	3.0	Model 2.1: Pile is different soil type than Model 1.2 Note: Silty clay loam may better represent this pile material than sand
Turkey Run Ore Bin Pile (low grade mercury ore)	1) Sand-rock cover 40 percent 2) Sandy clay loam (low-mod OM)	1) 71 2) 5	1) 25 2) 5	1) Bare 2) Bare	3.2	0.99	Model 3.1: Pile same as model 2.1 but has low slope exposed soil at toe Note: Silty clay loam may better represent this pile material than sand
Turkey Run Ore Bin Pile Summary						**0.99-21**	Note: 21 t/ac/yr is almost 2X the Homestake maximum and may be excessive, considering the short slope involved. It should be considered an upper limit rate.
Turkey Run Road Pile (mine waste)	1) Silty clay loam (low-mod OM)- with 30 percent rock cover 2) Silty clay loam (low-mod OM)	1) 74 2) 10	47 6	1) Bare 2) Dense grass	31	5.9	Model 1.1: Pile = Silty clay loam with 30 percent rock cover; erosion down pile face to 6 feet lower steepness slope with dense grass, then to drainage

Site and Feature	Soil Type	Steepness (percent)	Horizontal Length of Slope (ft)	Cover	Slope Detachment (t\ac\yr)	Slope Delivery (t\ac\yr)	Notes
Turkey Run Road Pile (mine waste)	1) Silty clay loam (low-mod OM)-with 40 percent rock cover 2) Silty clay loam (low-mod OM)	1) 74 2) 10	1) 47 2) 6	1) Bare 2) Dense grass	23	4.4	Model 1.2: Pile has more rock cover than 1.1
Turkey Run Road Pile (Mine Waste) Summary						**Range 4.4 to 5.9**	Note: Sand not run as silty clay loam believed to better represent this pile material. Compare range with Homestake Mine waste rock pile rate of 6.3 t/ac/yr
Wide Awake Calcine-Waste Rock Pile	Sand	1) 78	1) 20	1) bare	11	11	Model 1.1
Wide Awake Calcine-Waste Rock Pile	Sand	1) 78	1) 40	1) bare	17	17	Model 1.2: slope length 2X that of Model 1.1. Upper range limit may be too high, compare with Homestake Mine waste rock pile rate of 6.3 t/ac/yr
Wide Awake Calcine-Waste Rock Pile	Sand-rock cover 20 percent	1) 78	1) 20	1) bare	5.3	5.3	Model 2.1

Site and Feature	Soil Type	Steepness (percent)	Horizontal Length of Slope (ft)	Cover	Slope Detachment (t\ac\yr)	Slope Delivery (t\ac\yr)	Notes
Wide Awake Calcine-Waste Rock Pile	Sand-rock cover 20 percent	1) 78	1) 40	1) bare	9.0	9.0	Model 2.2:
Wide Awake Calcine-Waste Rock Pile	Sand-rock cover 40 percent	1) 78	10 20	1) bare	2.7	2.7	Model 2.3
Wide Awake Calcine-Waste Rock Pile	Sand-rock cover-40 percent	1) 78	1) 40	1) bare	4.8	4.8	Model 2.4
Wide Awake Calcine-Waste Rock Pile Summary						Range 2.7 to 17	17 t/ac/yr may be too high and should be considered an upper limit maximum for erosion rate. Compare with Homestake Mine waste rock pile rate of 6.3 t/ad/yr
West End Waste Rock Pile	Sand-rock cover 40 percent	1) 78	1) 51	1) bare	5.9	5.9	Model 1.1
West End Waste Rock Pile	1) Sand-rock cover 40 percent 2) Sandy clay loam (low-mod OM)	1) 78 2) 5	1) 51 2) 9	1) bare 2) dense grass	5.0	0.023	Model 1.2 Low slope dense grass buffer at base of pile
West End Waste Rock Pile Summary						**Range 0.02-5.9**	

Site and Feature	Soil Type	Steepness (percent)	Horizontal Length of Slope (ft)	Cover	Slope Detachment (t\ac\yr)	Slope Delivery (t\ac\yr)	Notes
Cherry Hill	1) sand-rock cover 40 percent 2) sandy clay loam (high OM)	1) 67 2) 2	1) 60 2) 240	1) rough bare 2) dense grass	1.2	0.015	No contribution of Hg to the watershed
Manzanita	1-6) Sandy clay loam (low-mod OM)	1) 67 2) 5 3) 50 4) 5 5) 100 6) 2	1) 60 2) 30 3) 40 4) 20 5) 20 6) 60	1-5) rough bare 6) bare	55	4.7	
Manzanita	1-6) Sandy clay loam (low-mod OM)	1) 67 2) 5 3) 50 4) 5 5) 100 6) 2	1) 60 2) 30 3) 40 4) 20 5) 20 6) 10	1-5) rough bare 6) bare	70	11	
Manzanita	1-6) Sand	1) 67 2) 5 3) 50 4) 5 5) 100 6) 2	1) 60 2) 30 3) 40 4) 20 5) 20 6) 10	1-5) rough bare 6) bare	19	1.5	
Manzanita	1-6) Sand- rock cover 10 percent	1) 67 2) 5 3) 50 4) 5 5) 100 6) 2	1) 60 2) 30 3) 40 4) 20 5) 20 6) 10	1-5) rough bare 6) bare	15	1.3	

Site and Feature	Soil Type	Steepness (percent)	Horizontal Length of Slope (ft)	Cover	Slope Detachment (t\ac\yr)	Slope Delivery (t\ac\yr)	Notes
Manzanita	1-6) Sand-rock cover 30 percent	1) 67 2) 5 3) 50 4) 5 5) 100 6) 2	1) 60 2) 30 3) 40 4) 20 5) 20 6) 10	1-5) rough bare 6) bare		0.98	
Manzanita Summary						**Range 0.98 to 11**	
Empire	1-5) Sandy clay loam	1) 1 2) 75 3) 55 4) 1 5) 27	1) 35 2) 65 3) 90 4) 20 5) 110	1) dense grass 2) dense grass 3) dense grass 4) bare 5) dense grass 6)	0.61	0.46	Top of pile to creek
Empire	1-2) sandy clay loam	1) 1 2) 75	1) 35 2) 100	1-2) dense grass	0.61	0.61	Top to base of pile only
Empire Summary						**0.46-0.61**	Essentially no Hg contribution to the watershed
Central Calcine Pile	1) sand 2) sandy clay loam (low-mod OM)	1) 63 2) 24	1) 40 2) 560	1) bare 2) dense grass	1.4	0.29	

Site and Feature	Soil Type	Steepness (percent)	Horizontal Length of Slope (ft)	Cover	Slope Detachment (t\ac\yr)	Slope Delivery (t\ac\yr)	Notes
Central Calcine Pile	1) Sand 2) Sandy clay loam (low-mod OM)	1) 63 2) 43	1) 40 2) 280	1) bare 2) dense grass	2.4	0.36	
Central Upper area	1 and 2) sandy clay loam	1) 75 2) 38	1) 120 2) 710	1) bare 2) dense grass	15	1.4	
Central Upper area	1 and 2) sandy clay loam	1) 75 2) 38	1) 120 2) 710	1) dense grass 2) dense grass	0.84	0.84	
Central Upper area	1) sand 2) sandy clay loam (low-mod OM)	1) 75 2) 38	1) 120 2) 710	1) bare 2) dense grass	5.5	0.56	
Central Upper area	1) sand-rock cover 20 percent 2) 2) sandy clay loam (low-mod OM)	1) 75 2) 38	1) 120 2) 710	1) bare 2) dense grass	3.6	0.63	
Central Summary Calcine Pile: Upper Area						**0.29-0.36** **0.56-1.4**	
Elgin Lower Site Calc. Pile	1) sand	1) 76	1) 13	1) bare	7.8	7.8	Pile at creek

Site and Feature	Soil Type	Steepness (percent)	Horizontal Length of Slope (ft)	Cover	Slope Detachment (t\ac\yr)	Slope Delivery (t\ac\yr)	Notes
Elgin Lower Site Calc. Pile	1) sand-rock cover 20 percent	1) 76	1) 13	1) bare	3.7	3.7	Pile at creek
Elgin Lower Site Calc. Pile	1) sand-rock cover 40 percent	1) 76	1) 13	1) bare	1.8	1.8	Pile at creek
Elgin Lower Area	1) Sand-rock cover 10 percent	1) 30	1) 150	1) dense grass	0.076	0.076	Retort area
Elgin Upper area	1) sandy clay loam 2) sand-rock cover 40 percent	1) 46 2) 57	1) 150 2) 670	1) bare 2) rough bare	44	44	RUSLE2 may not apply to this situation
Elgin Upper area	1) sand 2) sand-rock cover 40 percent	1) 46 2) 57	1) 150 2) 670	1) bare 2) rough bare	35	35	RUSLE2 may not apply to this situation
Elgin Upper Area	1) sand 2) sandy clay loam (high OM) 3) sand-rock cover 40 percent	1) 46 2) 5 3) 57	1) 150 2) 50 3) 620	1) bare 2) dense grass 3) rough bare	34	29	RUSLE2 may not apply to this situation
Elgin Upper Area	1-5) sand-rock cover 40 percent	1) 44 2) 57 3) 71 4) 40 5) 29	1) 225 2) 140 3) 170 4) 100 5) 70	1-5) bare	26	26	

Site and Feature	Soil Type	Steepness (percent)	Horizontal Length of Slope (ft)	Cover	Slope Detachment (t\ac\yr)	Slope Delivery (t\ac\yr)	Notes
Elgin Summary **Calcine Pile** **Lower Area** **Upper Area**						**1.8-7.8** **0.08** **26-44**	RUSLE2 may not apply to this situation
Clyde Tailings	1) sand	1) 78	1) 50	1) bare	19	19	
Clyde Tailings	1) sand	1) 78	1) 30	1) bare	14	14	
Clyde Tailings	1) sand-rock cover 40 percent	1) 78	1) 50	1) bare	5.8	5.8	
Clyde Tailings	1) sand-rock cover 40 percent	1) 78	1) 30	1) bare	3.7	3.7	
Clyde Trench	1-3) sand-rock cover 30 percent	1) 30 2) 78 3) 40	1) 100 2) 50 3) 50	1-3) bare	14	14	
Clyde Trench	1-3) sand-rock cover 30 percent	1) 30 2) 78 3) 40	1) 130 2) 60 3) 90	1-3) bare	17	17	
Clyde Summary **Tailings Pile** **Trench-Pile**						**3.7-19** **14-17**	

Site and Feature	Soil Type	Steepness (percent)	Horizontal Length of Slope (ft)	Cover	Slope Detachment (t\ac\yr)	Slope Delivery (t\ac\yr)	Notes
Petray-Rathburn Middle Pit	1) clay loam (low-mod OM) 2) sandy clay loam (low-mod OM) 3) sandy clay loam (low-mod OM)	1) 71 2) 40 3) 15	1) 120 2) 100 3) 170	1) rough bare 2) bare 3) bare	77	40	Rate too high—no rock cover. Compare with Homestake Mine waste rock pile rate of 6.3 t/ad/yr
Petray-Rathburn Middle Pit	1-3) Sandy clay loam (low-mod OM)-40 percent rock cover	1) 71 2) 40 3) 15	1) 120 2) 100 3) 170	1) rough bare 2) bare 3) bare	26	26	Try sandy clay loam with rock cover
Petray-Rathburn Middle Pit	1-3) Silty clay loam (low-mod OM) 40 percent rock cover	1) 71 2) 40 3) 15	1) 120 2) 100 3) 170	1) rough bare 2) bare 3) bare	40	40	Try silty clay loam with rock cover. Erosion rate may be too high. Compare with Homestake Mine waste rock pile rate of 6.3 t/ad/yr
Petray-Rathburn Middle Pit	1-3) sand	1) 71 2) 40 3) 15	1) 120 2) 100 3) 170	1) rough bare 2) bare 3) bare	26	13	Try sand
Petray-Rathburn Middle Pit	1-2) sand	1) 40 2) 5	1) 250 2) 700	1) bare 2) bare	10	4.9	Sand, different slope
Petray-Rathburn Middle Pit	1-2) sand-rock cover 40 percent	1) 40 2) 5	1) 250 2) 700	1) bare 2) bare	3.7	2.9	Sand with rock cover different slope
Petray-Rathburn Middle Pit Summary						**2.9-26**	Using the upper limit of 40 t/acre seems excessive. Compare with Homestake Mine waste rock pile rate of 6.3 t/ad/yr

Definitions of Erosion Hazard from Lake County Soil Report

Erosion Hazard ratings in the Lake County soil report are based on predicted annual soil loss under bare conditions (no plant cover) and were determined using the Universal Soil Loss equation, where A equals tons per acre per year; R, 50; K, actual value for the surface layer; L, 10 feet; S, actual percent slope of the map unit; C, 1.0; and P, 10. Three erosion hazard classes are recognized. They are slight—less than 5 tons per acre, moderate—5-20 tons per acre; and severe—20-50 tons per acre or more.

Abbott-Turkey Run Site

142 Soil: Henneke-Montara-Rock outcrop complex, 15-50 percent slopes—Serpentinite soil, 50% soil surface covered with a pavement of stones, cobbles and pebbles; surface is gravelly loam 3 inches thick; surface runoff is rapid, **erosion hazard is severe**, Ca to Mg ratio is less than 1.

212 Soil: Skyhigh-Sleeper-Millsholm association, 30-50 percent slopes—**erosion hazard is severe**, shrink-swell potential, is high, surface runoff is rapid. Unit susceptible to slumping and gullying.

Premining (Homestake period) soil loss rates calculated for the Old Manhattan Mine site as part of the Homestake EIR (Calculated using RUSLE)

Immediate Manhattan Mine area: 9.85 t/ac/yr
Waste Rock Piles: 6.30 t/ac/yr
Mill Site: 2.47 t/ac/yr
Low-grade Ore Pads: 1.77 t/ac/yr
Mine Facilities Area: 1.77 t/ac/yr
Tailings Sites: 1.44 t/ac/

APPENDIX N. AVERAGE ANNUAL MERCURY DELIVERY FROM MINE SITE FEATURES

Site	**Feature**	**Area (ac)**	**RUSLE2 erosion rate(s) (t/ac/yr)**	**Annual erosion (t/yr)**	**Mercury (ppm)**	**Annual mercury delivery (Kg/yr)**	**Notes**
Abbott	Large Calcine Pile	1.1 acres (only south face of pile)	9.3-13 erodes directly to ditch; 0.2 through grass to ditch	7.3	20 to 220; high of 1530; minus 0.149mm fines = 160 ppm	**1.1** max.est. **0.3** min. est. (not including toe erosion)	Large calcine pile down slope from rotary furnace. Pile is eroding into drainage ditch (Harley Gulch tributary) along HWY 20. About half of pile erodes directly to the ditch while the other half erodes onto a grassy area and then to ditch.
Abbott	Large Calcine Pile—Toe Erosion			0.5 to 3.1	220 ppm used for upper limit estimate.	**0.6** max. est. **0.1** min. est.	Erosion from the toe of the calcined tailings pile was assumed to be at least 11 cubic yards and at most 53 cubic yards. If this occurred over the last 26 years since mine closure the rate is 0.4 to 2.3 cubic yards/year. At 1.35 tons/cubic yard the rate is 0.5 to
Abbott	Old furnace calcine area	0.7	Assume 10.8-max. erosion rate	7.6	20 to 270	**1.9** max. est. **0.3** min. est	Assumed a maximum erosion rate of 10.8 tons/acre/year (the maximum erosion rate from the McLaughlin mine EIR)
Abbott	Upper area					**Included with estimate for Turkey Run**	Erosion from surface cuts and glory hole area, upper Abbott mine site. Some of the eroded material is blocked from drainage to the ditch along HWY 20 by the calcine pile while other material may be transported to the lower Turkey Run down erosion gullies, only during severe storm events.

Site	Feature	Area (ac)	RUSLE2 erosion rate(s) (t/ac/yr)	Annual erosion (t/yr)	Mercury (ppm)	Annual mercury delivery (Kg/yr)	Notes
Turkey Run	Ore bin pile	0.09 (slope portion of pile)	1.0-21 t/ac/yr	1.89 max	1370-1390 minus 0.149mm = 3510 ppm	**6.0 max est.** **0.3 kg min est.**	Waste/low grade ore at the ore bin area, central part of lower Turkey Run site
Turkey Run	Road pile	0.13	4.4-5.8 t/ac/yr	0.57-0.75	160	**0.08 to 0.11**	Waste pile on southwest edge of lower Turkey Run site, adjacent to road to Abbott.
Turkey Run	Fill/pad area gully erosion		Est. lost 800 tons/26 years	30.8 t/yr	1.5 to 20 ppm	**0.04 to 0.6**	Alluvial/artificial fill area underlying the lower Turkey Run area *Note: Contribution of Hg from the surface of the alluvium/pad area is inconsequential—assume 0.3-0.4 acres of surface, Hg at 1.5 to 20 ppm, @ an erosion rate of 1.5 t/ac/yr would have 0.0006 kg Hg; @ 7 t/ac/yr would have 0.05 kg Hg/yr*
Turkey Run	Upper area			100.5 tons @ 1.5 tons/acre 402 tons @ 6 tons/acre	0.1 to 390 ppm	0.040 to 142? *These figures are not included in annual site delivery. Significant materil movement down slope may only occur during severe storm events.*	Surface cuts: 67 acres of disturbed area in the upper part of the Abbott-Turkey Run site. Soil loss is probably between 1.5 t/ac/yr and 6 t/ac/yr (average rate at Homestake site prior to open pit mining). On the Abbott portion of this site, some of the displaced upper mine material is trapped behind the large calcine pile and some is diverted to the lower Turkey Run site by an erosion gully. On the Turkey Run site some material is likely trapped on long heavy grass slopes before it reaches the drainage along HWY 20

Site	Feature	Area (ac)	RUSLE2 erosion rate(s) (t/ac/yr)	Annual erosion (t/yr)	Mercury (ppm)	Annual mercury delivery (Kg/yr)	Notes
Totals for Abbott and Turkey Run Sites						**1.1 to 10.3**	Note: It is unlikely for mercury contributions from upper mine site areas except during severe storm events ***UC Davis estimate of annual Hg load for Abbott/Turkey Run = 0.1 to 35 kg/yr***
Wide Awake	Calcine/waste rock pile	0.13 to 0.47	2.7-17	0.35 to 8.0	60 or less, used 60	**0.02 to 0.44** *[max=**1.2** kg/yr @ 160 ppm]*	Mixed calcine and waste rock pile adjacent to drainage out of site.
Wide Awake	Grass covered waste pile				90	0?	Heavily vegetated waste pile (calcines??), probably little or no erosion
West End	Waste rock pile	0.3 acres	5.9 (where directly eroding to creek) 0.023 (where eroding to 9-foot grassy area)	0.007 to 1.77	300	**0.002 to 1.1**	Mine dump, related to adits, on north side of Sulphur Creek
Cherry Hill	Mine slope/ mill site		0.016		6 to 47	No material appears to be eroding to Sulphur Creek from mine and mill site.	Surface cuts related to adits and mill area south of Sulphur Creek.

Site	Feature	Area (ac)	RUSLE2 erosion rate(s) (t/ac/yr)	Annual erosion (t/yr)	Mercury (ppm)	Annual mercury delivery (Kg/yr)	Notes
Cherry Hill	Waste pile along Sulphur Creek	0.04		0-9?	280	0-2?	A 580 cu yard grass and thistle covered waste pile is present along Sulphur Creek. Annual mercury contribution from this pile is likely to be less than 1 kg of mercury.
Cherry Hill Total						**0-1**	
Empire	Waste pile/ slope	0.68	0.46-0.61	0.31-0.41	150	**0.04-0.06** (max)	Grass covered waste pile and grassy slope to tributary to Sulphur Creek
Manzanita	Mined slope/ benches	5	0.98 to 11	4.9-55	67 to130	**0.3-6.5**	Surface cuts/ adits/ and benches to the north of Sulphur Creek. The maximum of 6.5 kg/year mercury is based on an erosion rate of 11t/ac/yr which is probably too high a rate to be applied to the whole site.
Central	Calcine pile/ slope	0.1 to 0.2	0.29 to 0.36	0.029 to 0.072	30; 420 in front of brick retort	**0.0008 to 0.03**	Calcine pile and grassy slope/small drainage feature above Sulphur Creek
Central	Upper cut and waste pile area	About 0.7 (dump slope)	0.56 to 1.4	0.47 to 0.98	4.2	**0.002-0.004**	Moderate sized surface cut and waste pile on south facing slope near top of ridge; long distance to Sulphur Creek—may not be contributing significant material to drainage.

Site	Feature	Area (ac)	RUSLE2 erosion rate(s) (t/ac/yr)	Annual erosion (t/yr)	Mercury (ppm)	Annual mercury delivery (Kg/yr)	Notes
Totals for Wilbur Springs Area Sites						**0.4 to 8.1**	The annual amount of mercury eroded from stream bank alluvium is uncertain.
Elgin	Upper mine area/ slope to creek	0.7 acres--slope area to creek	26-44	18-31	240 to 330	**3.9 to 9.3**	Area of surface mining eroding to a bench where it is caught. Mining waste rock extends from this bench (and pool area) down slope to creek. Material is mixing with thermal spring water from the Elgin pool area as it travels down slope and ultimately into the creek. RUSLE2 might not properly model this situation.
Elgin	Lower area—processing site	0.08 (60'x60')	0.08 to 0.31	0.025	20 to 3030	**0.017 to 0.069** @ 3030 ppm	Grassy area believed to be a former retort location
Elgin	Lower area—pile at creek	0.02	1.8 to 7.8	0.036 to 0.16	20	**0.001 to 0.003**	Small pile, calcined material?, at creek edge
Totals for the Elgin Site						**3.9 to 9.4**	

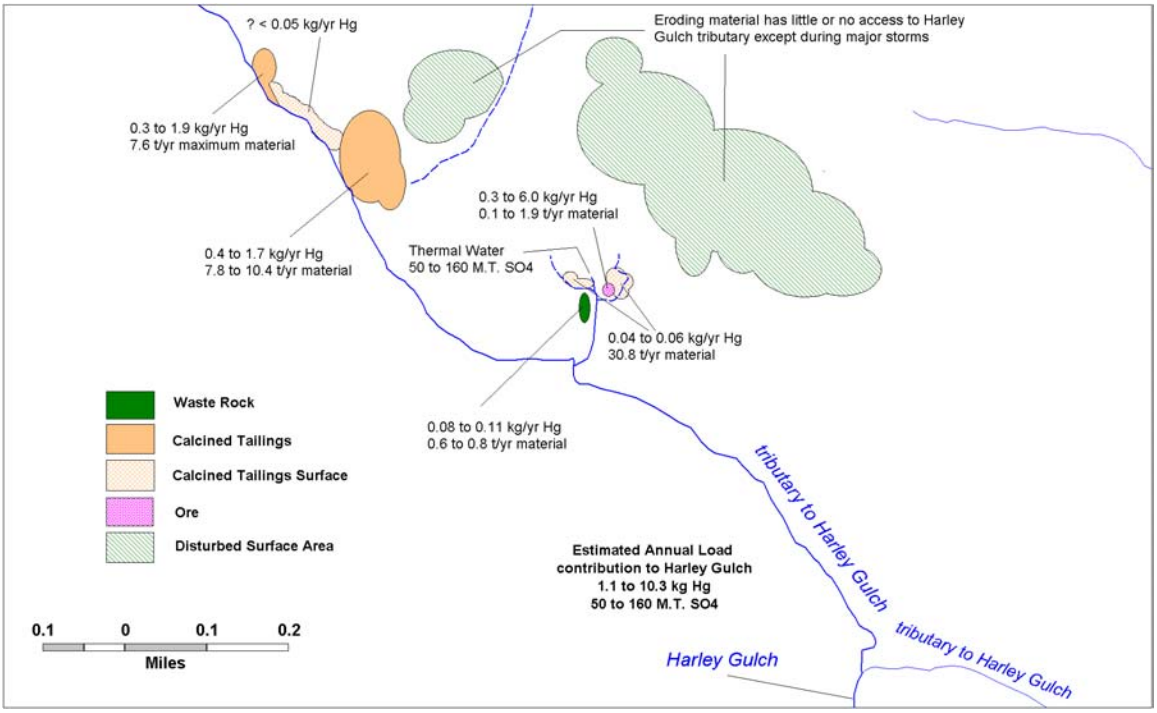
Site	Feature	Area (ac)	RUSLE2 erosion rate(s) (t/ac/yr)	Annual erosion (t/yr)	Mercury (ppm)	Annual mercury delivery (Kg/yr)	Notes
Clyde	Large tailings pile at creek --- est. gully erosion (total)	0.38 (area of base – area of top of pile)	3.7 to 19	1.4 to 7. 17 t / time? (30 years?)	6.7 @6.7	**0.009 to 0.044** 0.003 kg-Hg	Tailings pile with gully erosion and sheet flow erosion to creek Total Hg from gully erosion (time period?)
Clyde	3 Trenches/ piles	0.38	14 to 17 [too high?]	5.3 to 6.5	5.0	**0.024 to 0.029**	3 trenches with waste piles on west sloping hillside above creek [erosion rate may be too high]
Totals for the Clyde Site						**0.033 to 0.11**	
Totals for Sulphur Creek Watershed						**4.3 to 17.6 [max] if Elgin is correct**	UC Davis estimate for annual Hg load of Sulphur Creek = 0.5 to 160 kg/yr
Rathburn	Open pit/ dumps				38.6 to 42.7	**0**	Probably little material movement off site. Area is relatively flat. Area around pit erodes to pit
Rathburn	Retort area?				470	**0**	Flat area w/ vegetation—no erosion off site

Site	Feature	Area (ac)	RUSLE2 erosion rate(s) (t/ac/yr)	Annual erosion (t/yr)	Mercury (ppm)	Annual mercury delivery (Kg/yr)	Notes
Rathburn-Petray	Open pit/ dump (Middle Pit Area)	East Dump = 3.2	2.9 to 40	9.3 to 128 by sheet flow	80 to 170	**0.67 to 19.7** to bottom of ravine by sheet flow	Area immediately surrounding pit erodes to pit. Dumps to west are on relatively flat area and material probably does not move to drainage. Dumps to East are actively eroding (gully and sheet flow) to ravine to east. Movement of this material to Bear Creek is uncertain. The bottom of the ravine is relatively flat—may drain straight west or to north, depending upon location.
Petray	South cut-pit	3.44 acre (cut-pit area)			110 for small piles	Probably small, **0.4-0.8?**	Most of disturbed material probably remains in pit/cut area. Small erosion out of cuts to the northwest. Movement of this material to Bear Creek is uncertain.
Petray	Crushing/ loading site/ dump	0.07			26.6, small pile = 1070	Probably small;	Mine dump on south side of small ravine. Assuming erosion rate @ 10 t/ac/yr would have 0.7 t/yr. @ 26.6 ppm Hg would have 0.017 kg Hg/yr delivered to gully
Petray	North open pit/ dump	0.8 acre pit (east part)+ 0.6 acre slope = 1.4 acres	Assume 10.8	15.1	3 to 280	**0.04 to 3.8**	Deep open pit. Significant Gully erosion on north wall. Western 2/3 of pit area erodes to pit. Eastern 1/3 of pit area erodes to ravine to the east.

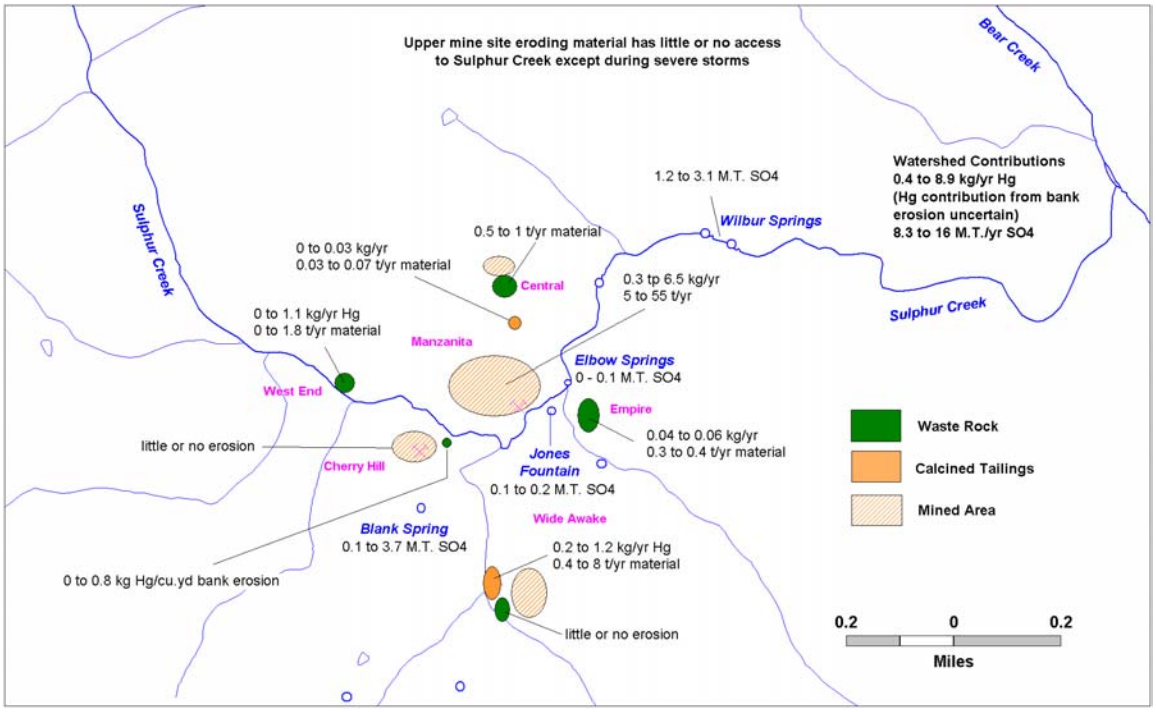
Site	Feature	Area (ac)	RUSLE2 erosion rate(s) (t/ac/yr)	Annual erosion (t/yr)	Mercury (ppm)	Annual mercury delivery (Kg/yr)	Notes
Totals for Rathburn-Petray Area Sites						**Probably 1.1 to 24.3 maximum is delivered to the ravine.**	This mercury is delivered to ravine to east of mining sites. The ravine appears to be dry except during major storm events. It is not known how much, if any, is transported out of the ravine and down to Bear Creek during storm events.
Background Hg for Abbott-Turkey Run Site		0.9 square miles = 576 acres	1.5 minimum; 11 maximum	864 minimum 6,336 maximum	0.1 to 0.3	**0.078 to 0.24** minimum **0.57 to1.7** maximum	The amount of mercury from this source that annually enters Harley Gulch is unknown.
Background Hg for Sulphur Creek Watershed		10.3 square miles = 6,592 acres	1.5 minimum; 11 maximum	9,888 minimum 72,512 maximum	0.1 to 0.3	**0.90 to 2.7** minimum **6.6 to 19.7** maximum	The amount of mercury from this source that annually enters Sulphur Creek is unknown

Note: On long slopes where a mining feature is in the upper part of the slope, there should be mixing with material from the feature and the slope material. Consequently, the amount of mercury should be diluted (in most cases) by the time it reaches the bottom of the RUSLE2 slope. Applying a mercury level representative of the mine site feature to the entire slope should yield an upper limit to the annual amount of mercury delivered to the base of the slope. For example, the Empire mine dump. An example where a relatively high mercury level should be applied to the entire slope may be the western part of the Elgin mine.

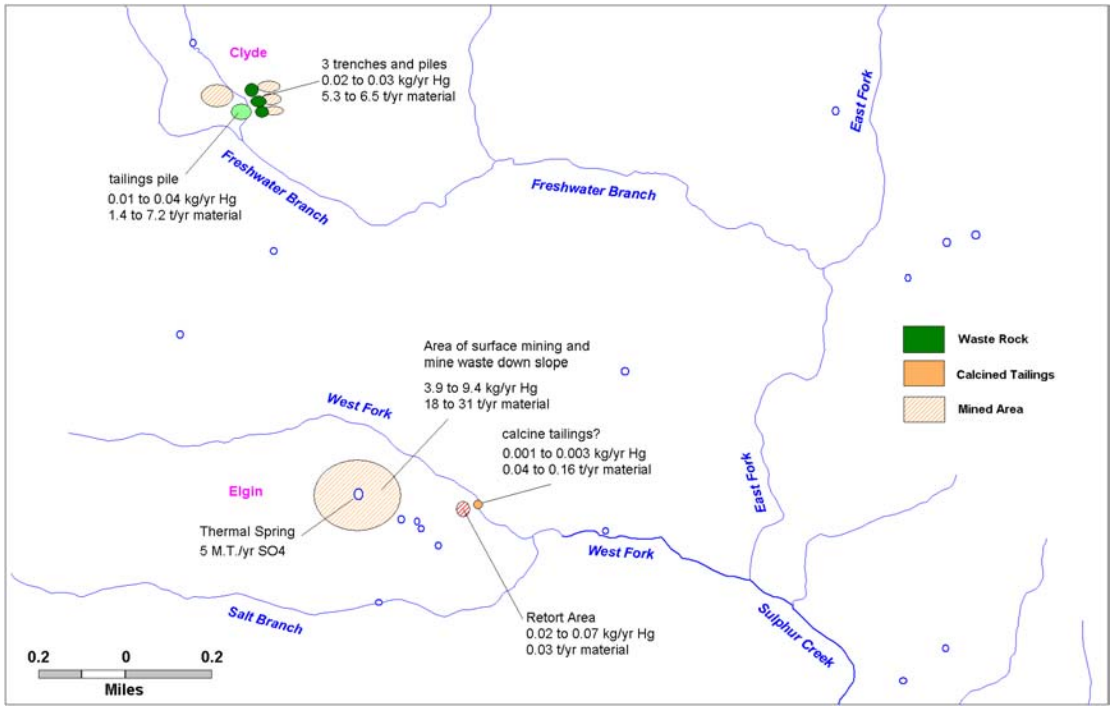
APPENDIX O. AVERAGE ANNUAL MERCURY MOVEMENT DUE TO EROSION AT MINE SITES



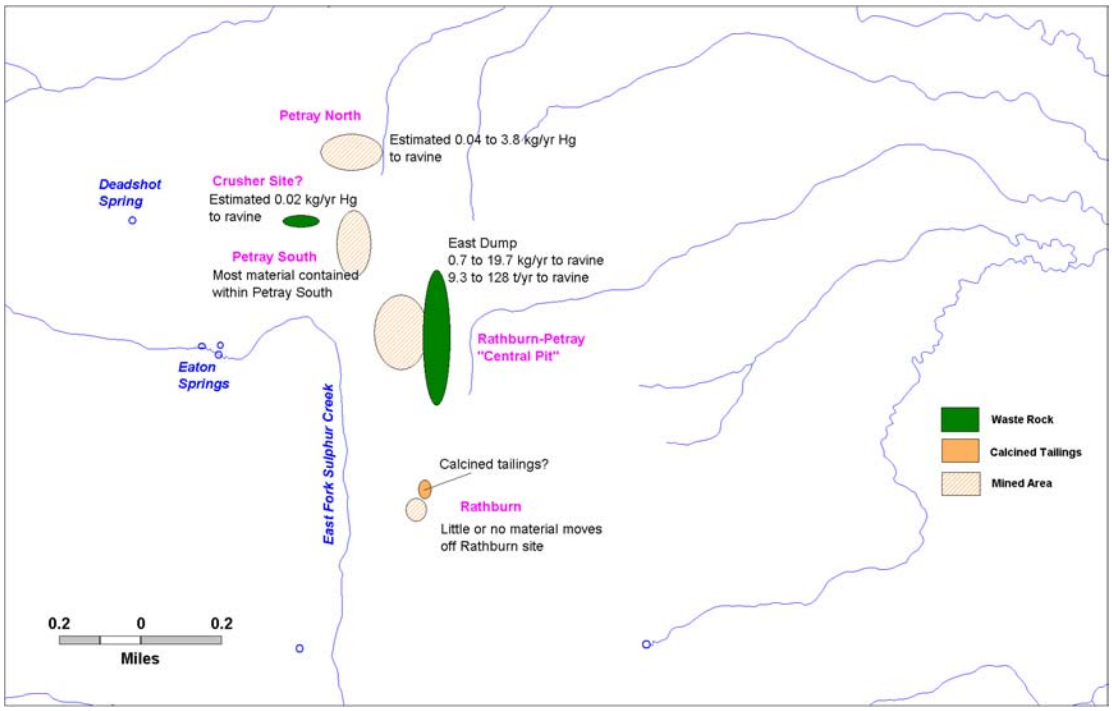
Estimated Average Annual Mercury Contributions to the Watershed by Feature, Abbott-Turkey Run Mine Site



Estimated Average Annual Mercury Contributions to the Watershed by Mine Sites near Wilbur Springs



Estimated Average Annual Mercury Contribution to the Watershed by the Elgin and Clyde Sites



Estimate Average Annual Mercury Movement at the Rathburn and Petray Sites

APPENDIX P. ESTIMATES OF ANNUAL MERCURY CONTRIBUTIONS FROM THERMAL SPRING WATER
(Flow rate and mercury data are from Goff and others, 2001)

Spring	**Flow Rate (l/min)**	**Annual Flow**	**Mercury (ppm) (= mg/l)**	**Annual Mercury Delivery (kg/yr)**	**Comments**
Turkey Run	50-57	26,280,000 – 29,959,200	0.0002	0.005-0.006	
Total Harley Gulch (west) Watershed				**0.005-0.006**	
Blank	1-14	525, 600 – 7,358,400	0.0013-0.0070	0.0007-0.052	
Jones Fountain	20 at peak *use 10 as average for period of flow--RKC*	876,000	0.0017-0.0135	0.001-0.012	Erupts about every hour for about 10 minutes--*RKC*
Elbow	0.5	262,800	0.0023-0.0138	0.0004-0.004	
Unnamed	0.5	262,800	0.0037	0.0010	
Wilbur-Don White's	5	2,628,000	0.0053-0.0071	0.014-0.019	
Wilbur-Main	20	10,512,000	0.0056	0.059	
Wilbur-bet. Main and road.	10	5,256,000	0.0075	0.039	
Elgin-Main	20-26	10,512,000-13,665,500	0.0050-0.0070	0.053-0.096	
Elgin-Orange Tub	41.6	21,864,960	0.0002	0.004	
Total Sulphur Creek Watershed				**0.173-0.292**	

Note: Using UCD's Jones Fountain water analysis of 24,000 ng/l (0.024 ppm) and 876,000 l/yr flow, the annual Jones Fountain mercury contribution is 0.021 kg/yr

APPENDIX Q. ESTIMATES OF ANNUAL SULFATE CONTRIBUTIONS FROM THERMAL SPRING WATER
(Flow rate and mercury data are from Goff and others, 2001)

Spring	**Flow Rate (l/min)**	**Annual Flow**	**SO4 (ppm) (= mg/l)**	**Annual SO4 delivery (kg)**	**Comments**
Turkey Run	50-57	26,280,000 – 29,959,200	1930-5310	50,720 – 159,083	
Total Harley Gulch (west) Watershed				**50,720 – 159,083**	
Blank	1-14	525, 600 – 7,358,400	292-506	153-3,723	
Jones Fountain	20 at peak *use 10 as average for period of flow--RKC*	876,000	109-220	95-193	Erupts about every hour for about 10 minutes--*RKC*
Elbow	0.5	262,800	56.5-455	15-120	
Unnamed	0.5	262,800	194	51	
Wilbur-Don White's	5	2,628,000	141-420	371-1,104	
Wilbur-Main	20	10,512,000	72.7-187	764-1,966	
Wilbur-bet. Main and road.	10	5,256,000	14.8	78	
Elgin-Main	20-26	10,512,000-13,665,500	104-221	1,093-3,020	
Elgin-Orange Tub	41.6	21,864,960	262	5,729	
Total Sulphur Creek Watershed				**8,349-15,984**	

APPENDIX R. MINE SITE MERCURY EMISSION CALCULATIONS

Mercury Flux Estimates for Task 5C Mine Sites and Watershed Based on Flux Rate Data from the Knoxville Mining District (Gustin and others, 2000)

Mine	**Feature**	**Acres**	**Meters^{2*}**	**Est. Flux Rate ng/m2/h**	**Est. Annual Flux kg**
Abbott-Turkey Run	Disturbed Surface	67	271,140	674	1.60
Abbott	Calcines (piles and pad)	4.7	29,947	214-2100	0.06-0.55
Turkey Run	Ore Pile	0.13	162	10000	0.014
Turkey Run	Waste Rock	0.16	647	1000	0.006
Turkey Run	Calcines (pad and road)	1.7	6,880	214-2100	0.013-0.13
Abbott-Turkey Run Total		**73.69**			**1.69-2.30**
West End	Waste Rock Pile	0.16	647	1000	0.006
Cherry Hill	*Disturbed Surface*	*0.49*	*1,983*	*674*	*0.012*
Manzanita	*Cut Surface+Disturbed Area*	*5.2*	*21,044*	*674*	*0.124*
Empire	Waste Rock Pile + Disturbed Area	0.5	2,023	1000	0.018
Central	Calcined Tailings	0.15	607	214-2100	0.001-0.011
Central	*Disturbed Surface Area + Waste Rock*	*1.9*	*7,689*	*674*	*0.045*
Wide Awake	Calcined Tailings/Waste Rock	0.47	1902	214-2100	0.004-0.035
Wide Awake	*Surface Disturbance*	*1.6*	*6,475*	*674*	*0.038*
Wilbur Mines total		9.97			***0.25-0.29***
Wilbur	*Bedrock Geochemical Anomaly (natural > 1.6 ppm Hg)*	*120*	*485,623*	*389-1714*	*1.66-7.29*
Elgin	Disturbed Area + Hillside Mine Waste	3	12,141	674	***0.07***
Clyde	Disturbed Area	5	20,234	674	0.119
Clyde	Tailings	0.38	1538	1000	0.013
Clyde	Trenches	0.52	2,104	674	0.12
Clyde total		5.9			***0.25***
Sulphur Creek Mines total		**15.9**			**0.57-0.61**
Rathburn	Pit	0.17	688	674	0.004
Rathburn	Tailings Piles	0.5	2,023	1000	0.017
Rathburn	Other Disturbed Areas	1.7	6,880	674	0.041
Middle-Pit	Pit	3.6	14,569	674	0.086
Middle-Pit	Eastern Waste Rock Pile	3.4	13,759	1000	0.121
Middle-Pit	Upper Area Waste Rock Piles+ Disturbed Areas	5.3	21,448	1000	0.188
Middle-Pit	Other Disturbed Areas	4.6	18,616	674	0.110
Petray South	Pit	4.1	16,592	674	0.098
Petray North	Pit	1.1	1,452	674	0.009
Petray North	Waste Rock	2.2	8,903	1000	0.078

Mine	Feature	Acres	Meters^{2*}	Est. Flux Rate ng/m2/h	Est. Annual Flux kg
Petray	Other Disturbed Areas	6.9	27,923	674	0.165
All Rathburn-Petray Areas		**33.6**			**0.92**
All Mine Features					**3.18-3.83**
Sulphur Creek Watershed	Background flux to ATM	6528	26,417,902	0-15	0-3.47**
Harley Gulch West	Background flux to ATM	627	2,537,381	0-15	0-0.33**
Bear Creek	Background flux to ATM	58,816	238,020,118	0-15	0-31.3**

*1 acre = 4,046.86 Meters^2

**Only a fraction of this amount falls directly into waterways or is transported to waterways.

Note—regional background mercury in soil is up to 4 times higher than the 0.08 ug/g cited by Gustin and others, 2000, so the background area mercury flux rates may be higher in the study area than in the area surrounding the Homestake mine.