FORT KNOX MINE

CLOSURE MANAGEMENT PLAN FOR THE PROPOSED HEAP LEACH FACILITY

June 2006

2643/R1

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1 INTRODUCTION

Fort Knox Gold Mine, Inc. (FGMI) is currently in the design and permitting phase of developing a heap leach facility at the Fort Knox Mine. Water Management Consultants, Inc. (WMC) and FGMI have prepared this closure management plan for the proposed heap leach facility in support of pre-construction permitting. The closure plan includes an analysis of the initial draindown and long-term discharge rates, geochemical characterization of the ore and solution chemistry, and presentation of the solution management plan and the closure approach. The analyses presented in this plan are based on the information available to date. Data collection is currently on-going and the plan will be updated once all information is available.

1.1 Background

The Fort Knox Mine is located approximately 15 miles northeast of Fairbanks, Alaska. The site includes several sections in T2N, R2E and T2N, R3E, Fairbanks Meridian near the head of the Fish Creek drainage. Figure 1.1 illustrates the regional site location.

The current mining operation includes a mill and processing facilities for ore benefaction. Mill tailing is placed in an existing tailing storage facility (TSF) located in Fish Creek.

The proposed heap leach pad will be located in Walter Creek directly upgradient of the TSF (Figure 1.2). The heap leach facility will be a valley fill type with a liner and internal solution collection system. A complete description of the facility design is presented in Section 3.

1.2 Objectives

The objectives of the closure plan are as follows:

- Develop an initial estimate of draindown quantity and quality based on currently available information.
- Estimate the long-term discharge rate and quality.
- Develop a solution management plan which is integrated with the short and long-term closure plan developed for the TSF directly downgradient.
- Present the steps comprising the closure and monitoring plan.

1.3 Summary of field work and testing activities

Data collection activities initiated to support the engineering design and permitting are outlined below. Relative to the Closure Management Plan, the objective of these activities was to define local hydrogeologic conditions, and assess the geochemical character of the ore and leach solution. Estimates of the hydraulic characteristics for soil cover and ore material were also derived from geotechnical test work completed for engineering design purposes.

Condemnation/geotechnical drilling

Condemnation/geotechnical drilling included completion of four core holes, six reverse circulation holes, and five geotechnical holes at the locations illustrated in Figure 1.2. The purpose of the drilling was to collect mineralogical, geological, geotechnical and hydrogeological data prior to initiating construction activities. Hydrogeological data collected by FGMI during the drilling includes:

- Lithology
- Water levels
- Air-lift flow rates
- Hydraulic conductivity estimates
- Groundwater quality

Geochemical characterization

Geochemical testing completed to support the closure plan includes:

- Acid-base accounting on fresh and spent ore samples
- Column testing to evaluate cyanide destruction during solution recirculation
- Meteoric Water Mobility Procedure (MWMP) testing on the spent ore from column testing
- Chemical characterization of the leach solution

Physical and hydraulic characterization

Test work completed to characterize the physical and hydraulic properties of the ore includes:

- Particle size distributions
- Saturated hydraulic conductivity estimates

- Moisture release characteristics
- Specific gravity measurements
- Column draindown tests

1.4 Available data

The data available to support development of the closure approach includes:

- Facility design information (Knight Piesold, 2005a,c)
- Facility water balance estimates (Knight Piesold, 2005b,c)
- Baseline groundwater and surface water data (various)
- Local geologic information in Walter Creek (Knight Piesold, 2005c)
- Physical and chemical characteristics of the ore (FGMI and Knight Piesold, 2005c)
- Chemical composition of the leach solution (FGMI)
- Information regarding the physical configuration of the TSF and downgradient seepage management system (FGMI, WMC, 2005)
- Climatological information (various).

1.5 Construction and commissioning schedule

Facility construction will be initiated in 2006, and ore loading will begin in late summer 2007. The facility will be built-out in phases between 2006 and 2015. Figure 1.3 illustrates the construction and loading phases for the facility.

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Figure 1.1 Regional location map

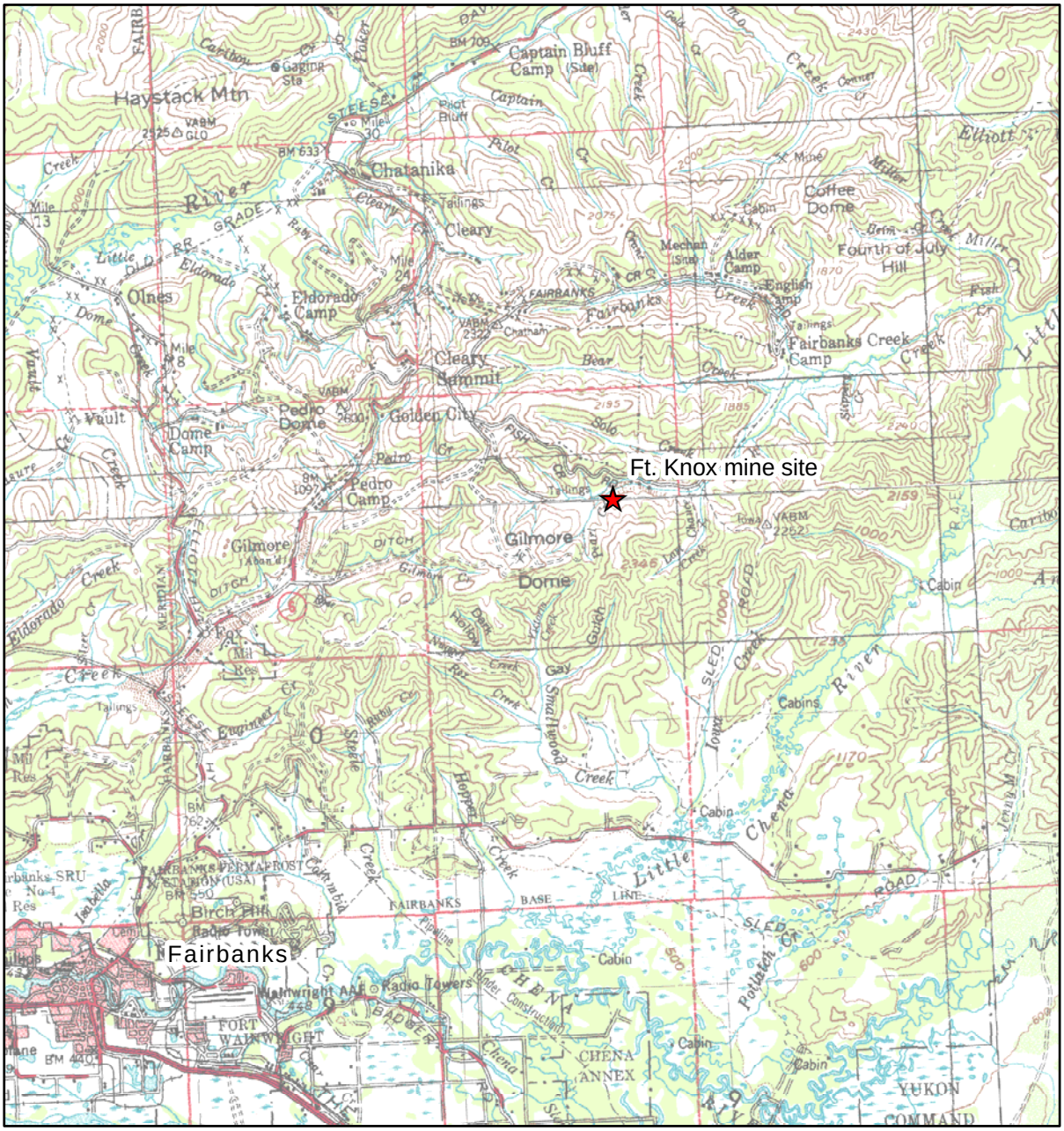

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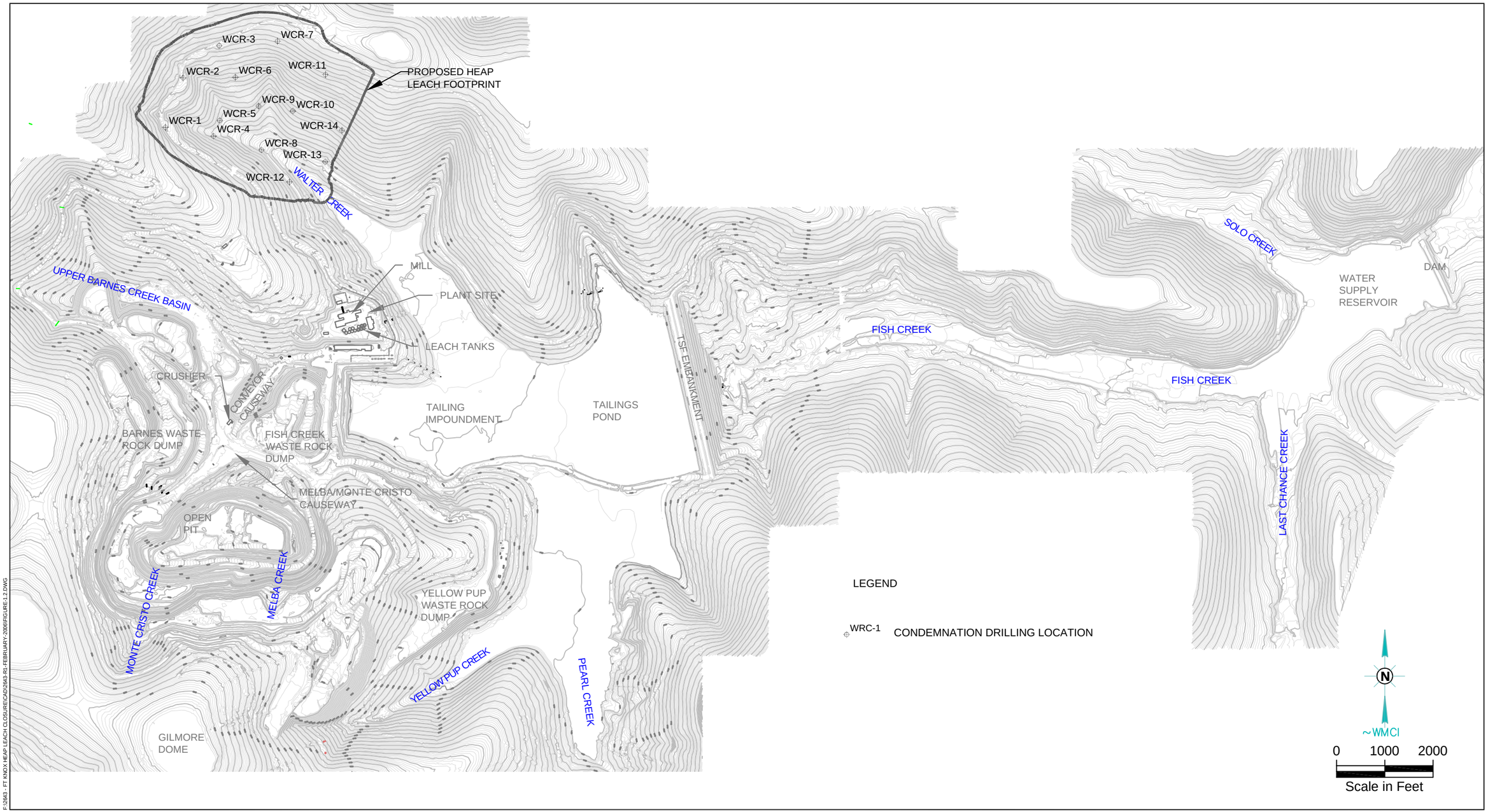
Figure 1.2 General facility layout map



F:\2643 - FT KNOX HEAP LEACH CLOSURE\CAD\2643-R1-FEBRUARY-2006\FIGURE-1.2.DWG

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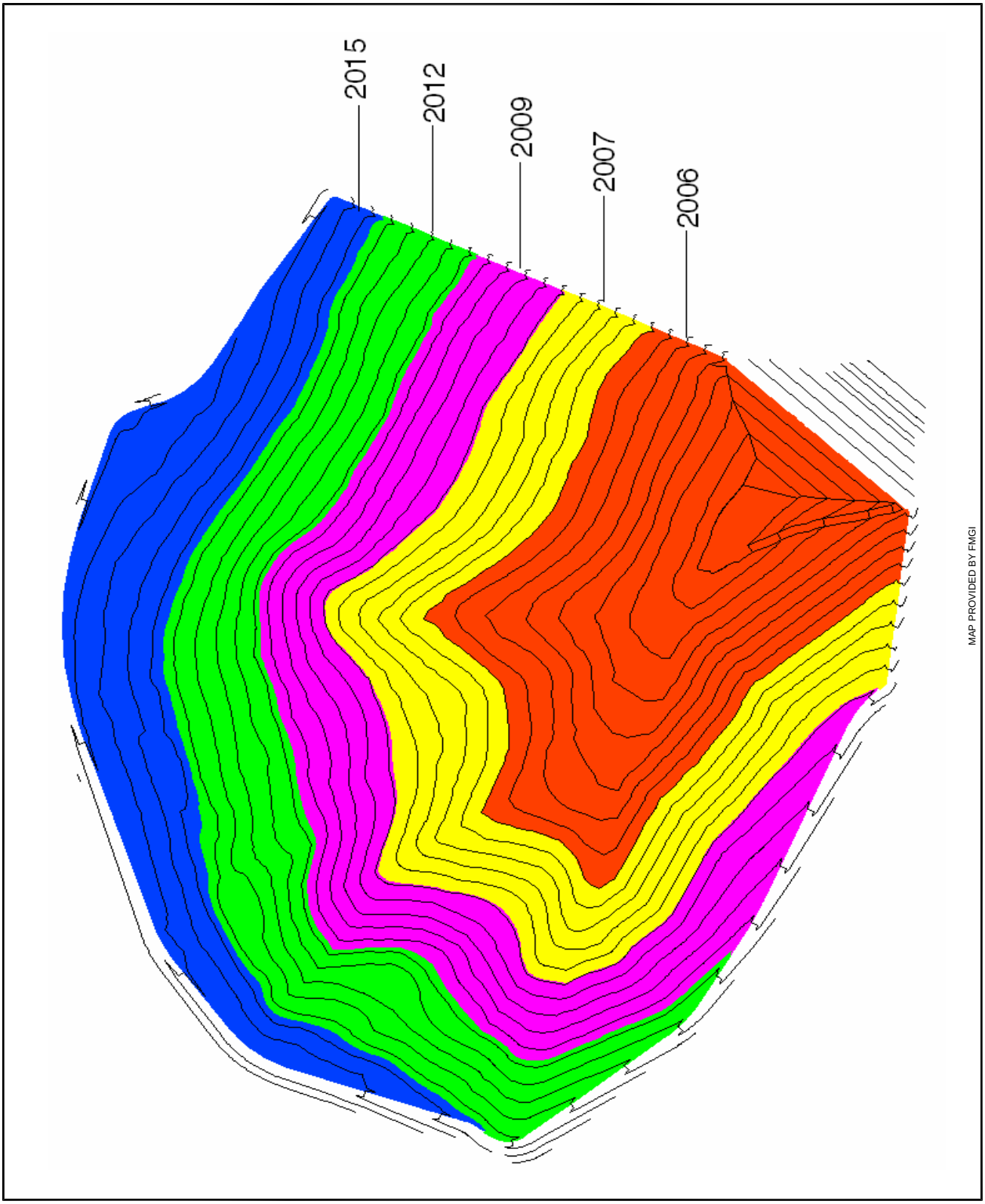
Figure 1.3 Construction and loading phases for the proposed heap leach pad



F:\2643 - FT KNOX HEAP LEACH CLOSURE\CAD\2643-R1-FEBRUARY-2006\FIGURE-1.3.DWG

2 PHYSICAL SETTING

2.1 General

The Fort Knox site is located in the Chena River basin within the Yukon-Tanana Uplands physiographic province. The site is situated within the Fish Creek sub-basin, which is tributary to the Chena River. Rounded, even topped ridges with gentle slopes characterize the higher elevations ranging between 1,200 and 1,300 ft above mean sea level (ft amsl). The broad flat drainages are elongated east-west to southwest-northeast. The open pit is centered on the north flank of Gilmore Dome on a ridge between Melba Creek and Monte Cristo Creek. The remaining site facilities including the waste rock piles, TSF, water reservoir, mill and plant are located within the Barnes Creek or Fish Creek drainage. The proposed heap leach facility will be located in the Walter Creek drainage, upgradient of the TSF. Figure 1.2 shows the facility locations at the site.

2.2 Climate

The climate at the site is continental sub-arctic with the majority of precipitation occurring during the months between May and September. Approximately seven years of monthly precipitation data (December 1997 to December 2004) are available from the weather station at the Fort Knox Mine (elevation 1,621 ft amsl). Another four years of monthly precipitation and temperature data were collected at a local station at the mine site (the Valley station) from October 1990 to September 1994. This station was located about 1,350 ft south of the Fort Knox Mine station at elevation 1,400 ft amsl.

The remaining data were obtained from the weather station at Fairbanks International Airport. Table 2.1 lists the weather stations in the area that were used as sources for climatic data.

Table 2.1 Weather stations near the Fort Knox Mine

Station Name	Coop ID No.	Elev. above mean sea level (ft)	Period of record (Month/Year)	Lat./Long.
Fort Knox Mine	503160	1,621	12/97-12/04	65°00'N/147°20'W
Valley	N/A	1,400	10/90-09/94	65°00'N/147°20'W
Fairbanks Intl Airport	502968	432	01/23-02/05	64°48'N/147°53'W

Table 2.2 summarizes the monthly precipitation based on the entire period of record at the site (Fort Knox and Valley stations). Annual precipitation totals range from 14.45 to 23.14 inches and average approximately 20 inches per year. Most precipitation occurs between May and September.

Table 2.2 Mine site precipitation data

Month	1998	1999	2000	2001	2002	2003	AVG
January	0.10	0.93	2.11	0.39	1.03	0.36	0.82
February	0.14	0.19	0.00	0.49	0.70	1.03	0.43
March	0.11	0.67	0.03	0.40	0.15	0.13	0.25
April	0.11	0.63	0.00	0.21	3.14	0.01	0.68
May	1.66	1.06	2.13	1.05	0.87	0.30	1.18
June	1.51	1.73	1.57	2.09	2.69	1.20	1.80
July	4.93	3.38	2.41	3.38	4.96	7.70	4.46
August	4.23	2.78	6.42	3.59	5.22	3.59	4. 31
September	2.76	3.13	3.66	0.27	1.98	2.68	2. 41
October	0.16	2.64	1.73	1.83	1.85	1.42	1.61
November	0.73	2.26	0.83	0.14	0.02	2.78	1.13
December	1.24	1.56	0.38	0.61	0.53	1.49	0. 97
ANNUAL	**17.68**	**20.96**	**21.27**	**14.45**	**23.14**	**22.69**	**20.04**

Mean daily, minimum daily, and maximum daily air temperature data were available from the Fort Knox/Valley station (October 1990 to September 1994). Table 2.3 provides a summary of the range in average monthly temperature values.

Table 2.3 Average monthly mean, minimum, and maximum temperatures at the Fort Knox Mine

Month	Average monthly mean (°F)	Average monthly minimum (°F)	Average monthly maximum (°F)
January	5.00	-3.12	11.95
February	7.39	-0.42	16.49
March	13.02	3.10	23.54
April	29.89	19.70	40.06
May	45.04	34.75	54.52
June	57.41	46.88	66.90
July	58.21	48.65	67.15
August	51.69	43.26	59.88
September	38.92	30.21	47.40
October	24.32	17.47	30.95
November	10.22	3.55	16.65
December	3.25	-4.01	10.41

Note: After Knight Piesold, 2005c.

Various reports have cited a range of free water evaporation rates. Evaporation rates used for water balance analyses completed by Halepaska have ranged from between 7.31 and 15.45 inches per year (John C. Halepaska and Associates, Inc. (JCHA), 1992). Knight-Piésold (1994) used a value of 17.02 inches per year. Dames and Moore maintained a Class A evaporation pan at the mine site for the months of June through September, 1990. Based on these data the total annual actual evaporation was estimated to be about 6 and 9 inches per year. Currently, FGMI uses annual values of approximately 10.4 inches for operational water balance purposes.

2.3 Geology

The results from test pits and borings completed by Knight Piesold (2005c) provide the basis for the description of the geologic conditions in the area of the proposed facility presented in the following sections.

2.3.1 Bedrock

The Fort Knox mine is located in the Fairbanks Mining District, in the northeast part of the Yukon-Tanana Upland. The mining district is divided into four metamorphosed stratigraphic groups; the Chatanika sequence, the Fairbanks Schist, the Chena River sequence, and the Birch Hill sequence.

Mapping indicates the leach pad area is underlain by quartz schist, muscovite schist and minor amounts of graphitic schist (Figure 2.1). The upper portion of the bedrock includes a zone of highly to moderately weathered muscovite-quartz schist which breaks down to soil-like material when excavated. The degree of weathering of this material decreases with depth. The thickness of this zone ranges from 4 to 20 ft, and the material consists mostly of silty gravel with sand and silty sand with gravel. Less frequent variations encountered are well graded gravel with silt and sand and well graded sand with silt and gravel (Knight Piesold, 2005c).

2.3.2 Alluvium/Colluvium

Bedrock on the valley side slopes is covered with generally 5 to 15 ft of colluvium comprised of dense silty sands and gravels. In some localized areas the overburden thickness is on the order of 30 ft.

Quaternary unconsolidated valley-fill deposits are found along the valley bottoms. These consist of silty gravels with sand and sandy silts with gravel. The alluvium consists primarily of a thin layer of organic soil and unconsolidated silt, sand, and gravel. In the larger valleys there is a basal gravel, which has grain sizes between sand and gravel size and may contain boulders as large as 1 to 2 ft in diameter. In many areas this basal unit between the surficial materials and the bedrock has been extensively placer mined in the area. It does not appear that placer mining occurred in Walter Creek where the proposed facility will be located (Knight Piesold, 2005c).

2.3.3 Geologic structure

The mine is situated on the southeast flank of a broad asymmetric synform structure with an east-northeast trending axis. Fish Creek parallels the general strike of the foliations. Several shear zones appear to have controlled the development of drainages in the area. The dominant structural trend of the district is expressed by numerous northeast trending faults and shear zones, which were important to the localization of gold mineralization.

A series of parallel northeast-to-southwest-trending faults traverse the areas adjacent to the project site (Figure 2.1). No faults have been mapped on the leach pad site and the recent drilling within the footprint area did not encounter any significant faults. Numerous relatively thin shear zones are present, and they appear to follow foliation or joints or both (Knight Piesold, 2005c).

2.4 Hydrology

The surface water and groundwater conditions across the site (including the area of the proposed heap leach pad) have been evaluated through various investigations prior to and during active mining. Preliminary work was completed during pre-feasibility (EBA Engineering, 1990) and initial design activities (JCHA, 1992a, 1992b, and 1996). Most recently, Knight Piesold (2005c) completed an investigation of the surface and subsurface conditions as part of the geotechnical work required for the engineering design. As mentioned previously, this consisted of test pit excavation, condemnation/geotechnical drilling, and laboratory testing. The following discussion is based on the hydrologic data compiled during these investigations.

2.4.1 Surface water hydrology

The project site lies in the Walter Creek sub-basin, which is tributary to the Barnes/Fish Creek drainage. It appears the bottom of the Walter Creek valley was never disturbed by placer mining. Walter Creek flows to the existing TSF basin. Tailing material is currently at an elevation of approximately 1,480 ft amsl within the Walter Creek drainage. The main drainage of the creek is active and fed by the springs and seeps. Instantaneous flow rates in Walter Creek were measured by FGMI in May and June, 2005 and ranged from 0.54 to 0.86 cubic ft per second (cfs) (Knight Piesold, 2005c).

2.4.2 Groundwater hydrology

The two principal hydrostratigraphic units in the area of the proposed heap leach facility are the alluvium that occurs within the Walter Creek drainage and the fractured bedrock. The following sections provide a description of each unit.

Alluvium

The alluvium in Walter Creek typically consists of a thin layer of organic soils, moss and vegetation, underlain by organic silts with occasional channel deposits of sand and gravel. Laboratory testing completed by Knight Piesold (2005c) indicates the alluvium consist predominantly of silty gravel with sand, gravely silt with sand, and well graded gravel with silt and sand. These soils are generally light gray to dark gray in color. The alluvium overlies an erosional surface of the weathered bedrock. The depth to groundwater in the alluvium ranges from 0 to 10 ft below ground surface (ft bgs).

Based on aquifer tests performed by JCHA (1992a) the permeability of the basal gravel ranges between 10^{-4} to 10^{-5} cm/sec. Hydraulic conductivity values for the alluvial material are estimated to range between 10^{-2} to 10^{-5} cm/sec with an average of 7×10^{-3} cm/sec.

Bedrock

The underlying bedrock aquifer consists primarily of schist (referred to as the Fairbanks schist) and is interpreted to be a pre-Cambrian Age. This schist is host to younger granitic intrusions, such as the one outcropping at the Fort Knox Mine site. Based on condemnation drilling results, the upper portion of the bedrock (ranging up to 20 ft in thickness) is highly weathered. The degree of weathering depends on the original lithologic content of the bedrock and exposure. Weathering characteristics consist of intense fracturing, alteration of primary minerals to clays and oxides (such as iron oxide), dislocation from soil creep and the filling of fractures with sand, silt, and clay.

Movement of groundwater in the bedrock aquifer occurs in open fractures. The degree of fracturing observed during the drilling of the condemnation holes was variable, as indicated by the range of hydraulic conductivities ranging from 10^{-2} to 10^{-5} cm/sec. Air-lift flow rates measured during drilling range from less than 1 to 25 gpm. Depth to water in the bedrock ranges from 2 to 56 ft bgs.

Table 2.4 summarizes water levels in the bedrock based on data collected in the Walter Creek drainage prior to mining.

Table 2.4 Groundwater monitoring data

Well name	Approximate ground surface elevation (ft amsl)	Well depth (ft)	Groundwater elevation* (ft amsl)
BB-6D	1,935	60	1,922
FB-9D	1,860	93	1,822
WB-1S	2,200	33	2,145
WB-1D	2,200	151	2,144

* Water levels measured in 1992

Permafrost

No permafrost was encountered in the footprint of the proposed facility except for along the southern margin of the Walter Creek valley bottom. In this location permafrost was exposed in a recent road cut and was about 6 ft thick (Knight Piesold, 2005c).

Groundwater flow

Pre-mining groundwater elevations in the alluvium ranged from about 1,700 ft amsl in the upper reaches Barnes Creek and Walter Creek to 1,000 ft amsl in the vicinity of the freshwater reservoir. Hydraulic gradients within the alluvium, present in the upland areas such as Walter Creek, average approximately 0.06 ft/ft. The groundwater flow direction in the alluvium is generally from west to east and follows the topography. Figure 2.2 illustrates the baseline groundwater elevations within the alluvium. These data were collected from wells which have since been decommissioned.

Figure 2.3 illustrates the pre-mining bedrock groundwater elevations in the vicinity of the proposed heap leach pad. Based on recent water levels collected during condemnation drilling, current conditions are similar to those measured during baseline characterization. Groundwater flow directions in the bedrock generally follow surface topography. In the vicinity of the proposed facility, groundwater elevations range from 1,822 ft amsl to 2,145 ft amsl. Hydraulic gradients in the bedrock ranged from 0.08 to 0.10 ft/ft in the Walter Creek drainage.

2.5 Downgradient facilities

Facilities located downgradient of the proposed heap leach pad include the TSF, the seepage collection system, and the freshwater reservoir. Of these, the TSF and seepage collection system are the most significant because they will provide contingency containment during operation and will be an integral part of site-wide closure. This will include the closure management plan developed for the heap leach pad.

The TSF has been designed as a zoned earthfill/rockfill structure capable of withstanding full hydrostatic load. Slurried tailings are currently discharged sub-aerially from pipes located at the upstream margin of the TSF facility. Approximately 40,000 to 45,000 tons per day (tpd) are processed and deposited in the TSF. To date, approximately 123 million tons (Mt) of tailings have been placed in the facility. A decant pool covers an area of approximately 175 acres and serves as the source of makeup water to the mill.

Seepage from the TSF is collected in a seepage collection sump located at the downgradient toe of the embankment. The sump is connected to the foundation drain in the dam. Solution collected in the sump is pumped out and returned to the TSF. In addition, there are six interceptor wells that collect any bypass flow from the sump. Pumping from these wells has created a cone of depression that provides hydraulic containment.

2.6 Surface water and groundwater quality

2.6.1 Surface water quality

Surface water quality data in the vicinity of Walter Creek are limited to baseline samples collected prior to mining. The samples collected closest to the proposed facility were collected in Upper Fish Creek. Table 2.5 summarizes the range of values for selected parameters.

Table 2.5 Summary of surface water quality

	Water quality criteria	Upper Fish Creek Min	Max	Average
pH	6.5-8.5	6.8	7.2	7
TDS	500	58	137	82
TSS		22	6,500	151(1)
Calcium		9.02	40.3	17.4
Magnesium		2.46	30.5	6.9
Sodium		2.14	5.97	3.79
Potassium		0.45	13.1	2.82
Chloride		0.11	1.5	0.37
Sulfate	250	6.09	28.8	11.4
Alkalinity		18	55	38
Arsenic	0.01	<0.001	0.056	0.016
Antimony	0.006	<0.003	-	-
Cadmium	0.0004	<0.0001	0.0003	0.0003
Copper	0.015	<0.07	0.153	0.024
Iron	0.3	1.85	117	16.9
Manganese	0.05	0.103	1.88	0.43
Selenium	0.005	<0.002	0.005	0.0014
Zinc	0.191	<0.006	0.284	0.048
Nitrate	10	<0.03	0.4	0.24
Nitrite	1	<0.03	0.05	0.031
Ammonia	2.43-6.67	<0.05	-	-
Cyanide		<0.01	-	-
WAD cyanide	0.0052	<0.01	-	-

Note: All concentrations reported as mg/L.

The surface water quality is characterized by TDS of approximately 80 mg/L. The water is a calcium-bicarbonate type. The pH at Upper Fish Creek is near neutral with limited variability (6.8 to 7.2). The water quality in Fish Creek reflects the fact that the mineralized alluvium was mined previously as an ore body. Concentrations for arsenic, copper, iron manganese, selenium, and zinc exceeded the water quality standards prior to construction of the mine. It is likely that the water quality in Walter Creek is very similar to that found in the upper reaches of Fish Creek. Baseline data collected prior to mining indicates little variability in surface water quality within the upland areas such as Walter Creek.

2.6.2 Groundwater

Groundwater quality data are available from baseline characterization prior to mining and samples collected during the recent drilling program. Figures 2.2 and 2.3 illustrate the locations of the baseline groundwater monitoring wells in the Walter Creek drainage area. Groundwater quality data from these wells are available for the early 1990s. These data are summarized in Table 2.6. Table 2.7 summarizes the recent data collected from the condemnation drilling program. The drilling locations where the samples were collected are illustrated on Figure 1.2. Prior to mining, groundwater was generally near neutral pH with low dissolved solids concentrations.

Most baseline pH measurements were in the range 6 to 7. Electrical conductivity ranged from 10 to 60 µS/cm. Samples from WB-1D had electrical conductivity ranging from 300 to 400 µS/cm.

Trace metals present in detectable concentrations prior to mining included cadmium, copper, iron, manganese, selenium, and zinc. Sulfate concentrations are generally less than 20 mg/L, with the exception of the deepest well where the concentration is generally around 60 mg/L. Alkalinity is low in shallow ground water (about 2 mg/L in WB-1S), with concentrations generally increasing with depth to about 40 mg/L in WB-1D.

Current groundwater quality is similar in composition to that defined during baseline characterization. Values of pH are circum-neutral to slightly alkaline. Dissolved solids concentrations ranged from approximately 39 to 228 mg/L. Sulfate concentrations range from about 25 to 95 mg/L. Trace metals present in detectable concentrations include antimony (0.002 to 0.004 mg/L), arsenic (0.0178 mg/L), chromium (0.01 to 0.02 mg/L), manganese (0.003 to 0.3 mg/L), and zinc (0.013 mg/L).

Table 2.6 Baseline groundwater quality data summary

Parameter	Water quality criteria	BB-6D			FB-9D			WB-1D			WB-1S		
		Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg
pH	6.5-8.5	6.5	8.4	7.5	6.5	8.1	7.3	6.5	7.6	7.0	5.4	7.3	6.4
TDS	500	27	56	41	21	52	35	130	191	158	15	72	46
TSS		14	210	90	8	190	75	10	1,400	208	12	620	172
Alkalinity, total		20	25	22	<0.9	42	19	40	60	47	<0.9	3.0	1.4
Antimony	0.006	<0.0013	<0.005	0.003	<0.003	<0.005	0.003	<0.003	<0.005	0.004	<0.003	<0.005	0.003
Arsenic	0.01	<0.001	<0.006	0.003	0.002	<0.006	0.004	<0.001	<0.006	0.003	<0.003	0.008	0.004
Cadmium	0.0004	<0.0001	<0.005	0.001	<0.0001	<0.005	0.001	<0.0001	<0.005	0.001	<0.0001	<0.005	**0.001**
Calcium		3.0	5.5	4.3	2.3	34	10	2.2	39	23	1.1	3.7	2.0
Chloride		<0.1	0.95	0.39	0.14	0.23	0.19	<0.06	0.25	0.180	0.11	0.24	0.20
Copper	0.015	<0.006	0.022	0.010	<0.006	0.025	0.009	<0.006	0.016	0.008	<0.01	0.08	**0.03**
Iron	0.3	<0.007	2.33	0.282	<0.003	0.631	0.176	<0.007	1.72	0.67	0.018	0.30	0.08
Magnesium		1.6	3.0	2.5	1.2	6.4	2.7	0.75	7.7	4.7	0.54	1.8	1.0
Manganese	0.05	<0.005	0.044	0.020	<0.002	0.404	0.108	0.06	0.94	0.35	0.022	0.16	**0.07**
Nitrate	10	<0.03	<0.1	0.06	0.04	<0.1	0.06	<0.03	0.16	0.06	0.03	<0.1	0.05
Nitrite	1	<0.01	<0.1	0.04	<0.03	<0.1	0.04	<0.01	<0.03	0.022	<0.03	<0.1	0.042
Potassium		0.79	1.55	1.14	0.76	1.79	1.09	0.88	3.64	1.62	0.47	0.92	0.70
Selenium	0.005	<0.002	<0.005	0.003	<0.002	0.006	0.003	<0.002	<0.005	0.002	<0.002	<0.005	0.002
Sodium		1.8	3.0	2.1	2.3	15	4.8	4.0	7.4	6.1	3.1	4.2	3.8
Sulfate	250	<0.9	1.7	1.3	1.2	55.1	11	58	65	62	13	20	17
Zinc	0.191	<0.002	<0.011	0.008	<0.01	0.013	0.011	0.008	0.017	0.011	<0.01	0.06	0.02
Ammonia	2.43-6.67	<0.05	<0.9	0.32	<0.05	<0.9	0.40	0.33	<0.9	0.44	<0.05	<0.9	0.40
Cyanide		<0.01	0.02	0.006	<0.01	<0.01	0.01	<0.01	<0.01	0.01	<0.01	<0.01	0.01
WAD cyanide	0.0052	<0.01	<0.01	0.01	<0.01	<0.01	0.01	<0.01	<0.01	0.01	<0.01	<0.01	0.01

All concentrations reported as mg/L.
All data collected prior to mining. Monitoring wells have since been decommissioned.

Table 2.7 Current groundwater quality data

Date	TMW-08 8/3/05	WCR-05-10 12/15/05	WCR-05-11 11/18/05	WCR-05-12 11/4/05	WCR-05-14 12/9/05
TSS	<1.0	254	151	317	88
TDS	191	224	228	38.8	150
Ammonia	<0.050	0.0502	<0.050	<0.050	0.0688
Lab pH	7.7	7.72	7.99	7.82	8.22
Phosphate	<0.051	0.443	0.201	0.223	0.106
Lab EC	360	315	382	135	255
Cynanide	<0.0040	<0.0040	<0.0040	<0.0040	<0.0040
WAD Cyanide	<0.0040	<0.0040	<0.0040	<0.0040	<0.0040
Mercury	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
Chloride	<2.5	<2.5	<2.5	<2.5	<2.5
Fluoride	<1.0	<1.0	1.03	<1.0	<1.0
Nitrate	<1.0	<1.0	<1.0	<1.0	<1.0
Nitrite	<1.0	<1.0	<1.0	<1.0	<1.0
Sulfate	43.3	70.9	94.7	24.8	37.5
Antimony	<0.00050	0.002	0.00333	0.00163	0.00432
Arsenic	0.0178	<0.0010	<0.0010	<0.0010	<0.0010
Barium	0.000329	0.00161	0.00451	0.000874	0.00257
Cadmium	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
Calcium	49.8	29.2	42.5	12.1	27.1
Chromium	0.022	0.00938	<0.0050	<0.0050	<0.0050
Copper	<0.010	<0.010	<0.010	<0.010	<0.010
Iron	<0.050	<0.050	<0.050	0.0554	0.0507
Lead	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020
Magnesium	17.8	17.4	18.2	7.08	11.7
Manganese	0.00501	0.303	0.188	0.197	0.0699
Potassium	1.16	1.33	2.25	1.5	5.46
Selenium	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Silica	<0.50	6.16	4.68	6.18	1.42
Silver	<0.010	<0.010	<0.010	<0.010	<0.010
Sodium	<3.0	7.82	4.14	4.46	9.01
Zinc	<0.010	<0.010	<0.010	0.0129	<0.010
Total Alkalinity	138	82.3	97.5	38.3	89.2
HCO_3 Alkalinity	138	82.3	97.5	38.3	89.2
Ion Balance	3.8	1.22	1.87	2.78	4.32
H2S	<0.050	0.179	0.409	0.226	0.08

All values reported in mg/L, except pH (s.u.).
Samples collected during reverse circulation drilling.

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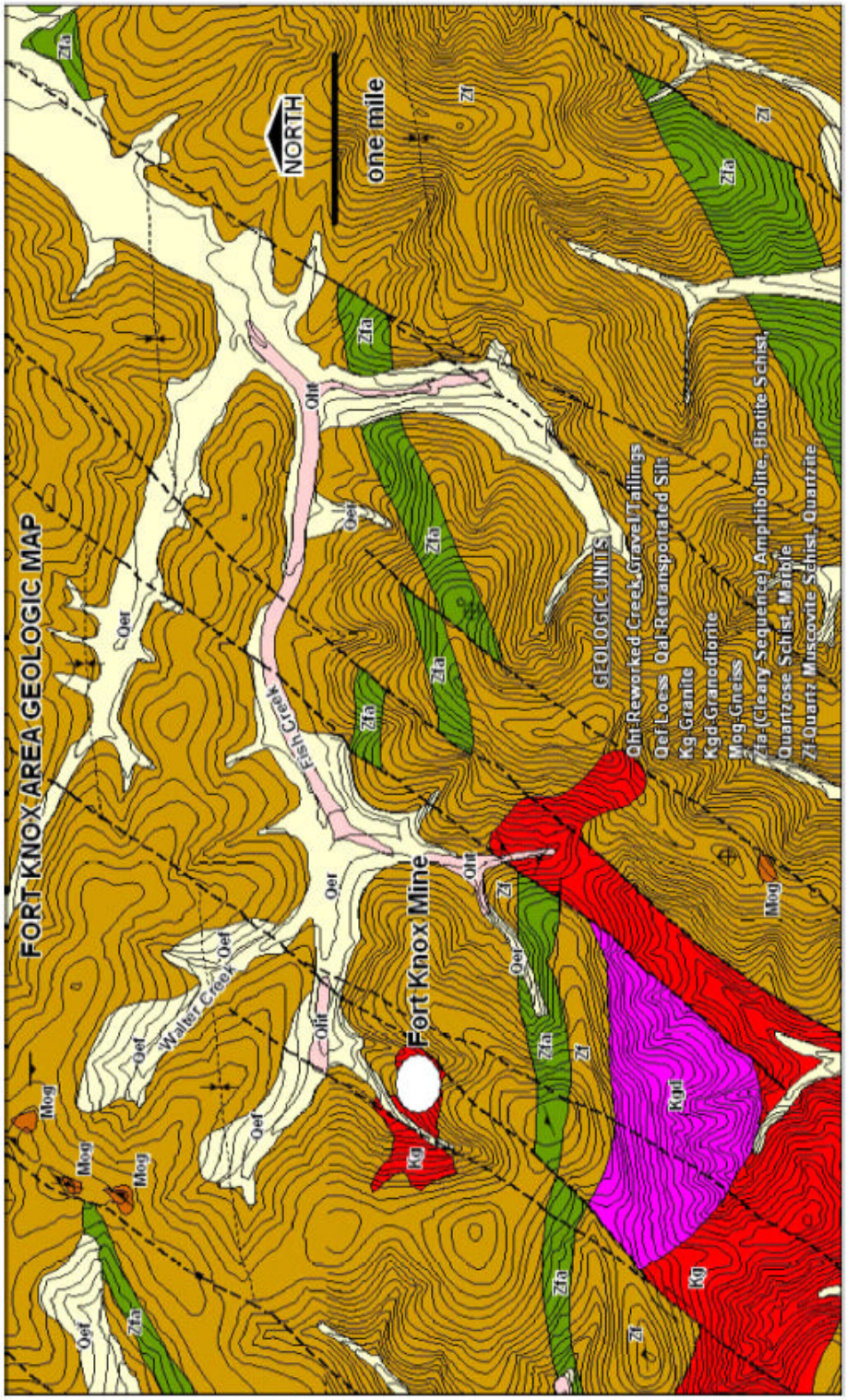
Figure 2.1 General geologic map of Walter Creek and surrounding area

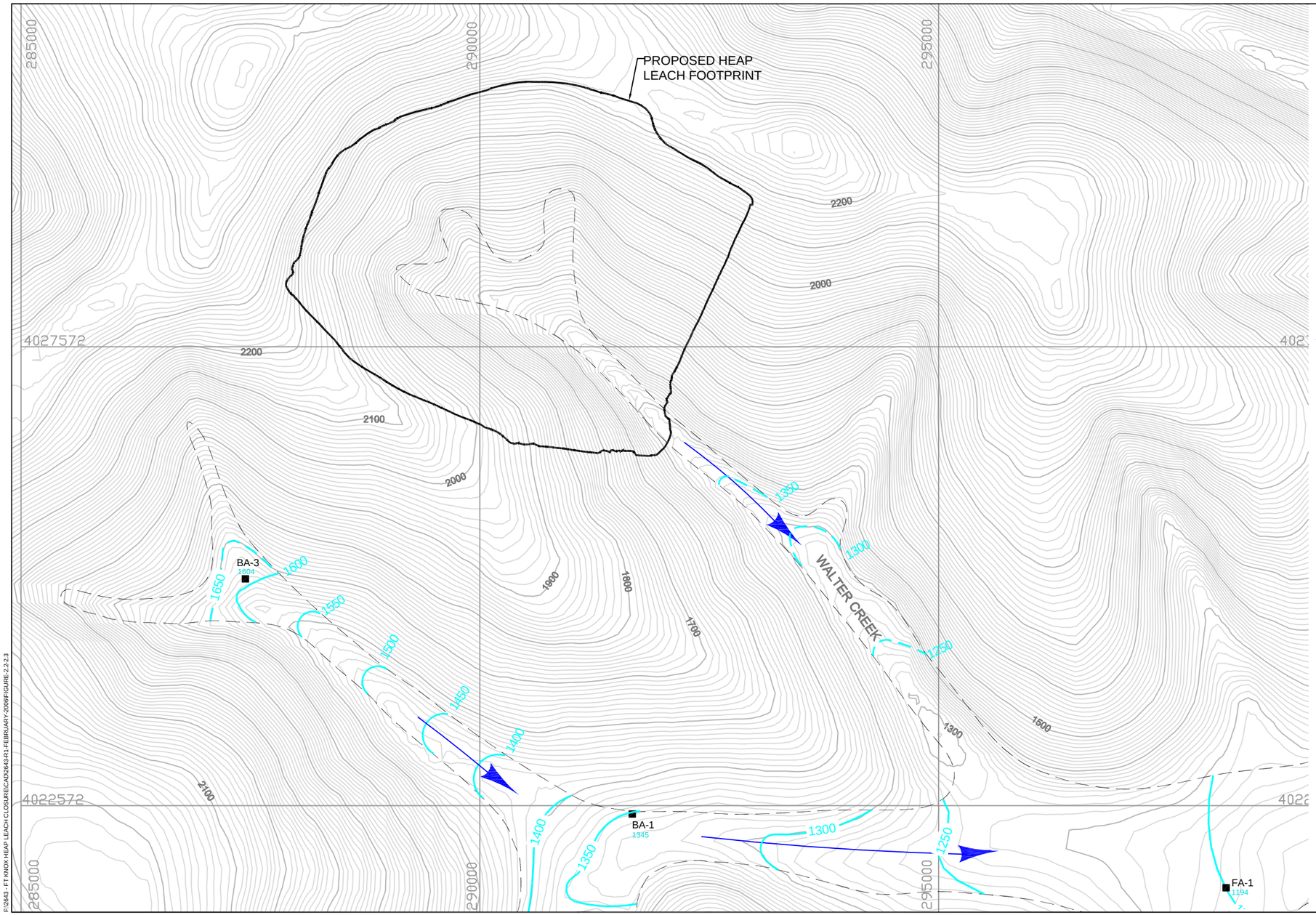


MAP PROVIDED BY KNIGHT PIESOLD

F:\2643 - FT KNOX HEAP LEACH CLOSURE\CAD\2643-R1-FEBRUARY-2006\FIGURE-2.1.DWG

WATER MANAGEMENT CONSULTANTS

Figure 2.2 Alluvial groundwater elevations



LEGEND

— — — OUTLINE OF MAIN ALLUVIAL AQUIFER SYSTEM

■ FA-1 1194 — ALLUVIAL WELL AND DESIGNATION WITH STATIC WATER LEVEL IN FT MSL

— 1000 — EQUIPOTENTIAL LINE
CONTOUR INTERVAL IS 50 FT
CONTOURS ARE DASHED WHERE INFERRED

DIRECTION OF GROUNDWATER FLOW

NOTES:

WATER LEVEL CONTOURS ARE DRAWN ASSUMING THAT THERE ARE NO DISTURBANCES TO ALLUVIAL AQUIFER.

WATER LEVELS PROVIDED BY HALEPASKA AND ASSOCIATES. MEASUREMENTS WERE TAKEN SEPTEMBER 1992.

ALL DATA COLLECTED PRIOR TO MINING. MONITORING WELLS HAVE SUBSEQUENTLY BEEN DECOMMISSIONED.

N

~WMCI

0 600 1200

Scale in Feet

F:\2643 - FT KNOX HEAP LEACH CLOSURE\CAD\2643-R1-FEBRUARY-2006\FIGURE 2.2-2.3

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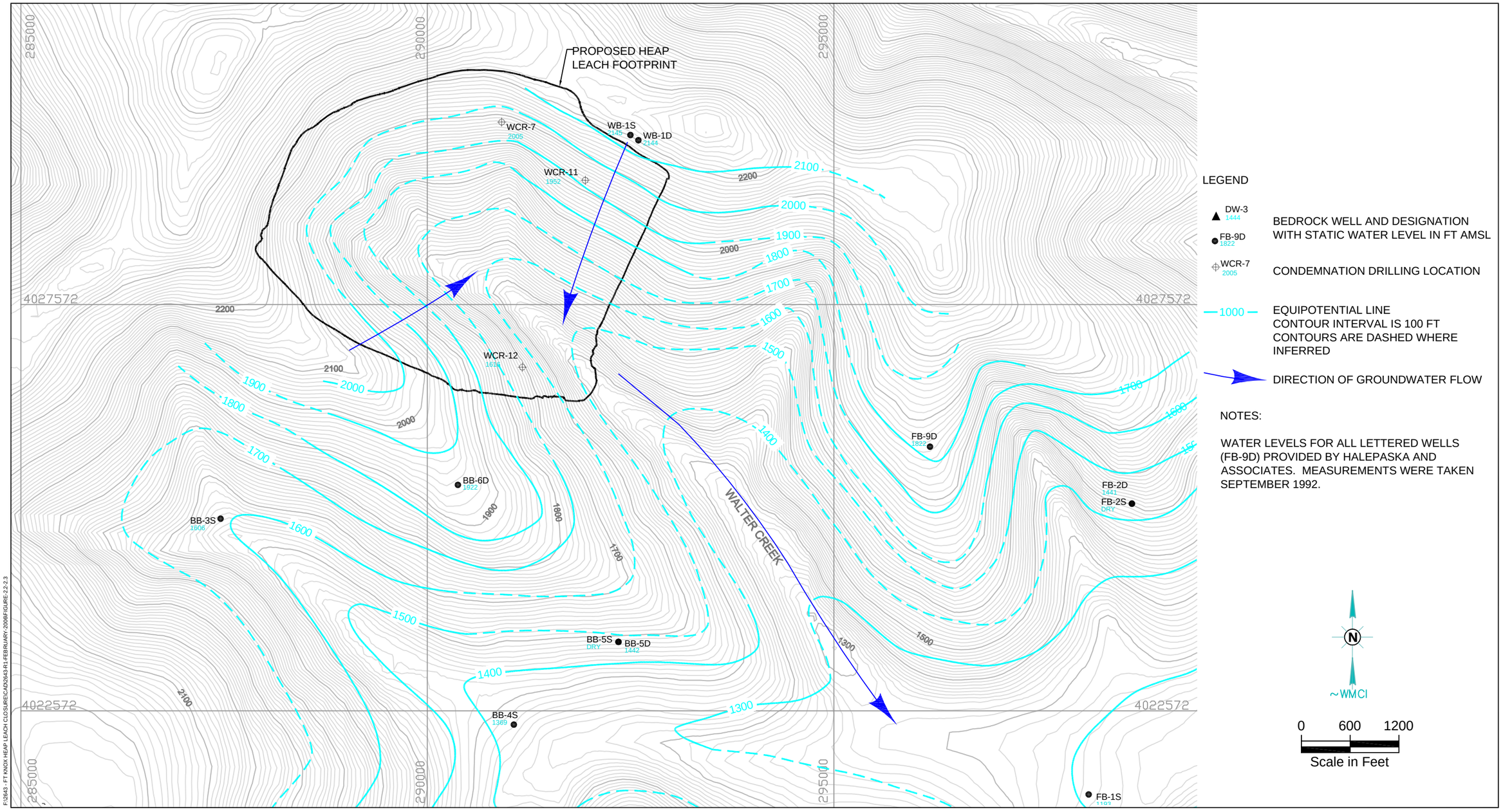
Figure 2.3 Bedrock groundwater elevations



3 HEAP LEACH PAD PRELIMINARY DESIGN

3.1 General

The general location of the proposed heap leach facility is shown in Figure 1.2. The final configuration of the heap will be optimized to account for practical and economical construction and to make the best use of the existing infrastructure. This will be an iterative process as additional information becomes available. However, the preliminary design used in this report reflects the best location and configuration to accommodate the required design leach ore volume, development of haul roads, and overall heap leach operation. Therefore, the final configuration is not expected to change significantly from the descriptions provided in the following sections.

3.2 Preliminary design and configuration

The preliminary heap configuration is shown on Figure 3.1. Typical sections through the leach pad are illustrated on Figure 3.2. The footprint area of the proposed leach pad is approximately 308 acres with a total capacity of 161 million tons (Mt).

Overall, the maximum heap height of the pad from toe to crest will be about 800 ft, and the maximum ore thickness in the pad will be about 500 ft. In-heap storage of process solution and storm water is planned. The ore placed in the pad will have an overall exterior slope of 3:1 (horizontal to vertical), and the exterior slope of the in-heap storage embankment will be 2.5:1. The interior slope of the in-heap storage embankment will be 3:1. The in-heap storage embankment will have a crest width of 50 ft at crest elevation 1,653 ft amsl. The downstream toe of the valley fill from crest to toe will be at about elevation 1,470 ft amsl. The overall fill height for the in-heap storage embankment is about 183 ft.

Two benches will be located on the overall downstream slope of the embankment fill, including one at about elevation 1,600 ft amsl, to reroute the existing pipeline and road across the Walter Creek valley. Another bench will be constructed at an elevation of 1,538 ft amsl to provide an area for installation of the collection and monitoring sumps for the underdrain system and process component and monitoring system (PCMS) (Knight Piesold, 2005c).

A platform fill will be constructed to provide a base for the in-heap storage embankment and an area to begin ore placement for leaching in the valley upstream of the in-heap storage embankment. The base platform will be constructed of random fill consisting of mine waste rock placed in 4-ft lifts compacted by controlled routing of the mine haul trucks. The platform has been designed so that the top is above the anticipated future level of tailing to be placed in the TSF. The ultimate level of the tailing will cover the lower 40 ft of the base platform. The top of the base platform will be about 10 ft above the ultimate tailing level. A horizontal bench 50 ft wide will be located at the top of the base platform downstream of the toe of the in-heap storage embankment. The underdrain PCMS collection sumps and monitoring infrastructure will be located on this bench.

A series of diversion channels will be constructed to divert runoff from the 100-yr, 24-hr storm around the various stages of the pad. The first diversion ditch will be included to provide diversion around the Stage 1 leach pad. Following construction of Stage 1, the main plant access road will be relocated, and a diversion ditch will be incorporated with that construction.

Diversion ditches will be constructed around the subsequent stages of construction to divert runoff from below the new access road and ditch and from the top of the stage. The runoff will be discharged into drainages downstream of the in-heap storage embankment. The addition of fresh water to the TSF is a key component of the closure plan for that facility. The surface water management plan for the heap leach pad is consistent with the TSF closure approach.

In the area of the in-heap storage reservoir the liner will be comprised of a double lined HDPE system over a 12-inch sub-base with a maximum permeability of 10^{-5} cm/s. In the areas of the pad above the reservoir the solution containment system will consist of a single HDPE liner over a 12-inch sub-base with a maximum permeability of 10^{-5} cm/s.

The current design criteria related to solution management and the operational water balance are summarized in Table 3.1

Table 3.1 Summary of design criteria related to solution management

Item	Design Criteria	Source
Start Loading	2007	FGMI
End of Loading	2021	Knight Piésold calculated
Project Life	14.8 years (residual leaching and reclamation not included.)	Knight Piésold calculated
Heap Leach Pad Loading Rate	30,000 tons/day (365 days/year)	FGMI
Leach Cycle	120 days	FGMI
Solution Application Rate	0.005 gpm/sf	FGMI (MLI #2517, ROM test)
Barren Solution Flow Rate	8,000 gpm (normal)	Knight Piésold calculated
Area Under Leach	1,600,000 sf	Knight Piesold calculated
Method of Application	Drip emitters (buried in winter)	FGMI and Knight Piésold
In-heap Storage Capacity	Includes: (1) the minimum operational in-heap storage volume, (2) the 100-yr, 24-hr storm volume, and (3) the 24-hr draindown volume.	Knight Piésold
Emergency Draindown Time	24 hours	FGMI
Design Storm Event	100-yr, 24-hr storm (3.5 inches)	State of Alaska and Knight Piésold
Residual Leach	Update	FGMI
Rinsing Leach	Update	Knight Piésold
Ore Dry Density	111.6 pcf	FGMI (MLI #2517, page 18)
Natural Ore Moisture Content (by weight)	2.58%	FGMI
Leaching Ore Moisture Content (by weight)	6.5%	FGMI (MLI #2517, page 18)
Draindown Ore Moisture Content (by weight)	2.58%	FGMI (MLI #2517, page 18)
Porosity at Low Stress	36%	Knight Piésold calculated

3.3 Pregnant leach solution collection and storage system

Pregnant leach solution will be conveyed to the in-heap reservoir via a drainage layer and network of collection pipes installed over the HDPE liner. The in-heap storage reservoir will have a volume of approximately 70 million gallons (Mgal). The in-heap storage reservoir will be sufficient to contain the 100-yr, 24-hr storm plus 24 hours of draindown. Solution will be removed from the in-heap storage pond using two vertical pumps each with a capacity of 4,000 gpm. A third pump with identical capacity will be installed for contingency purposes.

The PCMS consists of essentially a lined, buried channel running beneath the main collection pipes in the overliner. The main collector pipes will carry process solution on nearly a full-time basis whereas the lateral collector pipes placed in the herringbone pattern will carry process solution generally on a part-time basis related to the time of active leaching. Thus, the PCMS is located beneath the main collectors. The PCMS channel will be lined with 1 ft of prepared subbase overlain by smooth 80-mil geomembrane.

The Leachate Collection and Recovery System (LCRS) will be located under the in-heap storage reservoir. It will be designed to capture solution that may possibly penetrate the primary liner. LCRS outlet pipes will consist of 12-inch HDPE pipe which will extend to the in-heap storage reservoir crest and be booted through the primary liner. The outlet pipes will be pumped to retrieve solution if required.

3.4 Construction and operational schedule

The proposed operational schedule for the facility is outlined below (Knight Piesold, 2005b):

- 2007 – active loading and leaching of ore
- Late 2021 – final leaching of the ore that was loaded during 2021 (end of active loading)
- 2021 to 2022 – final rinsing of the heap
- 2022 – begin final draindown of the heap.

3.5 Solution application and leaching cycles

Solution will be applied using drip emitters at a rate of approximately 0.005 gpm/ft^2. The maximum active area receiving solution will be about 1.6 M ft^2 for a total flow rate of 8,000 gpm. Pumping rates may vary during operation depending on the amount of inflow resulting from spring melt and direct precipitation. The operational water balance completed by Knight Piesold indicates that the excess water during the month of May will require less barren solution addition to account for the surplus generated by snowmelt (Knight Piesold 2005b). Based on available metallurgical information, each new lift will be leached for approximately 120 days before bringing fresh ore under leach.

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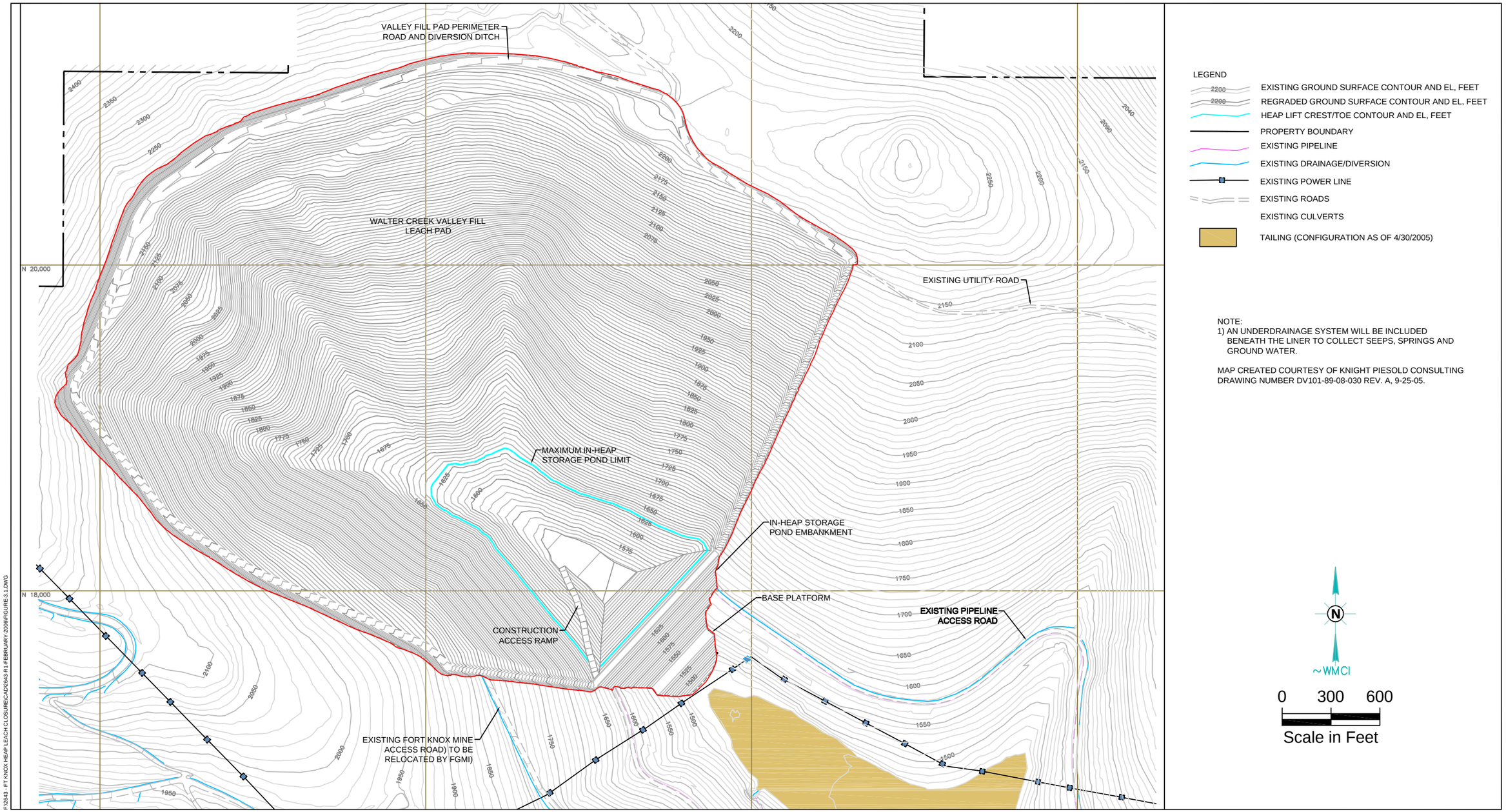
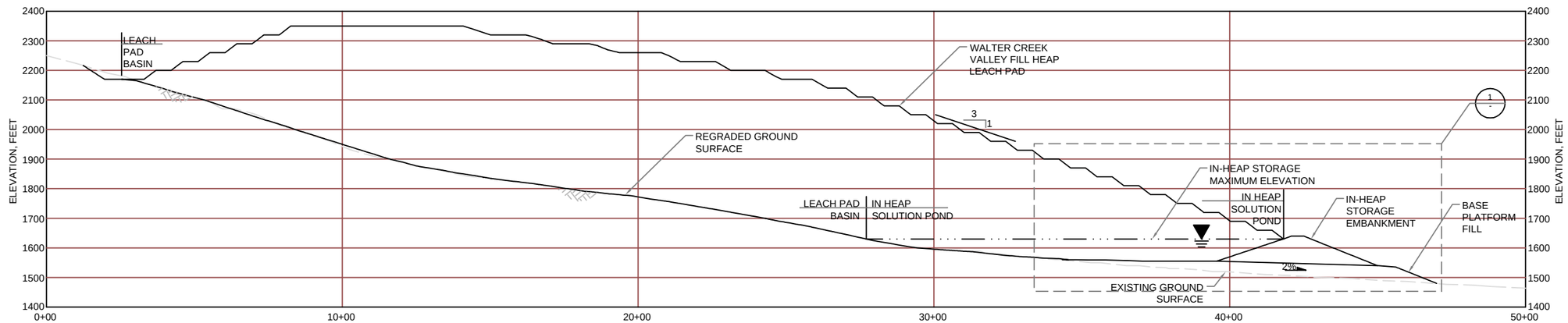
Figure 3.1 Proposed heap leach pad layout



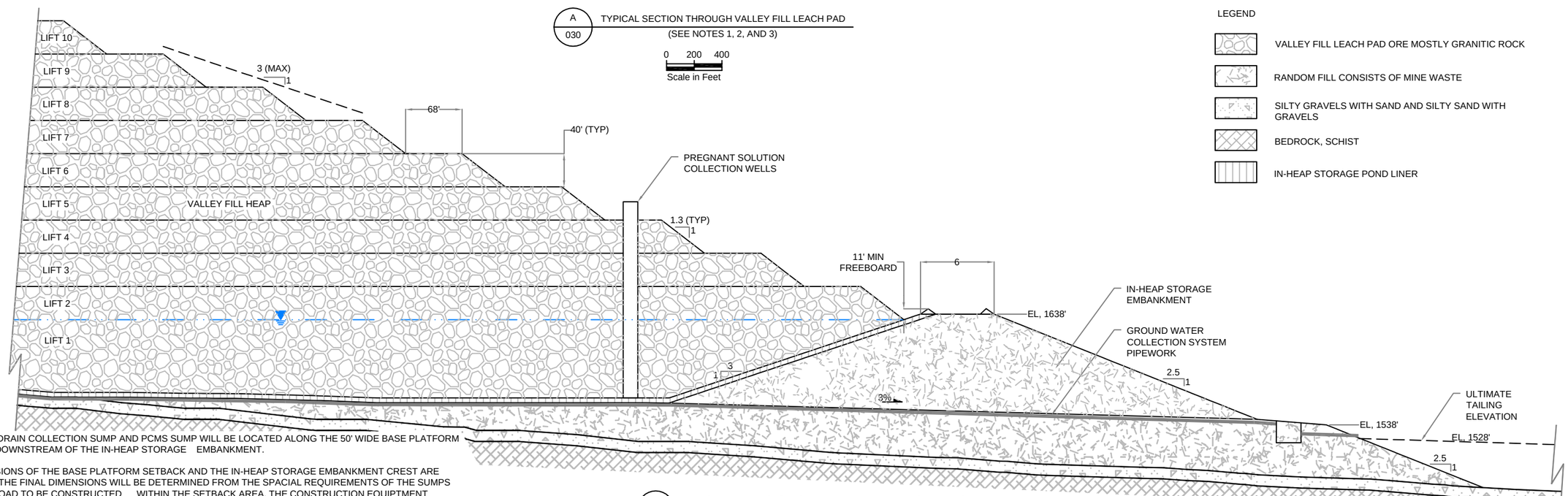
WATER MANAGEMENT CONSULTANTS

Figure 3.2 Typical sections through the heap leach pad



A / 030 TYPICAL SECTION THROUGH VALLEY FILL LEACH PAD
(SEE NOTES 1, 2, AND 3)

0 200 400
Scale in Feet



LEGEND

- VALLEY FILL LEACH PAD ORE MOSTLY GRANITIC ROCK
- RANDOM FILL CONSISTS OF MINE WASTE
- SILTY GRAVELS WITH SAND AND SILTY SAND WITH GRAVELS
- BEDROCK, SCHIST
- IN-HEAP STORAGE POND LINER

1 / - TYPICAL IN-HEAP STORAGE EMBANKMENT AND BASE PLATFORM

0 50 100
Scale in Feet

NOTES

1 . THE UNDERDRAIN COLLECTION SUMP AND PCMS SUMP WILL BE LOCATED ALONG THE 50' WIDE BASE PLATFORM FILL SETBACK DOWNSTREAM OF THE IN-HEAP STORAGE EMBANKMENT.

2. THE DIMENSIONS OF THE BASE PLATFORM SETBACK AND THE IN-HEAP STORAGE EMBANKMENT CREST ARE PRELIMINARY. THE FINAL DIMENSIONS WILL BE DETERMINED FROM THE SPACIAL REQUIREMENTS OF THE SUMPS AND ACCESS ROAD TO BE CONSTRUCTED WITHIN THE SETBACK AREA, THE CONSTRUCTION EQUIPTMENT REQUIREMENTS FOR THE EMBANKMENT CREST, AND THE OVERALL STABILITY OF THE HEAP.

3. DESIGN CONCEPTS SHOWN ON THIS FIGURE WERE PREPARED TO SUPPORT THE ASSESSMENT OF THE STATE OF ALASKA HAZARD POTENTIAL CLASSIFICATION FOR THE PROJECT. THE DESIGNS WILL BE UPDATED AS THE DESIGN PROCESS PROGRESSES.

MAP CREATED COURTESY OF KNIGHT PIESOLD CONSULTING
DRAWING NUMBER DV101-89-08-050 REV. A, 9-25-05.

F:\2643 - FT KNOX HEAP LEACH CLOSURE\CAD\2643-R1-FEBRUARY-2006\FIGURES 3.2.DWG

4 LEACH PAD WATER BALANCE

4.1 Approach for estimating the water balance

The purpose of the water balance evaluation is to quantify the discharge from the leach pad during short-term drain-down and over the extended post-closure period. The long-term estimates provide an indication of average drainage rate from the leach pad expected under representative weather and post-closure conditions.

Volumetric water flux into and out of the leach pad was calculated using a two-dimensional (2D) numerical model of unsaturated flow (VadoseW, GeoSlope 2004). After closure and reclamation, the water balance of the leach pad will be controlled by hydraulic properties of the soil cover, re-graded spent ore material, and climatological conditions. The key hydraulic properties of the cover material and spent ore include saturated hydraulic conductivity and moisture release characteristics. Climatological variables such as precipitation, temperature, wind blown snow, and solar radiation will play a key role in the long-term discharge rate from the facility. The unsaturated flow model incorporates these key hydraulic properties and climatological processes.

The approach included using available information to estimate parameter values and establish boundary conditions. A series of six 2D models were constructed to represent the range of spent ore thickness over the liner. The heights modeled were 25, 75, 125, 225, 325, and 425 ft. The total seepage was estimated by superimposing the results from each model to represent the entire facility area.

The models included three material types:

- topsoil/colluvium,
- uncompacted ore, and
- compacted ore.

A 1-ft thick cover consisting of topsoil/colluvium was defined for the nominal condition. The lower third of each model was assumed to be comprised of compacted ore. Uncompacted ore was defined from the bottom of the soil cover to the top of the compacted zone.

The boundary conditions included an atmospheric type at the surface and a seepage face at the bottom. The lateral boundaries were no-flow type. To be conservative, it was assumed that a poor stand of vegetation was established on the soil cover during each growing season.

4.2 Estimation of climatological variables

A long-term (20 year) climatological record was generated synthetically using WGEN, a stochastic weather generator (USACOE, 1998). The basis for the synthetic weather record was site-specific data and information obtained from the Fairbanks Airport weather station (Described in Section 2). The available information was used to condition the synthetic weather record to ensure that the observed seasonal variations were accurately represented in the estimated long-term record. In addition, the synthetic long-term record included extreme events such as the 100-yr, 24-hr storm (3.5 inches). The following sections provide a description of the data used to condition the synthetic record.

Precipitation

Average monthly precipitation values calculated from data collected at the mine site (discussed in Section 2.2) were used as seed values for the synthetic record. These data were used to generate the long-term precipitation record. A comparison of average monthly values calculated from the site specific and synthetic data sets are illustrated on Figure 4.1.

Temperature

Average monthly temperature values calculated from data collected at the mine site (discussed in Section 2.2) and were used as seed values for the synthetic record. These data were used to generate the long-term temperature record for low and high daily temperatures. A comparison of average monthly values calculated from the site specific and synthetic data sets are illustrated on Figure 4.2.

Relative humidity

Daily relative humidity values were estimated using data from the Fairbanks Airport weather station. The WGEN model was used to estimate the daily relative humidity values from actual monthly averages.

Solar radiation

Solar radiation values were estimated from data collected from the Fairbanks Airport weather station. WGEN was used to calculate daily maximum and minimum values used as input to Vadose/W.

Atmospheric boundary condition

The atmospheric boundary condition is an explicit representation of daily variations in temperature, solar radiation, precipitation, and relative humidity over the 20-year model period. Monthly variations in these parameters are used to estimate the form of daily precipitation (i.e., rain or snow), changes in snow pack, evaporation/sublimation, and freeze/thaw cycles. Vadose/W uses the Penman-Wilson equation to estimate actual evaporation from calculated values of potential evaporation. The Penman-Wilson accounts for temperature, solar radiation wind speed, and the relative humidity of both the air and soil surface. Ground surface temperature is calculated based on the air temperature and net radiant energy. Snow accumulation/melt are also based on an energy balance approach.

4.3 Leach pad hydrology

The following sections provide a description of the processes and physical characteristics of the leach pad that will control the short- and long-term drainage rate from the facility. The characteristics of the cover material and spent ore are described along with the estimated hydraulic properties.

Water balance components

Over time, redistribution of moisture within the leach pad will occur as a result of the following processes:

- evaporation/plant transpiration,
- storage of water as snow and ice,
- sublimation,
- infiltration,
- vertical migration via unsaturated flow, and
- gravity drainage.

The numerical model Vadose/W incorporates the processes listed above as part of the water balance calculation.

Material characteristics

The physical properties of the soil cover and ore were characterized through analysis of particle size distributions and specific gravity. This information was used along with dry bulk density values to estimate model input parameters such as porosity and saturated hydraulic conductivity.

The physical characteristics of the soil cover material were defined from samples collected during the test pit program completed by Knight Piesold (2005c). Figure 4.3 illustrates a typical particle size distribution for the soil cover material. Laboratory testing indicates the soil consists predominantly of silty gravel with sand, gravely silt with sand, and well graded gravel with silt and sand (Knight Piesold, 2005c).

Ore samples used for physical characterization were collected concurrently with those currently being used for metallurgical column testing. In addition, samples of run of mine, unmineralized granite, similar in nature to the ore were used from previous investigations to provide supplementary particle size distribution data. Figure 4.4 illustrates the average particle size distribution based on samples of spent ore taken by FGMI personnel. The large-scale sieve analysis indicates a fairly well-graded material containing approximately 5% fines. The data suggest that the ore material will have very high hydraulic conductivity. The amount of fines present result in low solution retention capacity suggesting that the ore will have a very rapid draindown response and low residual moisture content.

Particle and dry bulk density

The particle density of the soil cover material is expected to range between 2.6 and 2.65 g/cm^3 based on the descriptions provided in the test pit logs. Dry bulk density of the soil material would be expected to range from 1.7 to 1.9 g/cm^3. Using these values, the porosity of the soil cover material was estimated to be between 27 and 35 percent.

The particle density of the ore was measured to be between 2.66 and 2.68 g/cm^3 which is consistent with the density of ore currently reporting to the mill (Knight Piesold, 2005c). The dry bulk density of the ore material in the pad was estimated to range from 1.60 to 1.80 g/cm^3. Based on these values, the porosity of the ore was estimated to be between 33 and 40 percent.

4.4 Hydraulic properties

A summary of the hydraulic properties used in the model is provided in Table 4.1. The following sections provide an explanation of the data and methods used to generate the parameter estimates.

Saturated hydraulic conductivity

Hydraulic conductivity values for the soil cover and ore were estimated based on their respective textural characteristics using Hazen (1984) and Taylor (1948). The soil cover material was estimated to have a hydraulic conductivity of 0.015 ft/hr. Testing completed by Knight Piesold indicates that hydraulic conductivity of the overburden material in the footprint of the facility, that would potentially be used for the cover, can be as low as 1×10^{-4} ft/hr when compacted. A higher conductivity was selected in order to provide a conservative estimate of the soil cover characteristics.

Estimated saturated hydraulic conductivity values for the compacted and uncompacted ore range from 0.75 to 2.5 ft/hr, respectively.

Moisture release characteristics

Unsaturated flow parameters (van Genuchten parameters) used in the numerical model were approximated from material characteristics of the soil cover and ore material (Table 4.1). Figure 4.5 presents moisture content as a function of tension (i.e., negative pore pressure) and unsaturated hydraulic conductivity as a function of moisture content for materials used in the model.

Table 4.1 Model parameter estimates

Material type	Dry bulk density	Particle density	Saturated hydraulic conductivity	Porosity	van Genuchten parameters		
	P_{DB}	P_s	K_s	Φ	α	n	Θ_r
	(g/cm^3)	(g/cm^3)	(ft/hr)	(%)	(1/ft)		(%)
Soil cover	1.90	2.6	0.15	0.27	0.23	3.2	0.09
Ore-uncompacted	1.60	2.68	2.50	0.40	0.16	1.68	0.02
Ore-compacted	1.80	2.68	0.75	0.33	0.55	2.20	0.05

4.5 Simulation results for future heap configuration

Short-term drainage

The water balance model was used to project draindown conditions for the ultimate heap configuration. Figure 4.6 illustrates the predicted short-term draindown curve for the final life of mine heap leach pad over a period of one year subsequent to cessation of solution application. The initial discharge of 8,000 gpm is based on an active leaching area of approximately 1,600,000 ft^2 and an application rate of 0.005 gpm/ft^2. The model incorporates residual draindown from the other portions of the facility that will have been leached prior to the time of closure.

After 90 days of draindown, the discharge rate is predicted to decrease to approximately 170 gpm. After one year, the discharge is predicted to decrease to about 3 gpm.

Climatic conditions have only a small influence on discharge rate fluctuations over the initial draindown period. Given the magnitude of the draindown flow rate and the minor infiltration, significant variations in flow due to snowmelt or rainfall are not predicted during the first three to five months. As discharge rates continue to decline through time, the influence of infiltration on the margins of the pad (where ore thickness is less) begins to influence variations in flow.

Long-term drainage

The long-term drainage from the final life of mine heap leach pad is largely a function of infiltration of melting snow and direct precipitation. The snow melt period occurs over a one month period beginning in late April/early May.

Figure 4.7 illustrates the average discharge rate through a period of 20 years post closure. Long-term draindown rates tend to stabilize between 2 and 7 gpm depending on seasonal variations. During wet years the maximum flow rate may increase to 10 gpm during the spring melt period. The duration of the peak flows during the year is generally on the order of 10 to 12 days.

The maximum flow rates resulting from the 100 year, 24-hr storm (3.5 inches) range from 10 to 15 gpm depending on the antecedent moisture conditions.

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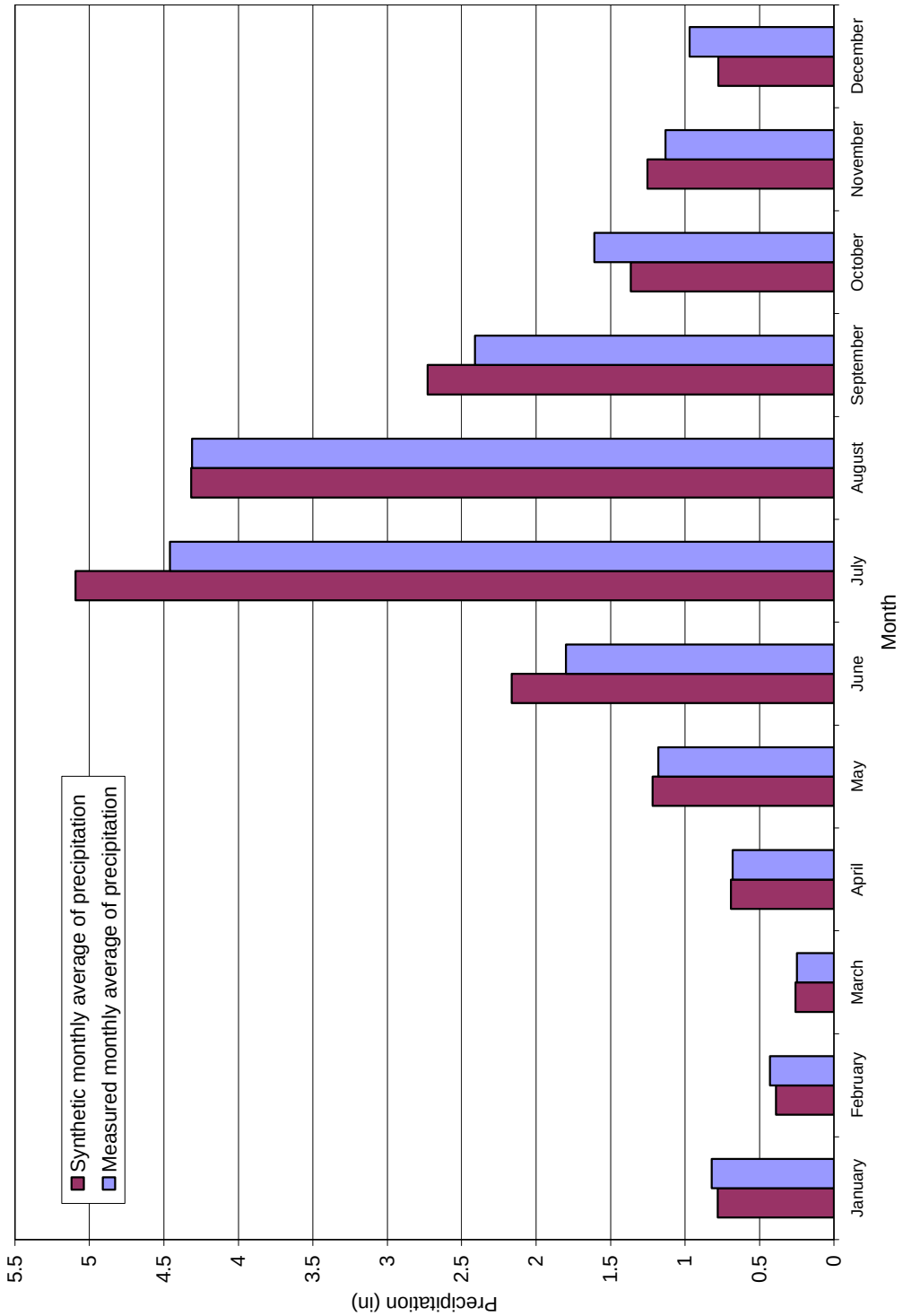
Figure 4.1 Comparison of synthetic and measured monthly average precipitation



F:\2643 - FT KNOX HEAP LEACH CLOSURE\CAD\2643-R1-FEBRUARY-2006\FIGURE-4.1.DWG

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Figure 4.2 Comparison of synthetic and measured monthly average temperature

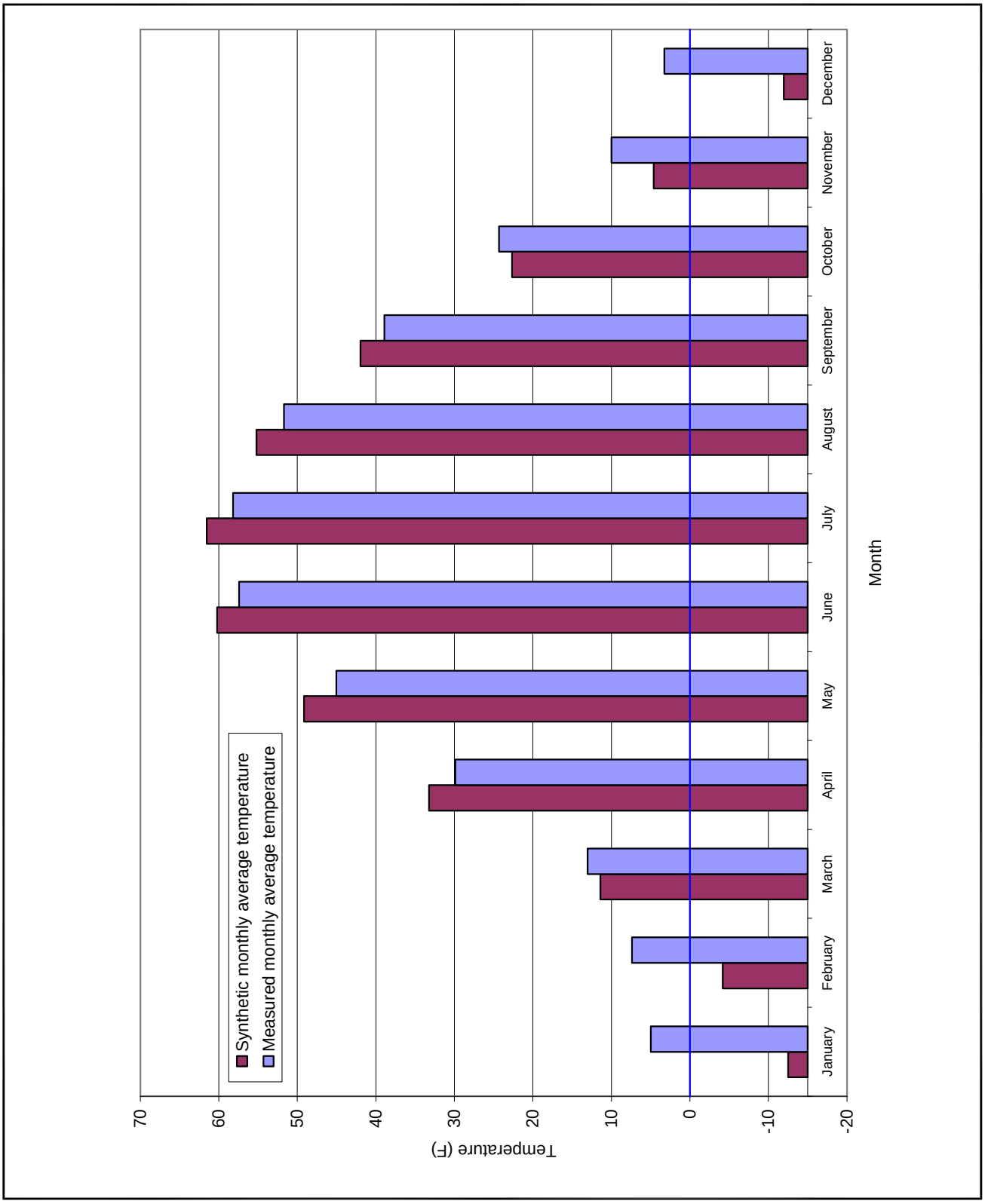

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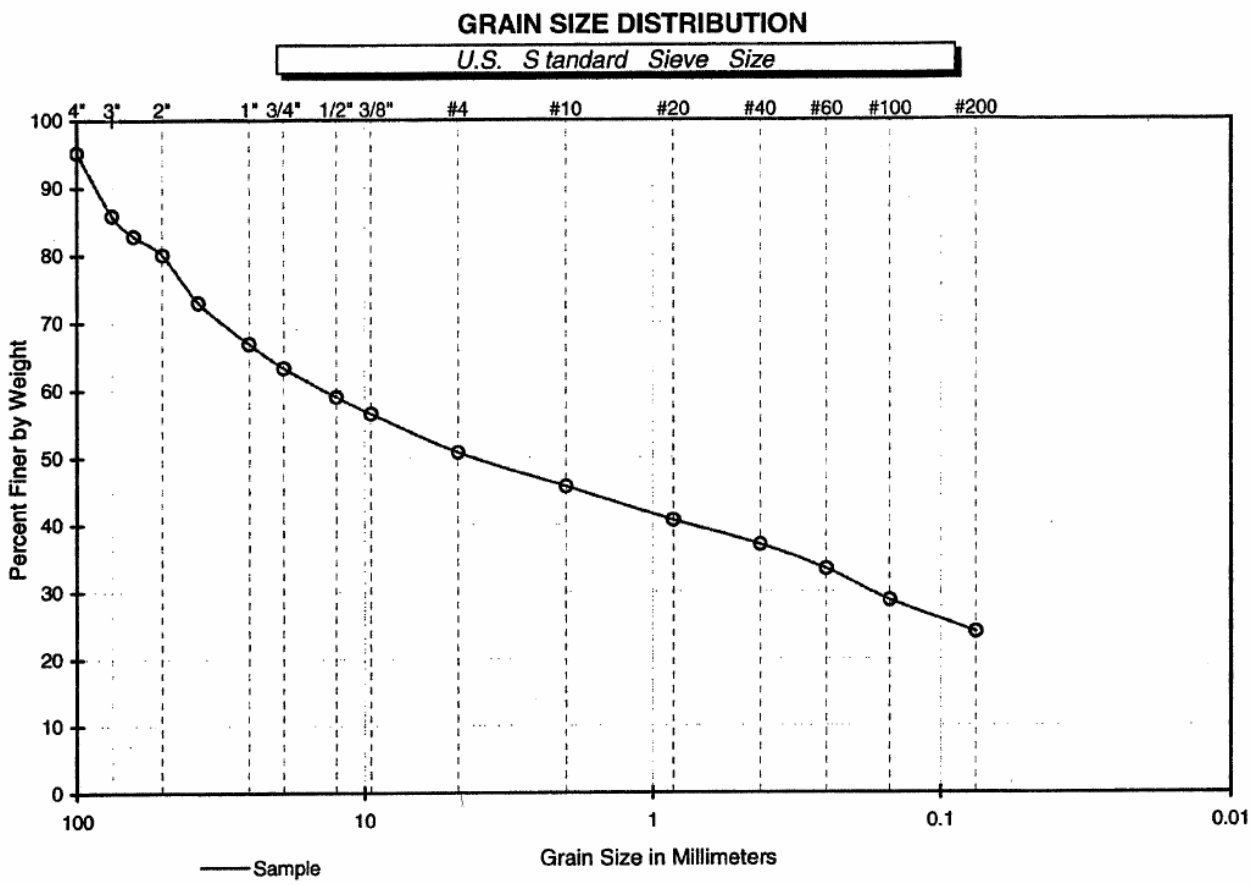
Figure 4.3 Particle distribution for the soil cover material



*Unified Soil Classification**

Silty gravel with sand (GM)

*** 100% passing 6 inch**

Not plastic

Parameter	Grain Size (mm)**
D10	nv
D16	nv
D30	0.174
D50	4.191
D60	13.835
D84	67.519

** nv - no value (insufficient data)

Cu = nv

Cc = nv

Sieve Size	Percent Passing by Weight
4"	95
3"	86
2.5"	83
2"	80
1.5"	73
1"	67
3/4"	63
1/2"	59
3/8"	57
#4	51
#10	46
#20	41
#40	37
#60	33
#100	29
#200	23.9
0.02mm	

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Figure 4.4 Particle size distributions for the run of mine ore

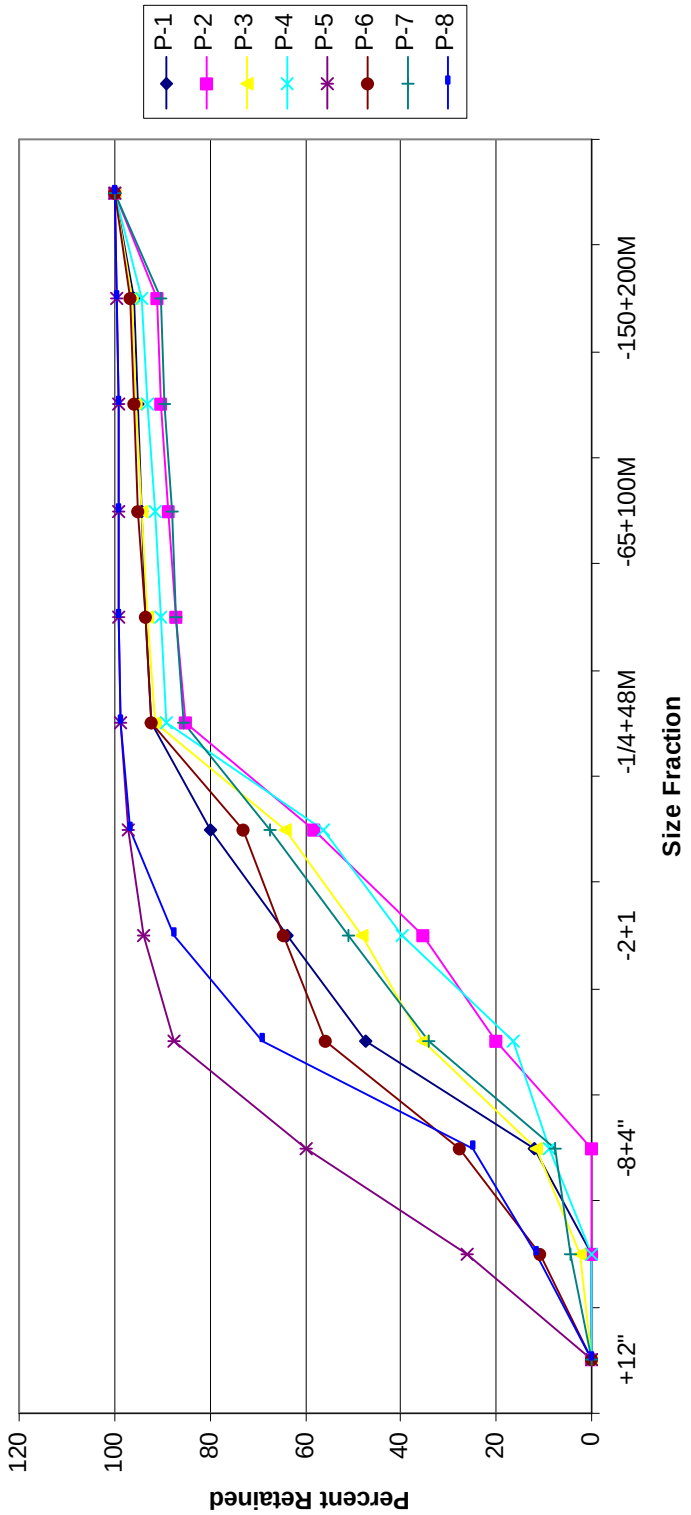

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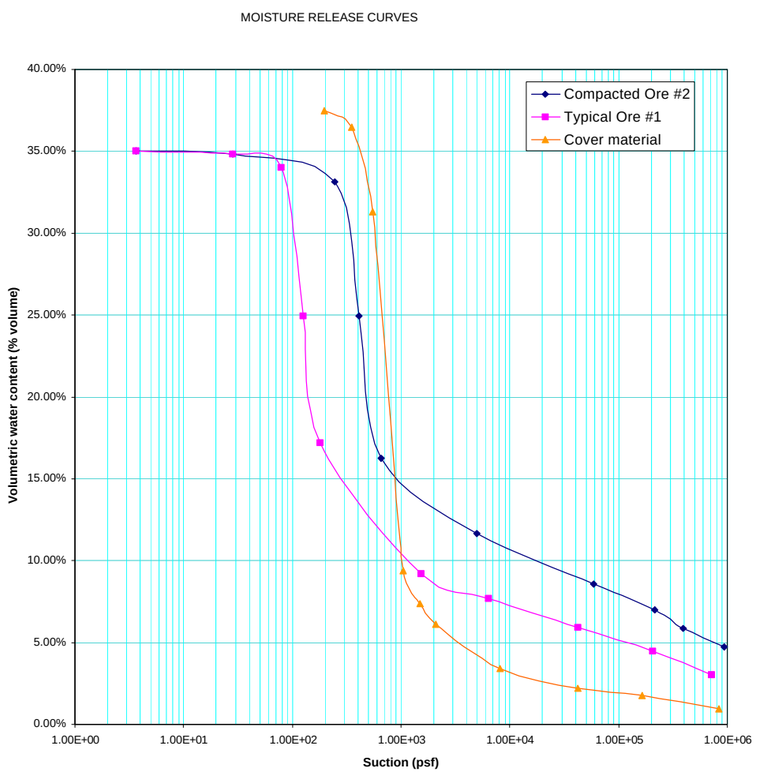
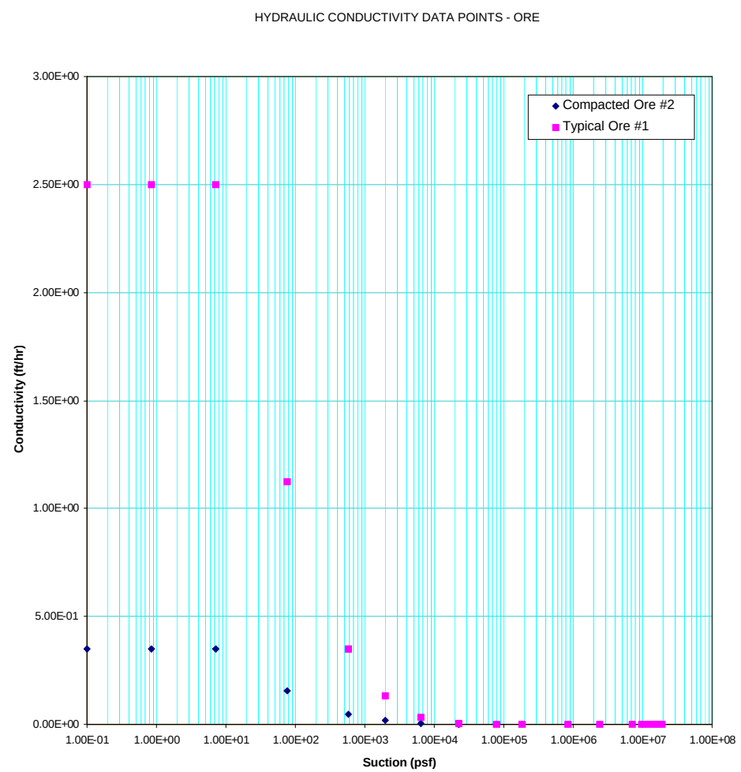
Figure 4.5 Moisture release characteristics of model material types





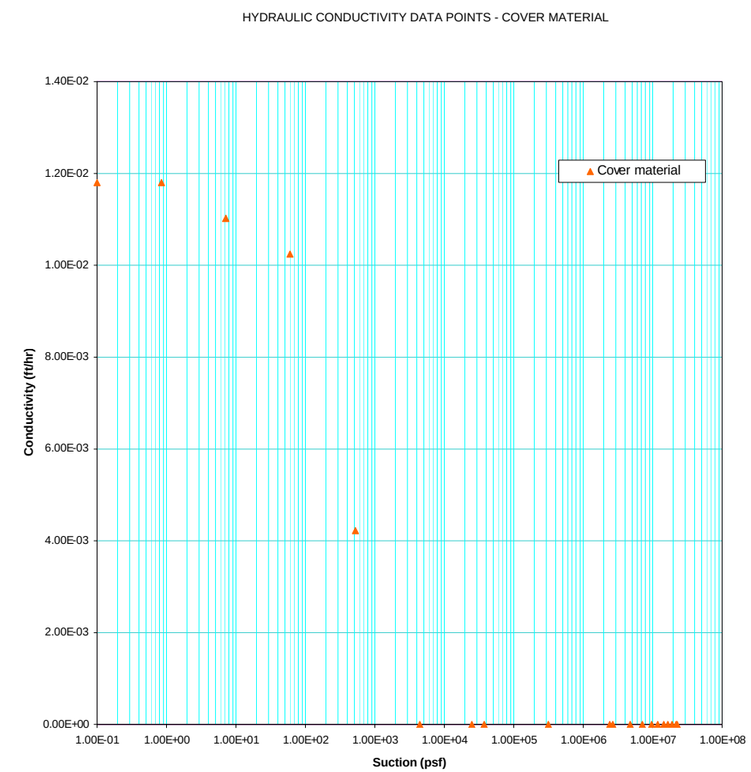


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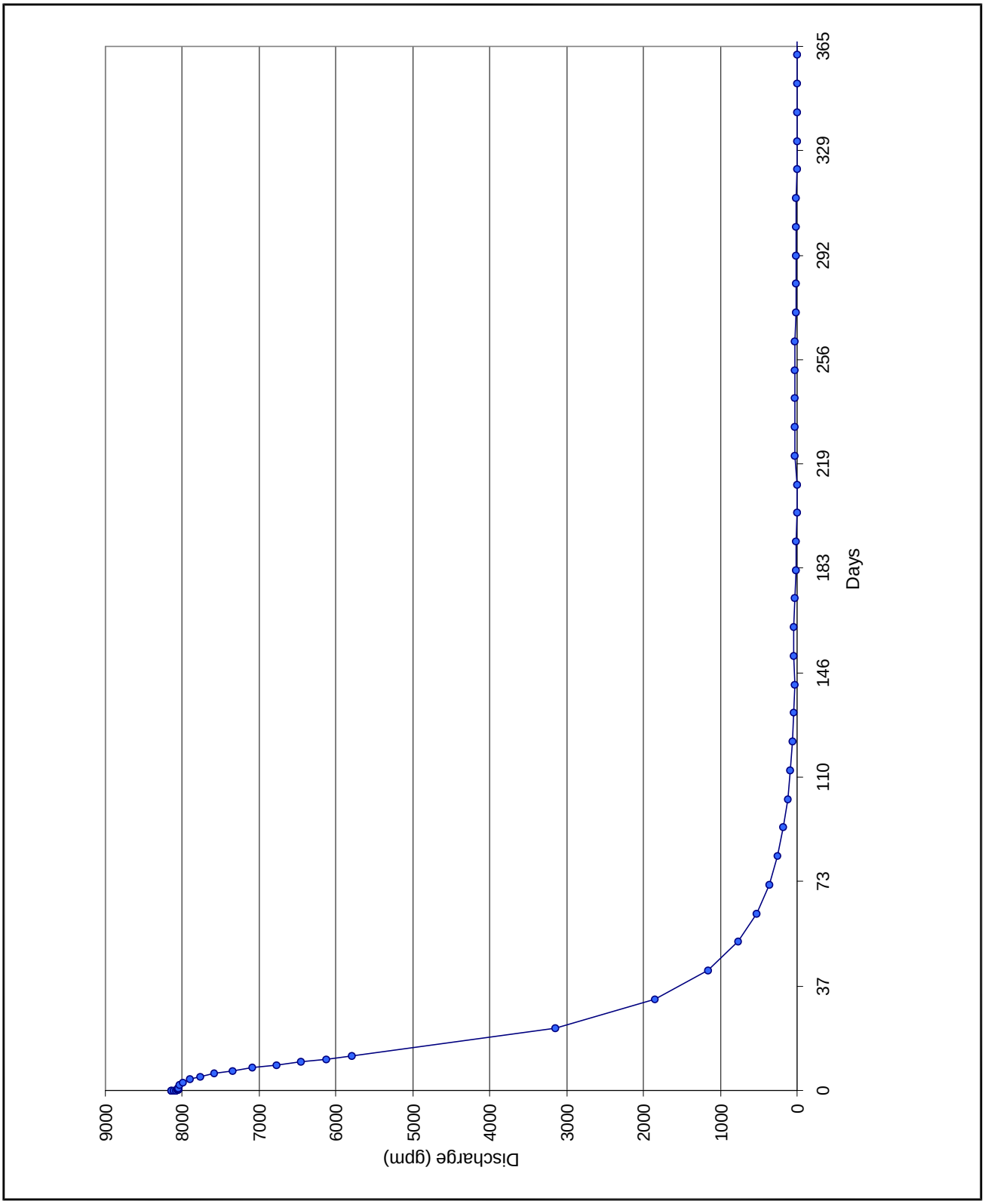
Figure 4.6 Short term draindown curve



F:\2643 - FT KNOX HEAP LEACH CLOSURE\CAD\2643-R1-FEBRUARY-2006\FIGURE-4.6.DWG

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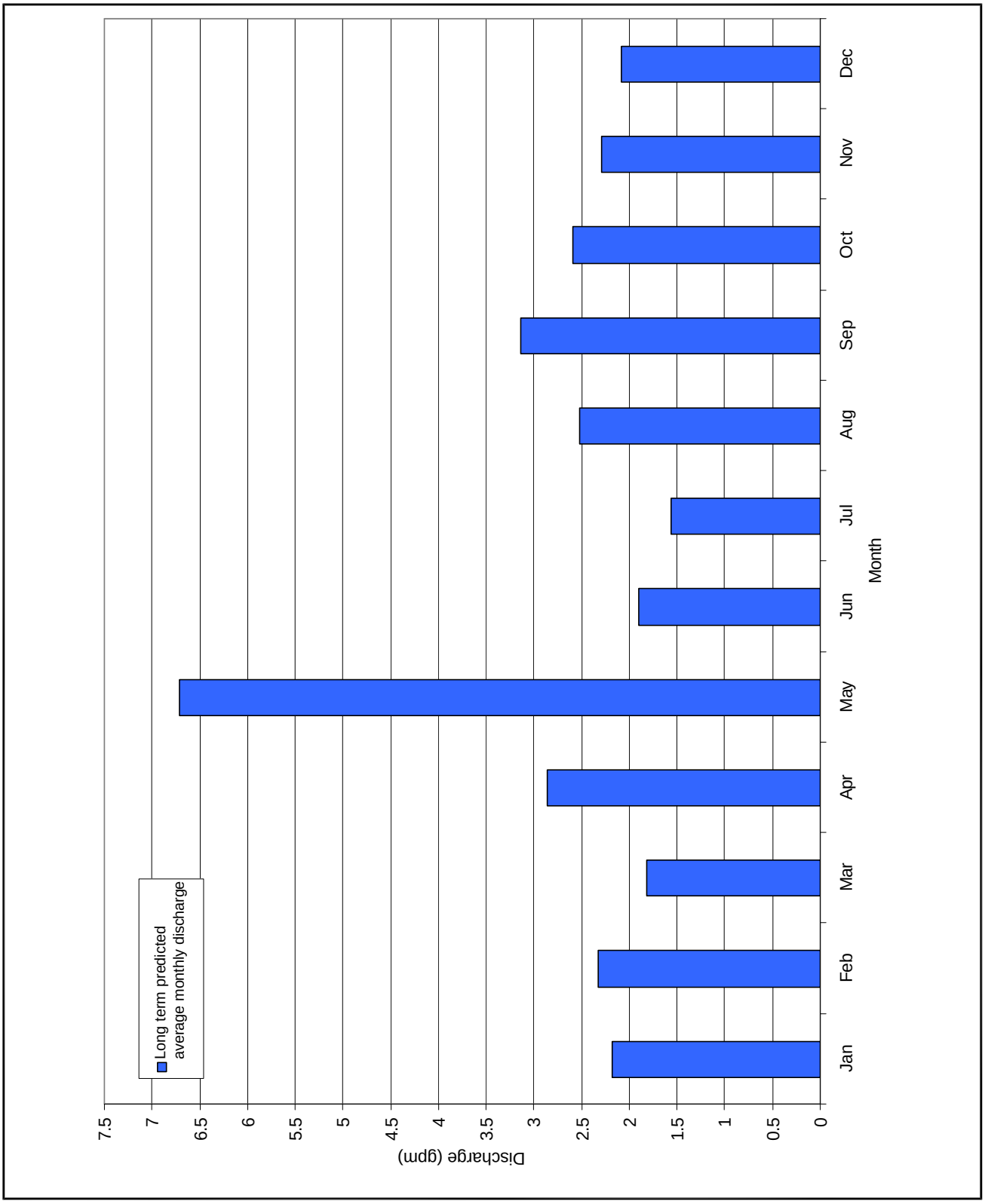
Figure 4.7 Long-term predicted average monthly discharge



F:\2643 - FT KNOX HEAP LEACH CLOSURE\CAD\2643-R1-FEBRUARY-2006\FIGURE-4.7.DWG

5 GEOCHEMISTRY

The following sections provide a preliminary description of solution and ore geochemistry based on currently available information. It should be noted that testing is on-going and the information discussed below will be updated once the final results become available.

5.1 Leach solution chemistry

The pregnant leach solution will have a pH between 10.5 and 11. The WAD cyanide concentrations will range between 100 and 200 mg/L during normal operational conditions. Based on column testing completed to date (discussed in the following section) it is expected that WAD cyanide concentrations will decline to levels at or below 0.2 mg/L after approximately one to two years of solution circulation after reagent addition has been stopped. Prior to closure, constituents such as arsenic, antimony, cadmium, copper, iron and manganese may be present at concentrations which exceed discharge standards. The closure plan outlined in Section 6 describes the steps that will be taken to reduce concentrations of cyanide and trace metals to levels appropriate for discharge.

5.2 Column rinse testing

The metallurgical columns are being used to evaluate the change in cyanide concentration through time subsequent to cessation of reagent addition. The purpose of this testing is to evaluate the effectiveness of freshwater rinsing and re-circulation in promoting cyanide destruction once active leaching becomes uneconomic. The columns will be rinsed between two and five pore volumes depending on the rate at which concentrations decline. The application rate during rinsing is the same as that used during the metallurgical testing. Results for one column (P-6) are currently available.

The initial WAD CN concentration in the pregnant solution prior to rinsing was approximately 370 mg/L. After 1.3 pore volumes, cyanide concentrations decreased by approximately 99.99 percent. WAD CN concentrations in the effluent decreased to 0.02 mg/L after 43 days of rinsing (1.3 pore volumes). Figure 5.1 illustrates the changes in WAD cyanide concentration as a function of cumulative rinse volume.

5.3 Geochemical characteristics of the ore

The acid neutralizing potential (ANP) values of the ore range from 23 to 42 tons $CaCO_3$/kT. The acid generation potential (AGP) values range from below detectable levels to 1.9 tons $CaCO_3$/kT. The ANP:AGP ratios range from 20 to over 100 indicating that the neutralization potential of the ore is significantly higher than the sulfide content. In general, ANP:AGP ratio values of 3 or greater are indicative of materials with low net acid generation potential. Based on the results of testing completed to date the spent ore is expected to have an insignificant potential for acid generation.

MWMP testing is in progress on six spent ore samples collected from several of the metallurgical columns directly after decommissioning. Table 5.1 summarizes MWMP results for tailing generated from the same ore that will report to the heap leach facility. The data indicate that arsenic, antimony, iron, cadmium, copper, and manganese may be mobilized during the rinsing cycle. Relative to the tailing pond chemistry, concentrations for most of these constituents are lower; suggesting that subsequent to rinsing, the discharge can be directed to the pond.

Table 5.1 Summary of tailing MWMP chemistry

	Average	Minimum	Maximum
pH	8.4	6.6	10.0
TDS	583	80	3,210
Sulfate	44	0.45	191
Iron(2)	0.58	0.01	2.43
Manganese(2)	0.095	0.003	0.651
Antimony(2)	0.013	0.003	0.092
Arsenic(2)	0.022	0.003	0.087
Cadmium(2)	0.0028	0.0003	0.0082
Copper(2)	0.012	0.005	0.076
Selenium(2)	0.003	0.003	0.008
Nitrate	1.4	0.50	3.6
Nitrite	0.02	0.01	0.04
Ammonia	1.4	0.1	4.6
WAD Cyanide	0.009	0.005	0.020

(1) Units in mg/L, except for pH (S.U.)
(2) Dissolved values used for metal constituents

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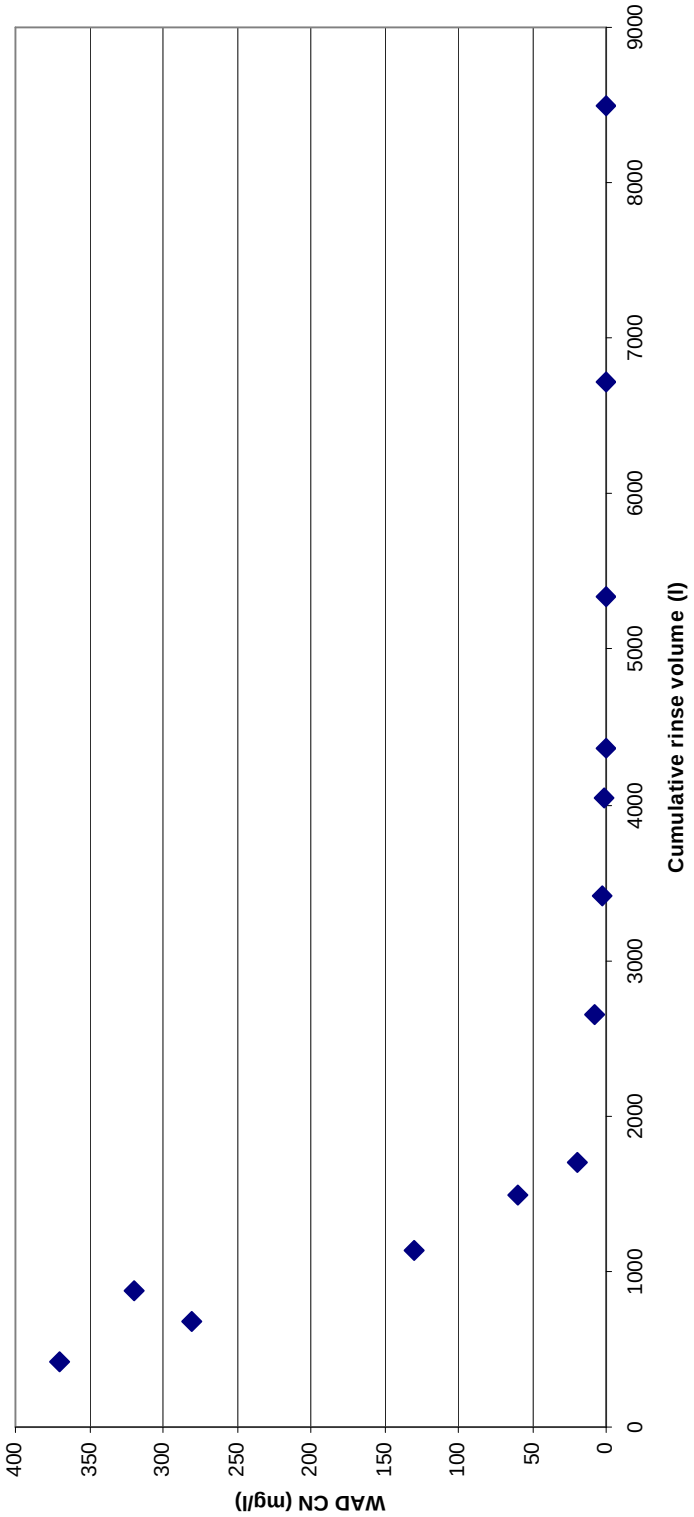
Figure 5.1 WAD cyanide rinse data for Column P-6



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6 CLOSURE MANAGEMENT PLAN

6.1 General closure concepts

The proposed method of closure for the Fort Knox heap leach pad is based on site-specific conditions, facility design, currently available test work, and the technical analyses completed as part of this project and the closure evaluation for the TSF (WMC, 2005). Key aspects of the site and operation that are considered for closure include the following:

- The climate at the site is characterized by moderate precipitation, low evaporation, and cold temperatures. As a result, the long-term drainage from the pad after closure is predicted to be minimal.

- Laboratory test work shows that cyanide concentrations will decrease rapidly through recirculation with freshwater if reagents are not added to maintain process-level concentrations.

- The TSF is located directly downgradient from the proposed heap leach pad and will be used as an integral part of the long-term solution management scheme. As part of the solution management plan, various passive or active treatment options are being considered including biologically mediated sulfate reducing systems, chemical reduction, oxide scavenging, and reverse osmosis.

- To facilitate closure management, a portion of the solution inventory may be directed to the pit or to an engineered treatment system once residual leaching is no longer economic. The volume of water that would report to the pit is less than 300 ac-ft which is 0.5% of the total volume of water expected in the stable pit lake. Long-term seepage will be routed to the surface of the TSF where it will be retained.

- The facility will be re-graded to an overall 3:1 slope and covered with growth media. The re-grading design will include erosion control measures as necessary to avoid loss of growth media.

- Due to the presence of tailing directly downgradient of the heap leach facility no suitable locations for groundwater monitoring wells exist. The presence of tailing likely has influenced local water quality which would limit the effectiveness of monitoring wells in detecting potential seepage. Therefore, monitoring will occur in the PCMS and LCRS systems during early stages of closure. Post-closure discharge from the drainage system will be monitored.

6.2 Closure steps and schedule

The closure schedule will include the following components:

- Step 1 - Residual leaching until uneconomic
- Step 2 - Solution recirculation/rinsing to destroy cyanide and meet compliance standards
- Step 3 - Release of draindown to TSF
- Step 4 - Release of minor long-term seepage to the TSF
- Step 5 - Re-grading and cover
- Step 6 - Monitoring

Step 1 – Residual leaching

Following completion of mining in the pit and final placement of ore on the pad, it is anticipated that leaching and gold recovery will continue for several years. As the recovery of gold begins to decline, the addition of cyanide will be discontinued. Gold recovery is often economic for a number of years after cyanide addition ceases. The exact duration of residual leaching will depend gold concentrations in the pregnant leach solution.

Step 2 – Rinsing of heap leach pad

After economic leaching has been completed, solution will continue to be re-circulated on the pad to promote cyanide destruction. Freshwater will be added to the system as required to facilitate rinsing and removal of metals. During the course of re-circulation it may be necessary to direct solution to the pit or to a treatment system in order to manage the water balance and remove chemical mass from the system. Routing solution to the pit will improve the effectiveness of rinsing by minimizing the influence of evapo-concentration and reducing cyanide and metals concentrations. Although the chemical mass that will be pumped to the pit (from both the heap leach and tailing facilities) is likely not sufficient to compromise the long-term water quality, the mass reporting to the pit will be monitored closely. If necessary, the treatment system would be utilized to reduce the chemical mass reporting to the pit. Treatment options being investigated include engineered wetlands reverse osmosis, oxide scavenging, chemical reduction, and biologically remediated reduction.

Rinsing will likely require less than one year because of the extended period of leaching with no cyanide addition and the high permeability of the ore. The minimum re-circulation rate will be 8,000 gpm. The actual duration of this step will be controlled by the time required for the water quality to meet compliance standards. If the tailing facility is still operating at the completion of draindown, residual drainage from the heap will be routed to the tailing pond if the quality will not cause an adverse impact to pond water quality.

Step 3 – Release of draindown to the TSF

Following completion of Step 2 (Rinsing), the liner would be perforated allowing drainage to flow to the TSF.

Step 4 – Release of minor long-term seepage to the TSF

The long-term seepage will be directed to the TSF and managed according to the closure plan for that facility. The surface of the TSF will be a combination of impounded water, wetland, and upland vegetation (WMC, 2005). Discharge from the heap leach pad will mix with the water impounded on the surface of the TSF.

Step 5 – Re-grading and cover

Following completion of Step 3, the heap will be re-graded to an overall 3H:1V slope. The grading plan will include erosion control measures as appropriate to avoid loss of growth media. A nominal 1 ft soil cover will be placed on the regraded surface. The soil material will be sourced from stockpiles created during foundation preparation. The cover material will be seeded and vegetated subsequent to placement.

Step 6 – Monitoring

The monitoring plan consists of the following general components:

- Monitoring of the flow and chemistry of the drainage waters (including underdrain).
- General inspection of the drainage system.
- Monitoring of the groundwater and surface water downgradient of the tailings facility. This forms part of the tailings facility closure monitoring plan.

Monitoring of the flow and chemistry

Monitoring of solution chemistry and pond levels will continue after economic leaching has been completed and recirculation/rinsing of the heap leach is in progress. During the recirculation/rinsing period, samples will be collected on a quarterly basis to assess the composition and the rate at which the solution chemistry is improving. Recirculation/rinsing will continue until water quality meets standards for discharge.

Once solution composition meets discharge standards, monitoring of the heap leach LCRS and PCMS and the underdrain system will occur on a quarterly basis (Table 6.1). The underdrain system will be sampled on a semi-annual basis for the Profile II list of analytes (Table 6.2). The underdrain system will be sampled via a well completed on the base platform which extends into the base of the underdrain material located within the ancestral drainage channel. During recirculation samples will be collected on a quarterly basis for Profile II analyses. Once water quality meets discharge standards the quarterly samples will be analyzed for WAD CN and pH. After the liner has been punctured sample collection from the solution recovery wells will cease and quarterly measurements of water levels will be made to ensure water is not accumulating within the in-heap pond.

Prior to the liner being punctured, the elevation of the in-heap storage pond will be monitored on a quarterly basis and if possible samples will be collected on a quarterly basis for WAD CN and pH.

Table 6.1 Summary of heap leach closure monitoring requirements

Identification	Parameter	Frequency
LCRS	Flow	Quarterly (during recirculation)
PCMS	Profile II WAD CN/pH	Quarterly (during recirculation) Quarterly (after recirculation)
Underdrain (via monitoring well)	Profile II WAD CN/pH	Quarterly (during recirculation) Quarterly (after recirculation)
Residual Solution (via storage pond recovery wells	Profile II	Quarterly (during recirculation)
In-heap storage pond	Elevation	Quarterly

Table 6.2 Analytical Profile II - groundwater inorganic parameters

Major Ion Chemistry	Minor Ion Chemistry	Trace Ion Chemistry
Lab pH	*Arsenic	*Antimony
Lab Conductivity	Cyanide	*Barium
Temperature (field)	Total	*Bismuth
Turbidity	WAD	*Cadmium
Total Suspended Solids	Fluoride	*Chromium
Total Dissolved Solids	*Iron	*Copper
*Calcium	*Manganese	*Lead
*Magnesium	Nitrogen, Ammonia	*Mercury
*Potassium	Nitrate as Nitrogen	*Selenium
*Silicon	Nitrite as Nitrogen	*Silver
*Sodium	Total Phosphorus	*Zinc
Chloride	TPH	
Alkalinity (as $CaCO^3$)		
Bicarbonate		
Total		
Calcium Hardness		
Magnesium Hardness		

* Dissolved

Long-term monitoring

The long-term monitoring will occur downgradient of the facility at the surface water and groundwater monitoring points established as part of the TSF closure plan (WMC, 2005). Figure 6.1 illustrates these locations. The monitoring plan proposed as part of the TSF closure includes water quality sampling (surface water and groundwater) and water level measurements to assess the performance of the hydraulic containment system. Table 6.3 summarizes the long-term closure monitoring proposed for the TSF.

Table 6.3 Summary of long-term closure monitoring

Monitoring location	Frequency	Parameter list
Decant pond	Quarterly	Complete
Pit lake	Annual	Complete
Groundwater monitoring wells	Annual	Complete
Surface water monitoring point	Monthly	Indicator

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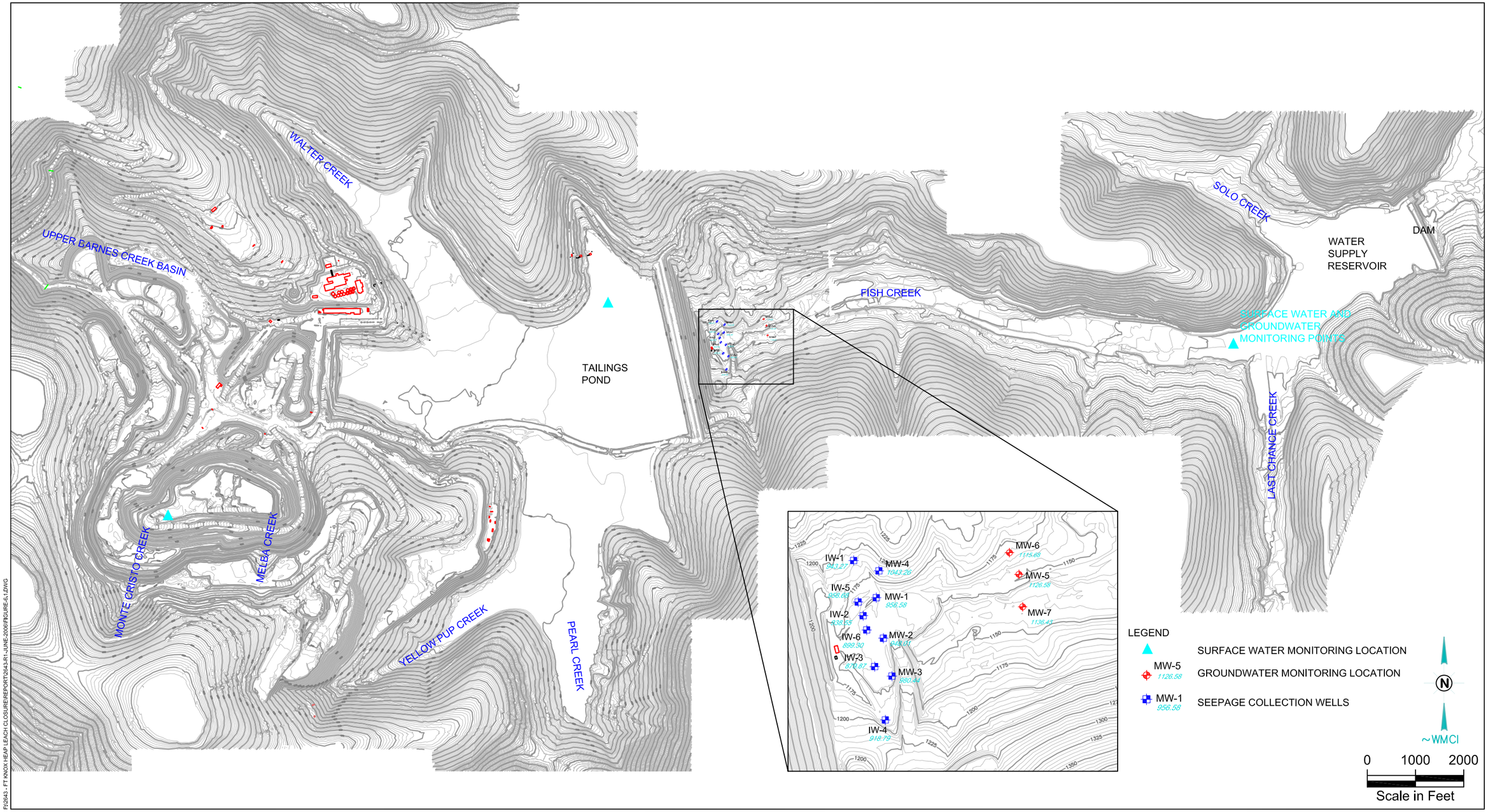
Figure 6.1 Long-term monitoring locations



F02643 - FT KNOX HEAP LEACH CLOSURE\REPORT\02643-R1-JUNE-2006\FIGURE-6.1.DWG

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