Keno Hill Water Treatment Systems
Sludge Management Plan
QZ06-074

Prepared by:

Elsa Reclamation and Development Company Ltd.

May 2009
Revision No. 2

ERDC

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1.0 BACKGROUND

Alexco Resource Corp. ("Alexco"), through its wholly owned subsidiary Elsa Reclamation and Development Company Ltd. ("ERDC"), owns the assets and claims within the Keno Hill Silver Mining District. ERDC maintains and operates the water treatment facilities at Keno Hill under Type "B" Water Use License (WUL) QZ06-074. Pursuant to Condition 23 of WUL QZ06-074, ERDC must submit a Sludge Management Plan to the Board 90 days prior to the implementation of the plan. This submittal fulfills the requirements of Condition 23.

There are currently five treatment locations authorized under WUL QZ06-074 including: Bellekeno 600, Galkeno 900, Galkeno 300, Silver King, and the Valley Tailings. Each of the treatment locations were upgraded and modified in 2007 in preparation for meeting discharge criteria set under the water license.

The water treatment systems use basic metal hydroxide precipitation technology. In general, lime solution is added to the adit waters and a zinc hydroxide precipitate ("sludge") is formed and settles to the bottom of lined ponds. The purpose of the sludge management plan is to outline the overall management of the sludge that is produced as part of the treatment systems.

2.0 TREATMENT SYSTEMS

2.1. PRECIPITATION CHEMISTRY

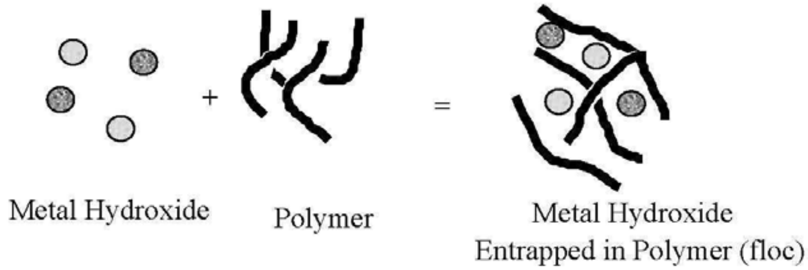
It is important to briefly outline the chemistry of metal hydroxide precipitation as a prerequisite to presenting final sludge disposal and management options.

In hydroxide precipitation, soluble heavy metal ions are converted to relatively insoluble metal-hydroxide precipitates by adding an alkali precipitating agent (i.e. lime solution in the case of Keno Hill). Precipitation reactions, which originate in a rapid mix tank to form metal hydroxide precipitates, are shown below, where M^+ is the soluble metal cation being removed.

$$\mathbf{M^{2+} + Ca(OH)_2 = M(OH)_2\ (s) + Ca^{2+}}$$

The metal ion combines with hydroxide ion to form the insoluble metal hydroxide solid. This reaction is pH dependent; as more base (i.e. lime solution) is added, the reaction is driven further to the right to precipitate more of the metals. Conversely, as the pH is decreased, the thermodynamic equilibrium moves to the left, causing more of the metals to resolubilize.

After the pH has been adjusted, an organic polymer is added. At the time of writing this report (May 2009) only Galkeno 300 is operated with the addition of a polymer. The polymers attach to the metal hydroxide particles. The hydroxide particles become entangled in the long chain polymers, causing the particles to increase in size and form flocs. As the flocs increase in size they become heavier and settle more quickly to the bottom of the pond. This floc formation is illustrated in the diagram below (University of Maryland, Engineering Research Center Report):



The solubilities of the metal hydroxide precipitates (sludge) vary, depending on the metal ion being precipitated, the pH of the water and to a limited extent the precipitating agent being used. Typically the solubilities of most metal hydroxide precipitates decrease with increasing pH to a minimum value beyond which the precipitates become more soluble (i.e. amphoteric properties). The solubility trend of zinc hydroxide vs. pH is shown in Figure 1.

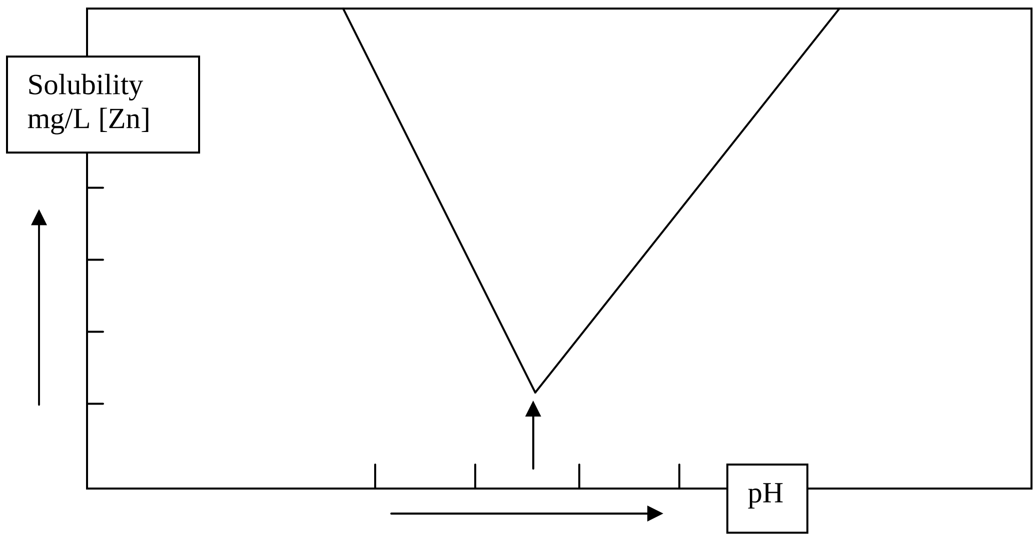


FIGURE 1 ZINC HYDROXIDE SOLUBILITY VS. PH

2.1.1. Lime Mixing and Consumption

All of the water treatment sites require the addition of lime slurry to precipitate zinc. Lime slurry preparation, conducted within the transport garage at Elsa, involves the addition of hydrated lime (CaOH) via an auger conveyor into a slaking tank, where water is added to produce lime slurry. Water for lime slurry mixing is delivered to the transport garage via a water tanker truck on a daily basis. In total, approximately 9,000 litres of slurry are mixed and delivered, via truck, to the various treatment sites. The Galkeno 300 system requires lime delivery 3-4 times per week and the other sites require lime slurry delivery 1-2 times per week. Slurry concentration is roughly 37.4 grams of lime per litre of water, equating to a consumption rate of approximately 21 tonnes of lime per month (consumption rate rises during spring freshet in May and June, when treatment is also required at the Valley Tailings). The Galkeno 300 treatment plant requires approximately 70% of the total lime consumed.

2.2. GALKENO 300

The process flow diagram for the modified Galkeno 300 treatment system is presented in Figure 2. A clarifier and additional sludge holding pond was added to the Galkeno 300 system in 2007. Water from the Galkeno 300 adit gravity flows through a 12” pipeline into the rapid mix tank. The clarifier is positioned to allow the overall process to be a gravity flow through system. The clarifier is equipped with its own chemical dosage system as well as a flash mixer. Primary pH adjustment is made in the rapid mix tank through the addition of a lime slurry solution. Lime solution is delivered to the lime storage tank via a 12,000 liter vacuum truck. The lime storage tank is located inside the clarifier building. The clarifier provides 30 minutes of retention time for flocculation to occur.

2.2.1. Clarifier Process Description

The following describes the unit processes within the Galkeno 300 clarifiers:

***Static Mixing*-** Raw water enters the plant through an electric modulating actuator. The valve is modulated by a 4-20 ma signal from a Mag flowmeter. Chemicals (polymer and lime solution) are added upstream of a static mixer and from here the water flows into the flocculators.

Flocculation – The water passes sequentially through a two stage mechanical flocculator. Variable-speed drives on each paddle permit a wide variation in energy input and allow tapered flocculation to optimize floc formation. Manual drain valves permit tank draining and cleaning which is anticipated not to be required at more than 6 month intervals.

***Settling* -** The settling clarifier is an up-flow solids contact unit complete with 60° settling tubes. The flow enters the bottom of the settler through a full length distribution manifold, and then passes upward as laminar flow. Heavier floc particles settle to the floor of the tank and lighter particles are retained within the tube settlers, coalesce into larger floc and then settle to the floor. Clarified water is collected from the surface of the tank through two, full length collection launders. The tube settlers are fabricated out of light resistant polystyrene. The tube cell size and angle ensure self cleaning under normal operation. A sludge blanket is maintained in the lower portion of the clarifier and its position can be monitored through sampling valves installed in the cell wall. The lower portion of the tank has a sloped, “V” section to encourage sludge thickening and collection in the central hopper. Periodically, this sludge is removed hydraulically through a full length, perforated sludge collector located at the foot of the “V”. The desludging operation is controlled automatically by timer controlled operation of an actuated valve programmed into the plant Process Logic Controller (PLC).

It is this formation of heavier floc particles and coalescence of lighter flocs into larger heavier flocs described above, that differentiates the clarifier from an open pond. Although additional ponds would provide additional retention time, the mechanics of floc formation do not occur in an open pond as efficiently and therefore additional retention time in ponds is not nearly as effective as the clarification provided in the clarifier and tube settlers.

Figure 3 and Figure 4 shows the various components of the Galkeno 300 treatment system.

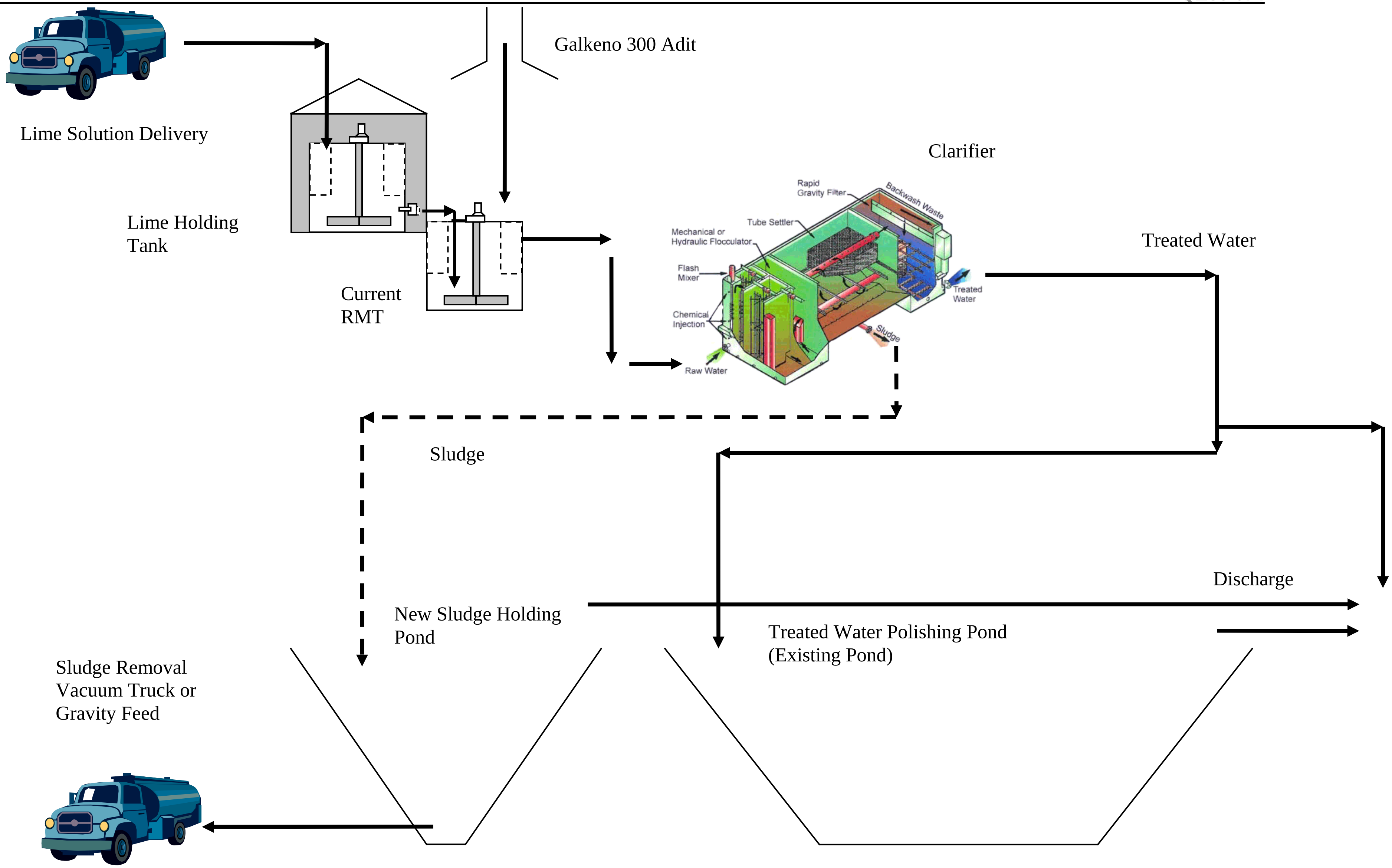


FIGURE 2 GALKENO 300 PROCESS FLOW DIAGRAM

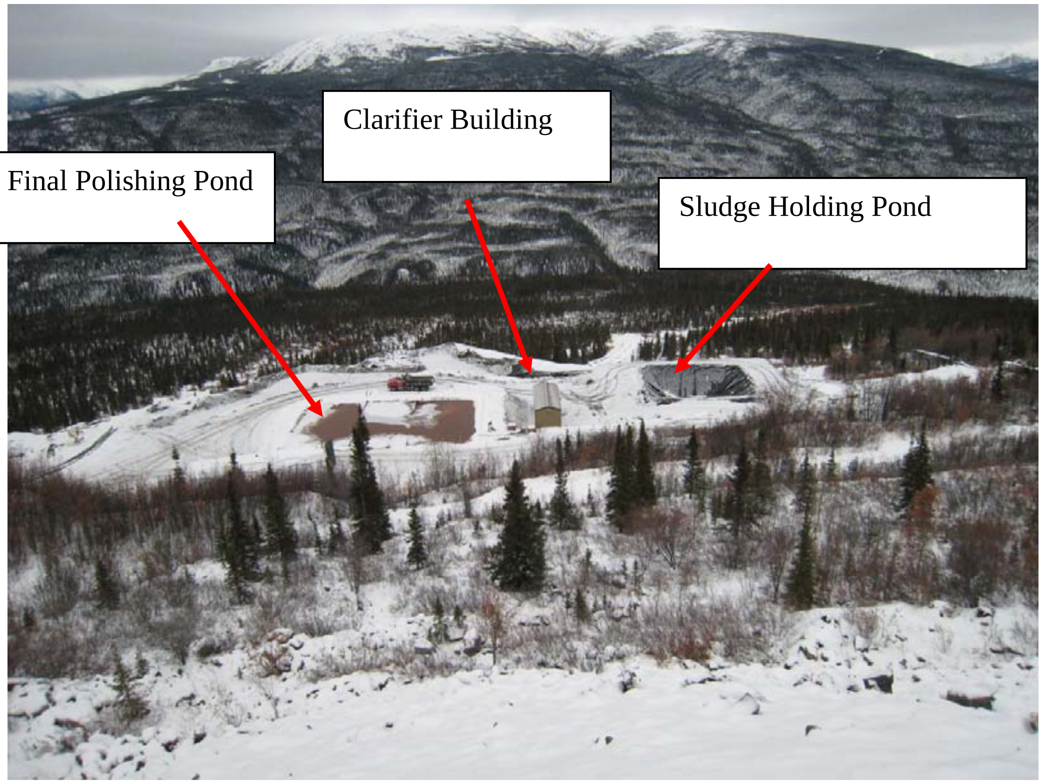


FIGURE 3 GALKENO 300 TREATMENT SYSTEM (VIEW FROM SIME OPEN PIT)

FIGURE 4 CLARIFIER INSIDE BUILDING

Sludge is periodically removed from the clarifier on an automatic timed basis and is deposited into the sludge holding pond. Figure 5 shows a typical release of sludge from the Galkeno 300 system.

FIGURE 5 HYDRAULIC DEPOSITION OF SLUDGE AT GALKENO 300 INTO POND

Once the sludge settles in the Galkeno 300 sludge holding pond it densifies and is then hydraulically removed into a 12,000 liter vacuum tanker and transported to the final sludge storage location. Figure 6 shows the sludge removal valve house at the toe of the sludge holding pond and Figure 7 shows the sludge being deposited into the Valley Tailing storage pond for final storage.

FIGURE 6 SLUDGE REMOVAL VALVE HOUSE

FIGURE 7 DEPOSITING SLUDGE INTO VALLEY TAILINGS AREA STORAGE CELL

2.3. GALKENO 900 AND BELLEKENO 625 TREATMENT SYSTEMS

The Galkeno 900 and Bellekeno treatment systems are nearly identical with a single rapid mix tank located below a lime holding tank. Lime solution is added to the adit water as it enters and is mixed in the rapid mix tank and then the metal hydroxide sludge settles in a lined holding pond. The Silver King system is essentially the same but it does not contain a rapid mix tank and the pond is not currently lined. Figure 8 and Figure 9 show the components of the Bellekeno and Galkeno 900 treatment systems.

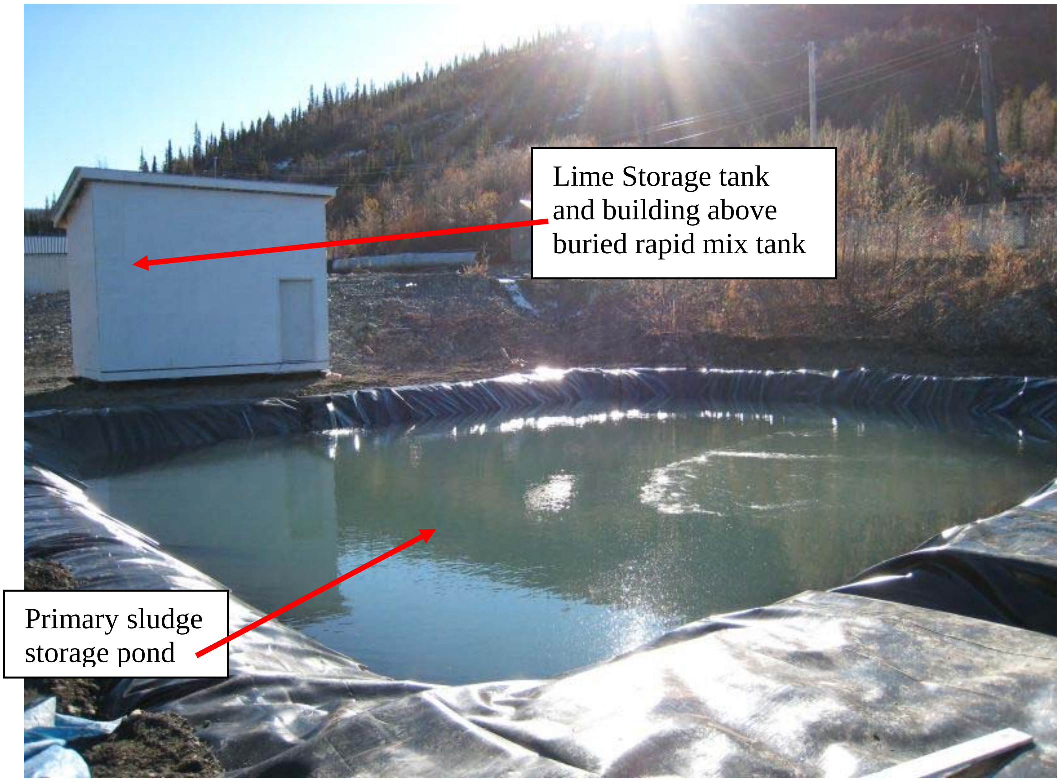


FIGURE 8 BELLEKENO 625 TREATMENT SYSTEM

FIGURE 9 BELLEKENO 625 TREATMENT SYSTEM

2.4. SILVER KING TREATMENT SYSTEM

The treatment system at Silver King is similar to the Bellekeno and Galkeno 900 locations with the exception it does not contain a buried rapid mix tank. In addition the treatment ponds at Silver King are not lined. The following two photos (Figure 10) show the components of the Silver King treatment system.

FIGURE 10 SILVER KING TREATMENT SYSTEM

2.4.1. Desludging

Desludging the Bellekeno 600, Galkeno 900 and Silver King sludge ponds is accomplished through a vacuum truck system. The sludge is "sucked" into a 12,000 liter holding tank via a 4" hose from a vacuum pump located on the truck. Once the truck is filled, sludge is transported to the Valley Tailings Area for deposition into the sludge holding cell. Because of the relatively low volume of sludge produced at these treatment sites, they are desludged on a campaign basis 1 – 2 times per year, generally in the spring and fall periods. Figure 11 shows typical desludging activities used at the Galkeno 900, Bellekeno 600 and Silver King sites.

FIGURE 11 EXAMPLE OF DESLUDGING PONDS

3.0 SLUDGE MANAGEMENT

3.1. SLUDGE VOLUMES

As the volume of sludge produced and stored in the ponds increases, it must eventually be removed and stored in a permanent location. The frequency of sludge removal from the various treatment locations is a function of the on site storage capacity and the daily amount of sludge generated. Galkeno 300 produces by far the largest volume of sludge, exceeding the volume of all other treatment systems combined. Table 1 provides a summary of the approximate volumes of sludge produced at each treatment location, based on the precipitation reaction previously shown and direct operating experience. The volumes presented are considered more accurate than previous estimates since these are updated based on actual operating experience and testwork since the new modifications to all of the treatment sites have been completed.

TABLE 1 ESTIMATED ANNUAL SLUDGE VOLUMES

LOCATION	POND CAPACITY (M^3)	ANNUAL M^3 SLUDGE	% SOLIDS (DENSIFIED)
Galkeno 300	1,000 (New Pond) 1,778 (Old Pond)	3,400	~ 10%
Galkeno 900	1,200	90	~ 10%
Bellekeno	2,600	90	~ 10%
Silver King	2,600	70	~ 10%

With the addition of the clarifier at Galkeno 300, testwork has been completed and the results indicate that the sludge discharge from the clarifier is producing approximately 1,200 mg/l of solids (100% basis). Because the Galkeno 300 treatment system produces a much higher volume than the other treatment systems it must be desludged more frequently. The floc produced at Galkeno 300 is much lighter and fluffier than the other treatment sites. The sludge characteristics at Galkeno 300 result in a less dense sludge in the sludge holding pond and therefore frequent desludging is required. The density of the sludge discharged from the Galkeno 300 clarifier is approximately 0.5wt% solids. Once the sludge has been removed and deposited into the final storage location and allowed to densify for extended periods (i.e. months – year) the density of the sludge increases and is expected to exceed 10%. For design purposes, the long term density of the sludge produced from all the treatment sites is estimated at 10%.

Additional dewatering and thickening processes are being investigated to densify the Galkeno 300 sludge and thereby reduce the overall sludge handling required.

3.2. SLUDGE CHARACTERISTICS

The characteristics of the sludge produced at Galkeno 300 were determined in 2005 by Yukon Government, Energy, Mines & Resources (EMR) as part of the operating management of Keno Hill. Several standardized tests were completed and the results are presented in Table 2 - Table 6.

CHARACTERIZATION REPORT

Client: Yukon EMR
Sample ID: G300 sludge

Date : 20-Jul-05
Project: 0505107

Objective: To determine the characteristics of G300 sludge

st description:
- a pail of G300 sludge was taken out and well mixed by agtitation
- small portions were split out for size analysis and pulp density determination
- about 5kg well mixed sludge was split out and weighted for testing
- the pre-weighed sludge was filtered and the filtrate was collected with weight and volume measured, a small portion of filtrate was submitted for assay
- the filter cake was washed with two times distilled water, the wash solution was combined and assayed
- a cut of washed cake was split out for moisture content , ABA and other various assays

Items	Parameters	Units	Results
Sludge	as -received pulp density	g/cm^3	1.06
Filtration of Sludge	Sludge wet weight	g/cm^3	5355
	Filtrate volume	mL	2130
	Filtrate weight	g	2130.9
	Filtrate SG	g/cm^3	1.00
	Wash solution volume	mL	1003
	Wash solution weight	g	1003
	Wash solution SG	g/cm^3	1.00
	Wet cake moisture	%, wet-basis	76.53

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ASSAY REPORT

Client: Yukon EMR **Date :** 20-Jul-05
Sample ID: G300 sludge filtrate and wash **Project:** 0505107

Objective: To determine the filtrate and wash solutions characteristics of G300 sludge

Items	Units	Sample ID		Detection Limits		Analytical	TCLP	Regulation
		Filtrate	Wash	Min.	Max.	Method		
TSS	mg/L	14	n/a					
pH	mv	7.35	7.20					
ORP		88.2	n/a					
Conductivity	us	3950	n/a					
Acidity	mg/L	3.28	n/a					
Fe+2	g/L	0.03	--	0.01	300	AsyWet		
Fe+3	g/L	0.01	--	0.01	100	AsyWet		
SO4-2	mg/L	4736.2	--	0.1	9999.9	Env-IC		
Cl-	mg/L	0.6	--	0.1	1000	Env-IC		
F-	mg/L	0.2	--	0.1	1000	Env-IC		
NO3-N	mg/L	<0.1	--	0.1	9999.9	Env-IC		
Al	mg/L	18.50	17.79	0.05	9999	EPA200.7	Al	
Sb	mg/L	0.29	0.20	0.05	9999	EPA200.7	Sb	
As	mg/L	<0.03	<0.03	0.03	9999	EPA200.7	As	5
Ba	mg/L	0.233	0.336	0.005	9999	EPA200.7	Ba	100
Be	mg/L	0.089	0.089	0.001	999	EPA200.7	Be	
Bi	mg/L	<0.1	<0.1	0.1	9999	EPA200.7	Bi	
B	mg/L	5.13	4.42	0.01	9999	EPA200.7	B	500
Cd	mg/L	0.069	0.166	0.005	999	EPA200.7	Cd	0.5
Ca	mg/L	619.37	443.36	0.05	9999	EPA200.7	Ca	
Cr	mg/L	0.31	0.36	0.01	9999	EPA200.7	Cr	5
Co	mg/L	0.53	0.52	0.01	9999	EPA200.7	Co	
Cu	mg/L	0.77	0.85	0.01	9999	EPA200.7	Cu	100
Fe	mg/L	40.16	31.20	0.01	9999	EPA200.7	Fe	
Pb	mg/L	6.35	5.38	0.05	9999	EPA200.7	**Pb**	**5**
Li	mg/L	0.48	0.48	0.02	9999	EPA200.7	Li	
Mg	mg/L	752.3	670.6	0.1	9999	EPA200.7	Mg	
Mn	mg/L	25.169	8.458	0.005	9999	EPA200.7	Mn	
Hg	mg/L	<0.02	<0.02	0.02	999	EPA200.7	Hg	0.1
Mo	mg/L	0.24	0.27	0.01	9999	EPA200.7	Mo	
Ni	mg/L	0.45	0.50	0.01	9999	EPA200.7	Ni	
P	mg/L	1.7	2.0	0.1	9999	EPA200.7	P	
K	mg/L	51	48	2	9999	EPA200.7	K	
Se	mg/L	<0.05	<0.05	0.05	9999	EPA200.7	Se	1
Si	mg/L	5.63	4.98	0.05	9999	EPA200.7	Si	
Ag	mg/L	0.41	0.44	0.02	999	EPA200.7	Ag	5
Na	mg/L	37.1	34.1	0.2	50000	EPA200.7	Na	
Sr	mg/L	4.826	3.234	0.005	999	EPA200.7	Sr	
Tl	mg/L	1.5	0.8	0.2	999	EPA200.7	Tl	
Sn	mg/L	0.3	0.3	0.1	9999	EPA200.7	Sn	
Ti	mg/L	1.23	1.14	0.01	999	EPA200.7	Ti	
W	mg/L	0.6	<0.1	0.1	9999	EPA200.7	W	
V	mg/L	0.34	0.32	0.01	999	EPA200.7	V	
Zn	mg/L	7.484	6.726	0.005	9999	EPA200.7	Zn	500

ASSAY REPORT

Client: Yukon EMR **Date :** 20-Jul-05

Sample ID: G300 sludge - dried solids **Project:** 0505107

Objective: To determine the characteristics of G300 sludge - dry solids

Items	Units	Sample ID Solids		Detection Limits Min.	Max.	Analytical Method
SG	g/cm^3	3.39				
S(tot)	%	1.62	1.63	0.01	100	Leco
SO4	%	4.85	4.85	0.01	100	AsyWet
Al	ug/g	1056	1080	100	99999	6010A
Sb	ug/g	<5	<5	5	99999	6010A
As	ug/g	532	521	5	99999	6010A
Ba	ug/g	10	11	1	99999	6010A
Be	ug/g	<0.5	<0.5	0.5	99999	6010A
Bi	ug/g	134	137	10	99999	6010A
B	ug/g	32	29	10	99999	6010A
Cd	ug/g	126.8	130.5	0.5	99999	6010A
Ca	ug/g	67867	68014	100	99999	6010A
Cr	ug/g	20	20	1	99999	6010A
Co	ug/g	204	204	1	99999	6010A
Cu	ug/g	28	29	1	99999	6010A
Fe	ug/g	52082	52622	100	999999	6010A
Pb	ug/g	<5	<5	5	99999	6010A
Li	ug/g	15	14	2	99999	6010A
Mg	ug/g	11437	11853	100	99999	6010A
Mn	ug/g	185360	185856	1	99999	6010A
Hg	ug/g	<2	<2	2	99999	6010A
Mo	ug/g	<1	<1	1	99999	6010A
Ni	ug/g	753	759	1	99999	6010A
P	ug/g	181	189	10	99999	6010A
K	ug/g	2642	2648	100	99999	6010A
Se	ug/g	<10	<10	10	99999	6010A
Si	ug/g	1499	1506	100	99999	6010A
Ag	ug/g	<2	<2	2	99999	6010A
Na	ug/g	1578	1600	100	99999	6010A
Sr	ug/g	363	366	1	99999	6010A
Tl	ug/g	<15	<15	15	99999	6010A

WHOLE ROCK ASSAY REPORT

Client: Yukon EMR
Sample ID: G300 sludge - dried solids

Date : 20-Jul-05
Project: 0505107

Objective: To determine the characteristics of G300 sludge - dry solids

Items	Units	Sample ID		Detection Limits		Analytical
		Solids		Min.	Max.	Method
Al2O3	%	0.97	1.03	0.01	100	WRock
BaO	%	0.01	0.01	0.01	100	WRock
CaO	%	9.44	9.42	0.01	100	WRock
Fe2O3	%	7.29	7.20	0.01	100	WRock
K2O	%	<0.01	<0.01	0.01	100	WRock
MgO	%	2.05	2.05	0.01	100	WRock
MnO	%	27.26	26.75	0.01	100	WRock
Na2O	%	0.49	0.57	0.01	100	WRock
P2O5	%	<0.01	<0.01	0.01	100	WRock
SiO2	%	4.63	4.44	0.01	100	WRock
TiO2	%	0.03	0.04	0.01	100	WRock
LOI	%	19.90	19.90	0.01	100	2000 F
Total	%	72.07	71.40	0.01	105	WRock

SIZE ANALYSIS REPORT

Client: Yukon EMR **Date :** 20-Jul-05

Sample ID: G300 sludge - dried solids **Project:** 0505107

Coulter Passing Size Distributions	
Volume, %	**Particle Diameter, micron**
10	3.33
20	4.87
25	5.70
30	6.61
40	8.67
50	11.15
60	14.43
70	19.05
75	21.91
80	25.13
90	33.33
100	76.98

ACID BASE ACCOUNTING TEST REPORT

Modified Sobek Method

Client: Yukon EMR

Date: 22-Jul-05

Sample ID: G300 sludge - dried solids

Project: 0505107

Item	Sample ID	$S_{(T)}$ %	$S_{(SO4)}$ %	Paste pH	Acid Potential	Neutralization Potential (NP)		
						Actual	Ratio	Net
1	G300 dried solids	1.62	1.62	8.2	0.10	255.9	2457	256

Alice Shi, Ph.D.
Laboratory Manager

Notes:
1. Analytical procedures from "Field and Laboratory Methods Applicable to Overburden and Minesoils". EPA 600/2-78-054, 1978. pp. 45-55.
2. Actual NP = Neutralization potential as determined by Sobek acid consumption test.
3. Acid potential = % total sulfur X 31.25
4. NP Ratio = Actual NP / Acid potential
5. Net NP = Actual NP - Acid potential
6. The acid potential and the neutralizing potentials are expressed in Kg $CaC0_3$ equivalent per tonne of sample.
7. **Samples with negative Net NP are potential acid producers**

Some of the general characteristics of the Galkeno 300 sludge can be described as:

- The sludge when it discharges from the clarifier is approximately 99% water with the 1% solids balance being lime-based metal hydroxide sludge principally comprised of excess lime, and hydroxides of manganese, iron and zinc;
- The only additive (other than lime) is polymer that is used to promote floc formation. The sludge is highly alkaline because of its significant makeup consisting of a hydroxide from the lime that is added';
- The maximum particle size of the sludge is approximately 76 um; and
- As expected, the sludge is highly Net Neutralizing (NP:AP = 2,457:1) because of the lime content.

Acidification or low redox generally would lead to particle breakdown. The circum neutral drainage from Galkeno 300 (and all other drainages in the district) indicates that there is no acid generating potential that would destabilize and re-leach metals from the sludge, especially in light of the significant NP:AP ratio of the sludge and the amount of AP necessary to breakdown the sludge.

3.3. SLUDGE MANAGEMENT AND DISPOSAL OPTIONS

During the period of commissioning the new clarifier at Galkeno 300, as well as operating experience before modifications were made, it has become apparent that the primary driver in maintaining compliance at Galkeno 300 is effective and consistent sludge management and removal. Because of this factor, it is imperative that alternative sludge storage locations, other than the Valley Tailings Area, be incorporated into the sludge management plan to ensure consistent desludging at Galkeno 300.

There are a number of different sludge disposal options practiced in the industry, ranging from off-site transport, disposal in tailings facilities, engineered and lined ponds, waste rock piles, underground workings and open pits. These different approaches are based on several factors including individual site treatment conditions, time of year, sludge production rates, costs, and weather and road conditions. The specific sludge storage locations and methodologies presented in this plan include:

1. Valley Tailings Area Storage Cells;
2. Sime Waste Dump Pond; and
3. Sime Open Pit (Lower and Upper).

Each of these locations and methodologies offers unique advantages for long term disposal of sludge from each specific treatment location. Not all of these methodologies have been used previously at the Keno Hill site. The methods presented in this sludge management plan are designed to provide the greatest degree of operational flexibility and environmental compliance and protection. Table 7 summarizes the location for sludge disposal and storage for each of the separate treatment locations.

TABLE 7 SLUDGE STORAGE LOCATIONS

TREATMENT LOCATION	SLUDGE DISPOSAL LOCATION AND APPROACH		
	Valley Tailings	Sime Open Pit (Lower and Upper)	Sime Waste Dump Pond
Galkeno 300	√	√	√
Galkeno 900	√		
Bellekeno	√		
Silver King	√		

The specific management program for each of these locations is further described in the following sections.

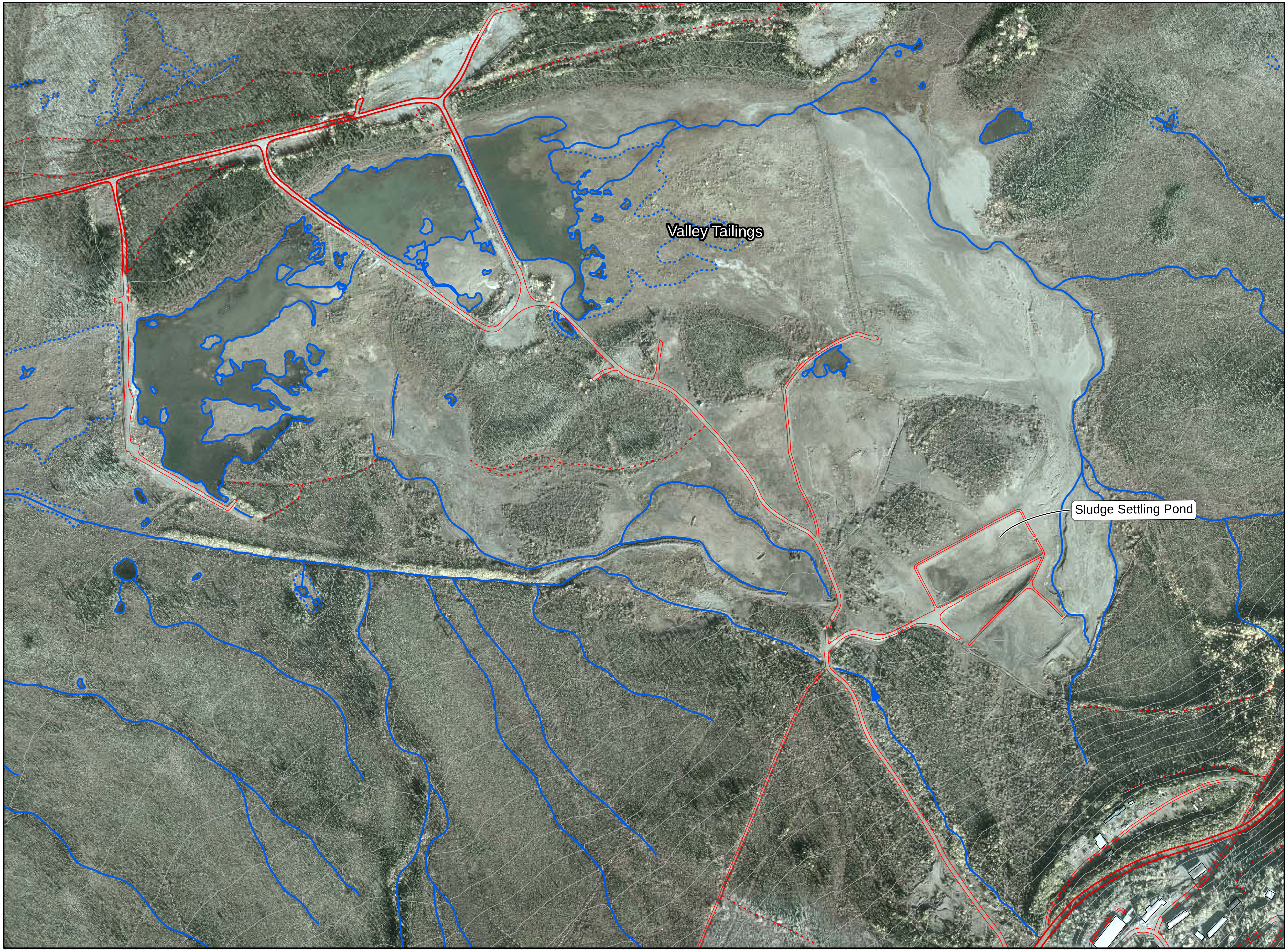
3.4. VALLEY TAILINGS AREA STORAGE CELLS

Sludge from all of the treatment locations is routinely deposited and stored in the Valley Tailings Area (VTA). Figure 12 shows the location of the VTA sludge cell. Prior to ERDC commencing care and maintenance at Keno Hill, this area was the primary and routine location for disposing sludge and has continued to be the primary location since. The VTA sludge cell has a capacity of 30,400 m^3. Based on the annual sludge volumes (3,650 m^3) presented in Table 1, the VTA sludge cell has an estimated capacity of over 8 years. This assumes that 100% of all sludge generated at the treatment sites is deposited in the VTA and none of the other storage locations presented in the management plan are used.

Additional storage cells are also located adjacent to the present and primary VTA sludge cell and are available for future use if necessary. The VTA sludge cells are located behind the VTA Dam #1 catchment area. Decanted water from the sludge remains within the Valley Tailings Area. This site is also routinely monitored and inspected and eventual discharge of water from the Valley Tailings Dam #3 must meet discharge water quality criteria for zinc and other parameters of concern.

The disadvantage to the VTA location is its considerable distance from each of the treatment sites. This distance is not as problematic for Galkeno 900, Bellekeno 600 and Silver King due to the relatively low sludge volumes produced. However the use of the VTA for sludge storage from Galkeno 300 presents an operating difficulty in maintaining adequate capacity in the Galkeno 300 treatment system. The roundtrip distance from Galkeno 300 is approximately 20 km posing logistic and safety concerns. The roundtrip distance to the other sites is even longer with the exception of Silver King.

The VTA will continue to be used as the primary storage location for sludge and the volume of sludge deposited in the Valley Tailings Area will be recorded and included in the monthly report to the Yukon Water Board.



Keno Hill Water Treatment Systems Sludge Management Plan

ERDC

Legend

- Public Road
- Exploration roads
- Trails
- Contour (Major 5m Intervals)
- Water Course (actual and potential)

2006 aerial photograph obtained from Geodesy Remote Sensing Inc., Calgary Alberta. Flown 13, 14 September 2006.

Figure 12

Valley Tailings Sludge Cell Storage Location

Scale: 1:6,000

0 25 50 100 150 200 250 m

ACCESS CONSULTING GROUP

Drawn by: HD	Checked by: DC

Date: February 2008

Our File: D:\Project\AllProjects\ALEX-05-01\gis\mxd\UKHM\SludgeMngtPlan\Feb08\Fig12_VT_SludgeStoreLoc.mxd

3.5. Sime Waste Dump Pond

A temporary sludge pond was constructed on top of the Sime waste dump in 2006. This storage location was constructed prior to issuance of QZ06-074 and was constructed in consultation with Yukon Government, EMR, Type II Assessment and Abandoned Mines Branch. The pond was lined with a bentonite geotextile and has a volume of approximately 600 m^3. This location offers a temporary location that is proximal to the Galkeno 300 treatment site in the event an increase in frequency of sludge removal is necessary or the primary sludge location (VTA) is inaccessible (i.e. poor road conditions). The location of this pond is shown in Figure 13. It is not anticipated that this location will be used as an ongoing or regular location for sludge deposition but will remain as a standby facility should the primary locations for Galkeno 300 sludge not be available. The Sime waste dump location has a limited volume remaining. Additional volume can be made available in the Sime waste dump location by rehandling the densified sludge through removal, using the vacuum truck, and transporting it to the VTA. Useable volume will be maintained in the Sime waste dump location in this manner to maintain this location as a backup storage site for Galkeno 300 sludge.

In the event this location is used, the volume of sludge deposited will be recorded and included in the monthly report to the Yukon Water Board.

3.6. Sime Open Pit

The Sime open pit offers an ideal sludge storage facility for permanent storage of sludge from the Galkeno 300 treatment system. Storage of metal laden hydroxide sludge in an open pit is an established practice and is currently being conducted at the Britannia Mine in British Columbia. The Sime pit (Figure 13) is located immediately (~300 m) up gradient from the Galkeno 300 adit and treatment system.

As previously mentioned, handling and transportation of sludge from the Galkeno 300 treatment system is the key to maintaining water quality discharge compliance. Handling and transportation of sludge from this location is logistically challenging and improvement in this aspect of the treatment system is critical. There are safety and environmental spill concerns associated with transporting sludge on a daily continuous basis over the 20 km. roundtrip journey.

3.6.1. Design Basis

The Sime pit is approximately 120 meters long, 16 meters wide and is triangularly incised into competent rock beneath the invert location (see Figure 14). Because it was a previous open pit, all four sides of the pit are contained within competent bedrock and as such there are no geotechnical concerns with respect to the possible failure of the pit and sudden release of stored sludge. The Galkeno 300 system produces approximately 3,400 cubic meters per year of settled and decanted sludge (see Table 1). Therefore, the calculated capacity of the Sime open pit is approximately 5.5 years if 100% of the sludge volume (at an assumed 10% solids long term) produced at Galkeno 300 is stored in the Sime pit.

For design purposes it is assumed that only 90% of the pit's capacity will be used for sludge storage. This provides a storage capacity of 17,300 m^3. In order to maintain the design parameter of 10% excess capacity, the amount of sludge (based on 10% density) deposited into the Sime open pit will not exceed 3,000 m^3/year.

There are 2 critical periods during the year when the Sime pit offers significant advantages for sludge disposal. The spring time when adit flows increase and higher sludge volumes are produced and in the winter months when road and severe weather conditions hamper the ability to desludge on a daily basis. At the current sludge production levels at Galkeno 300 daily desludging is required. However, the management plan for using the Sime pit for sludge storage is to restrict its use during the more critical time periods and secondly to maintain a maximum annual volume deposited into the pit at no more than 3,000 m^3 (@10% solids). Sludge from the Galkeno 300 pond will be transported to the Sime pit location using the existing vacuum truck or through pumping directly from the sludge storage pond into the open pit.

Calcium levels in the Galkeno 300 adit discharge serve as a good indicator of sludge decant waters seeping back into the Galkeno 300 underground workings. Dissolved calcium in the untreated adit water is normally 180 mg/l while the treated discharge water is approximately 350 mg/l. It is expected that a portion of the decanted water from the sludge solution will filter through the rock and re-enter the Galkeno 300 adit and mix with the current adit waters. This could be of benefit to the overall system as the treated water will add alkalinity to the untreated waters. The decanted water will also be low in zinc and will not increase the concentration of zinc exiting the Galkeno 300 adit water and which otherwise would require further treatment. In addition, the Sime pit is expected to act as a filter and serve to dewater the sludge faster than if it were to remain in a lined and submerged pond. Operating experience demonstrates that sludge densifies better when it is not constantly submerged in water.

As far as weathering effects on the sludge once it is deposited in the Sime Pit, larger sludge particles retained in the Sime Pit will tend to age and crystallize; becoming more mineralized. Fine particles will either break down and reform as larger particles, or will transit back into the adit treatment system. The best example of the effects of weathering can be seen in the sludge being deposited into the Valley Tailings. Sludge has been deposited in that location for over 10 years and there is no apparent negative effect on weathering over that time period. It is important to note that any effects on weathering or stability are not unique to the Sime Pit but would be the same regardless of the location of the sludge storage and are therefore being experienced right now in the Valley Tailings with no negative effect.

The proposal to store sludge in the Sime Pit rather than the VTA and this proposal does not modify the stability of the sludge. It is important to point out that the nature, stability and characteristics of the sludge from Galkeno 300 is exactly the same, regardless of whether it is stored in the Sime Pit or in the VTA. The accepted practice for many years has been to store sludge in an unlined area in the VTA as it has been recognized that the sludge is stable and not required to be stored long-term in a lined system.

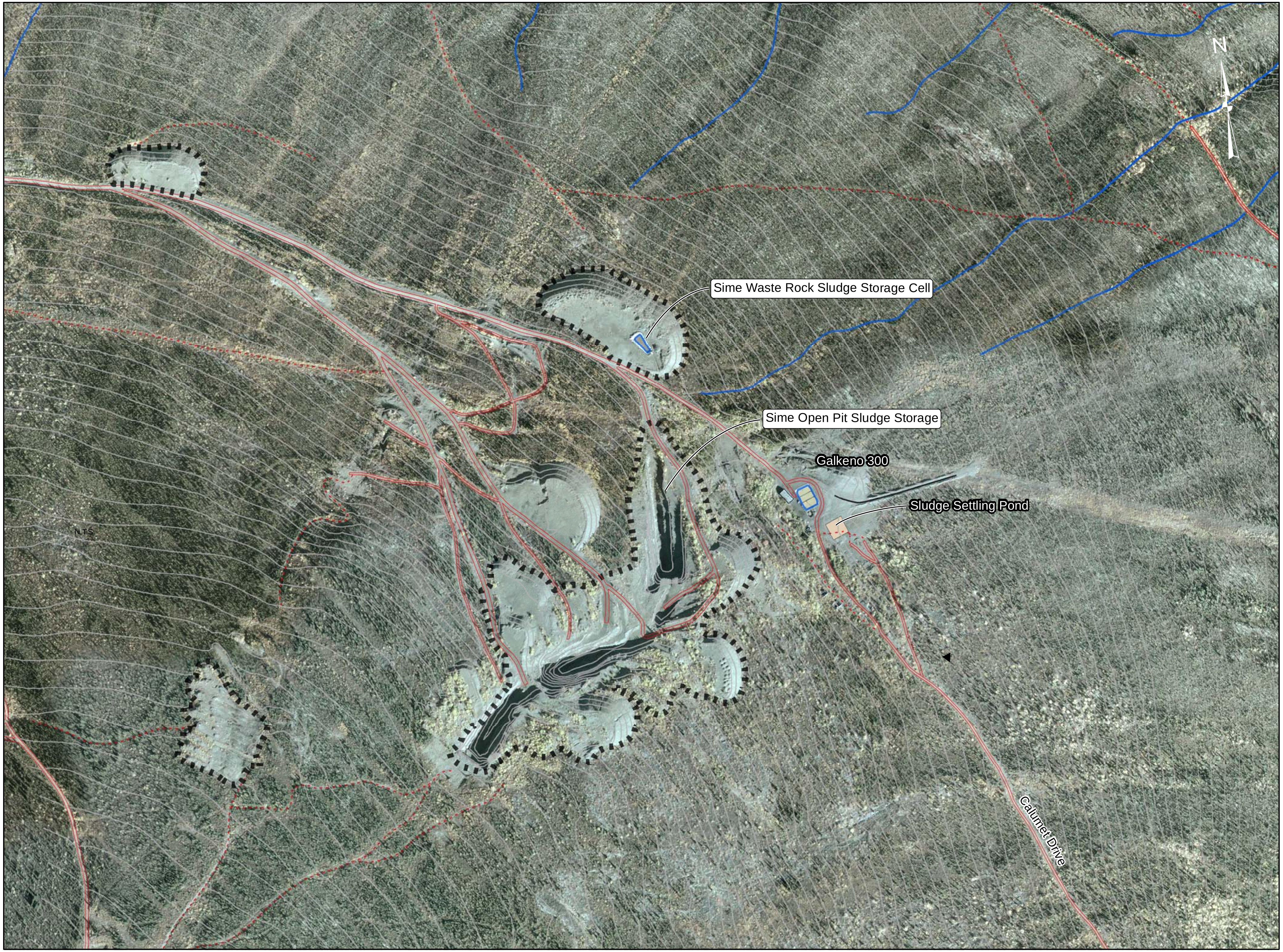
3.6.2. Solids Migration

Visual inspection as well as historic underground maps indicates that the Sime open pit was not mined out directly into the Galkeno underground workings. In other words the underground workings did not daylight into the bottom of the open pit and create a direct conduit for sludge solids to re-enter the workings. Since the bottom of the pit is not open to the underground workings, sludge solids will not enter the workings as a slug or large mass but will be filtered and left to densify in the bottom of the pit. Photo evidence shows that fresh water from spring freshet enters the Sime Pit faster than it can infiltrate and standing water accumulates in the pit. Over the course of the summer, the water infiltrates through the Sime Pit fractures until the pit is once again dry. This is good evidence that water and sludge entering the pit does not disappear as a slug back into the underground workings. The volume (depth) of water in the spring is more than seasonal evaporation alone can reduce which demonstrates that the reduction and fluctuation in water from the spring freshet is due to infiltration back underground.

The Sime Pit has recently been surveyed (March 2008) and the elevation of the bottom of the pit is approximately 1,150.4 meters (3,773 feet). The elevation of the Galkeno 300 adit is 1126.3 meters (3,694 feet) and the adit passes beneath the Sime Pit. The as-built maps show no stoping occurred below the Sime Pit and therefore the elevation difference between the bottom of the Sime Pit and the Galkeno 300 adit is approximately 24.1 meters (78 feet). Given this distance and the fact that there was no underground mining between the pit bottom and the Galkeno 300 adit, there should be no concern that erosion or a greater direct flow path could be established. It is not expected that erosion could occur through a solid mass of 78 feet of bedrock that exists between the pit bottom and the Galkeno 300 adit. The Sime open pit usable working volume is situated 10 meters beneath the overflow point. The calculated volume of the Sime open pit is 19,200 cubic meters of working volume.

It is expected that water seepage from the sludge will assist in densifying it by effectively “dewatering” the sludge while a portion of the decanted water re-enters the Galkeno 300 underground workings through cracks and small fractures in the pit bottom. Any movement or migration of sludge solids into the underground workings is expected to be on a “particle by particle” basis and no large volumes or masses of sludge solids have a conduit allowing release into the underground workings. Small individual sludge particles are not expected to impede any flow pathways, thus allowing continuous gravity flow of the underground adit water. Sludge particles that may re-enter the workings are expected to be carried back to the Galkeno 300 clarifier and water treatment system.

We can also estimate the upper limit of infiltration that is expected to occur through the Sime Pit and back into the underground workings. The current desludge volume of approximately 190 m^3/day and 1% solids is expected to thicken to a level of approximately 10% solids. Since the overall amount of sludge (on a 100% dry basis) will not change, the amount of water lost through infiltration through the Sime Pit can be estimated at approximately 90% of the water deposited into the pit. The amount of water entering the pit through direct precipitation is negligible compared to the amount of water contained within the sludge solution. There is a meteorological station in operation near the Sime Pit and this station will provide the information to help validate the infiltration estimates into the Sime Pit.



Keno Hill Water Treatment Systems Sludge Management Plan

ERDC

Legend

- Public Road
- Exploration roads
- Trails
- Contour (Major 5m Intervals)
- Water Course (actual and potential)
- Pit

2006 aerial photograph obtained from Geodesy Remote Sensing Inc., Calgary Alberta. Flown 13, 14 September 2006.

Figure 13

Sime Waste Rock Dump & Sime Open Pit Sludge Storage Location

Scale:

1:5,000

0 25 50 100 150 200 m

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Drawn by: HD	Checked by: DC

Date: February 2008

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FIGURE 14 SIME OPEN PIT

3.6.3. Underground Workings

A plan view of the Sime pit in relation to the workings is shown in Figure 15. A section of the Galkeno 300 workings and the relationship to surface and the other underground workings is presented in Figure 16. The figure looks to the northwest and shows the Galkeno 300 level portal workings including the 900 level with a non transparent surface. This figure shows the 200 and 300 portals and the open pits along the Sime vein above the Sime Workings. The figure also shows where the Hector Calumet and Galkeno Mines connect.

The Hector Calumet and Galkeno Mines are joined by an internal shaft connecting the Galkeno 300 level adit and the Hector Calumet 775 level drift. The shaft is approximately 65 feet in depth and in order for water to flow from the Galkeno Mine to the Hector Calumet, the Galkeno 300 adit would have to be completely plugged.

The rail elevation of the Hector Calumet 775 level at the internal connecting shaft is 4,125 feet and the Hector Calumet 400 level adit is approximately at 4,465 feet. This means that a 340 foot head of water would have to be backed up behind a plug of the Galkeno 300 adit to cause water to discharge from the Hector Calumet 400 Level Adit. Because of this elevation difference, it is reasonable that any seepage water or fine sludge particles from the Sime open pit would remain within the Galkeno 300 adit and not report out any other mine opening. The majority of water entering the Hector Calumet Mine would preferentially discharge through the Galkeno 300 Adit. The Hector Calumet Mine is unlikely to be flooded past the 775 level.

Water diverted into the Sime or McLeod workings would have to flow through the Sime or McLeod vein/fault systems between the Galkeno 500 Levels (3,800 ft) and the Galkeno 900 Level (3,255 ft) as there are no connecting workings between the Galkeno 300 and Galkeno 900 levels.

We do not anticipate any deterioration of adit water quality from the decanted sludge water as they mix. The decanted water from the sludge in the current lined pond is allowed to be directly discharged to the receiving environment because of it non deleterious nature. The water decanting into the Galkeno 300 adit from the Sime Pit will be the same water quality as is currently licensed to be discharged to the receiving environment. There is no anticipation that the water quality from the Galkeno 300 adit can deteriorate any further than it already is at 125 mg/l zinc. The decanted water from the sludge is more alkaline than the adit water being treated and therefore should benefit the adit water quality and not deteriorate it.

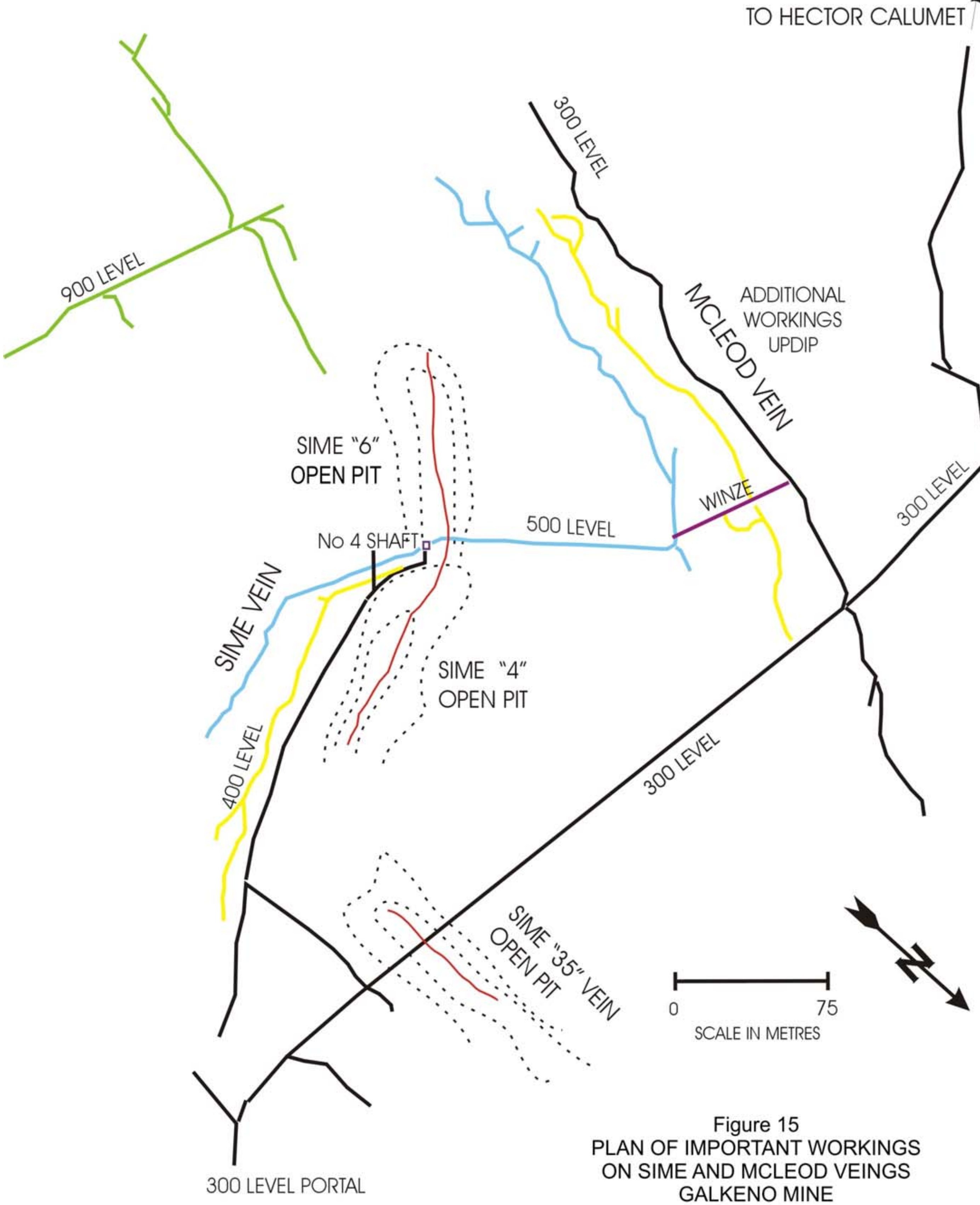


Figure 15
PLAN OF IMPORTANT WORKINGS
ON SIME AND MCLEOD VEINGS
GALKENO MINE

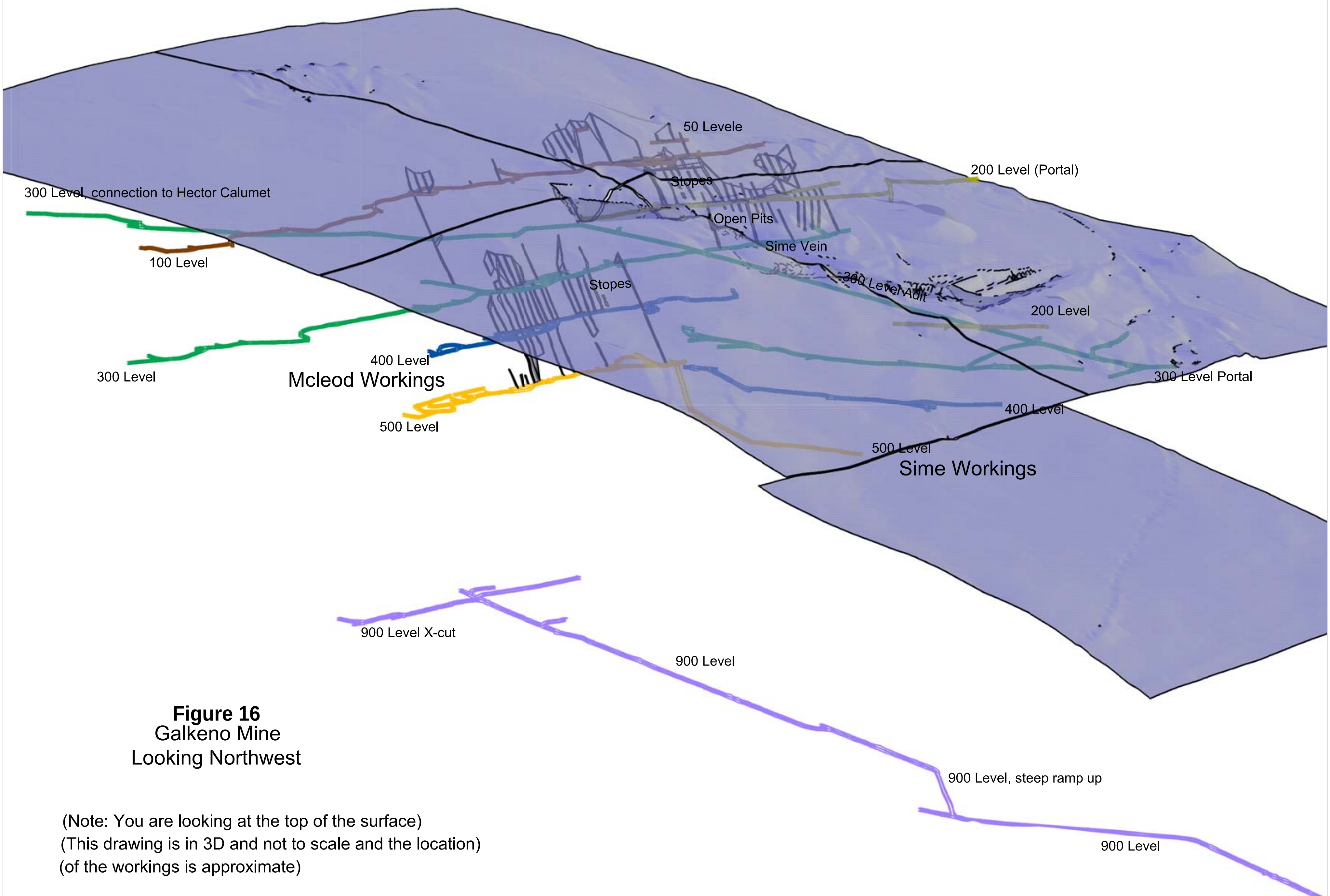


Figure 16
Galkeno Mine
Looking Northwest

(Note: You are looking at the top of the surface)
(This drawing is in 3D and not to scale and the location)
(of the workings is approximate)

3.7. SLUDGE STORAGE LOCATION SUMMARY

A summary of the sludge storage locations presented in the management plan are shown in Table 8.

TABLE 8 SLUDGE LOCATION SUMMARY

SLUDGE LOCATION	LOCATION VOLUME (M^3)	ANNUAL VOLUME DEPOSITED (M^3)	EXPECTED CAPACITY YEARS	SLUDGE SOURCES
Valley Tailings	30,400	3,650 [2]	8 +	Galkeno 300, Galkeno 900, Bellekeno Silver King
Sime Waste Dump	600	0	0	Galkeno 300
Lower Sime Open Pit	17,300 [1]	3,400	5	Galkeno 300
Upper Sime Open Pit	404.4[1]	Contingency	5	Galkeno 300

[1] Based on 90% capacity of total volume
[2] Does not take into account volume deposited in Sime pit

In summary, benefits of using the Lower and Upper Sime pits for sludge disposal include:

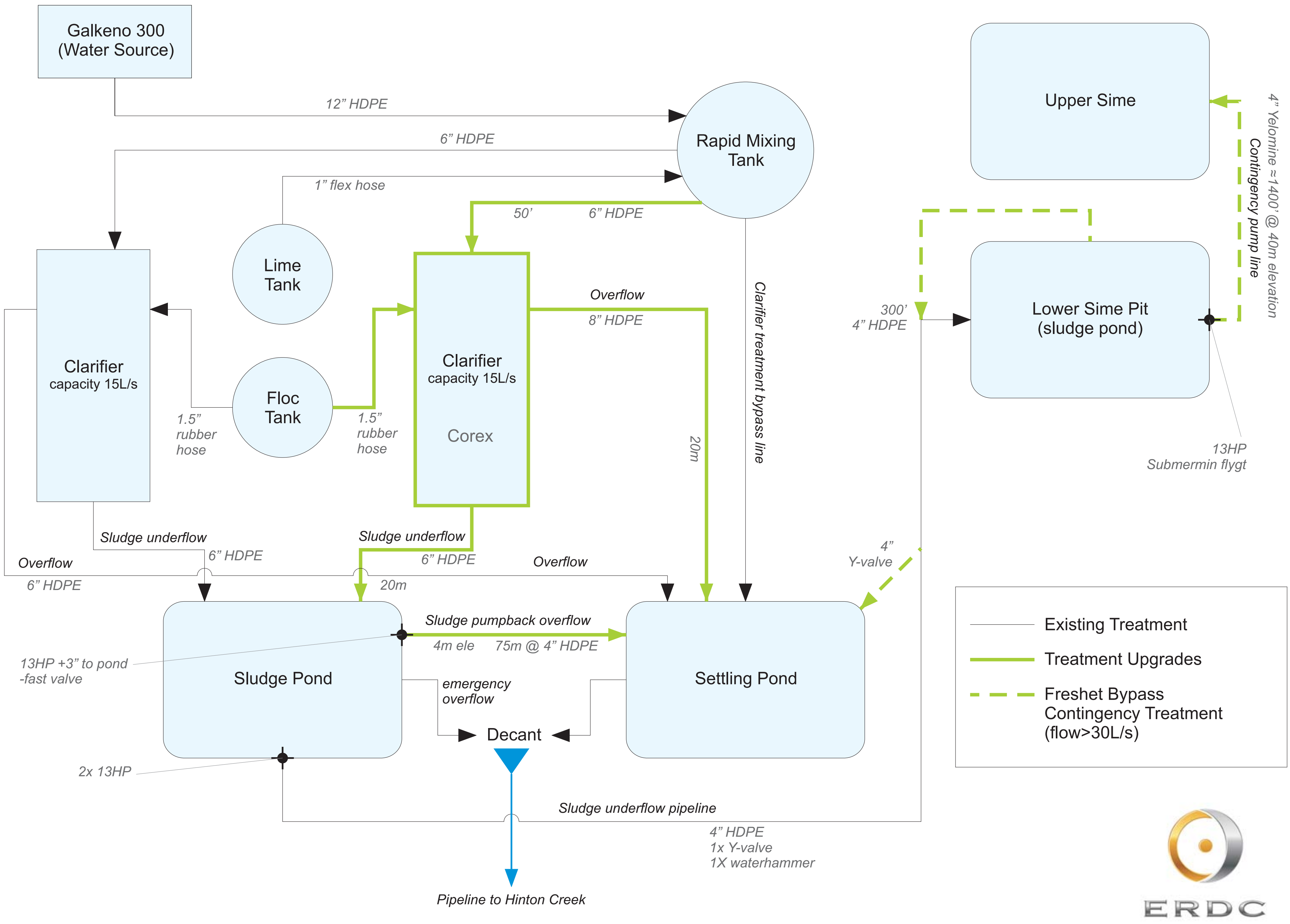
- Use of the Upper Sime pit provides for increased wastewater and sludge storage capacity if flows in the G300 adit exceed the treatment facility capacity of 30 lps;
- Increased capability and capacity to further densify the sludge with primary settling occurring in both the G300 treatment settling pond and final settling in the Sime pits;
- The Sime pits are geotechnically stable as it is excavated into bedrock on all 4 sides;
- Use of the Lower Sime pit has shown that sludge and wastewater can be stored in this pit without affecting the lower mine workings stability or influencing G300 adit chemistry. This benefits are expected to be similar for the Upper Sime pit;;
- Containment of the sludge and associated wastewaters within the same collection and treatment area, reducing the dispersion of sludge and localizing the sludge within the areas from which the sludge contaminants originated;
- Treatment of sludges for the Simes Pits will be addressed as part of the overall Existing State of Mine Closure Plan;
- Decreased risk of truck overturn or accident from longer haulage routes to the Valley Tailings Facility;
- Decreased impact of truck traffic on the roads, culverts and ditches which are integral parts of site operations;
- Decreased risk of treatment upset conditions during critical times of the year through effective desludging.

3.8. INTERIM UPPER SIME PIT USE

As an interim contingency measure to address G300 adit flows above 30 lps, a 4" Yelomine pipeline running from the Lower Sime Pit to the Upper Sime pit will be installed. The Lower Sime pit will allow for proper retention time to settle out the sludge solids and if necessary the decant water can then be pumped (13 hp Flygt submersible) into the Upper Sime pit for temporary storage if necessary. If necessary overflow from the Lower Sime pit can also be pumped and directed to the existing settling pond through the existing 4" PVC pipeline to return treated wastewater and then discharged through the settling pond to the environment. Figure 17 shows a site plan depicting the G300 treatment system and Sime Pits sludge storage area. Figure 18 shows a schematic diagram of the Galkeno300 Treatment System Modifications which outlines the proposed improvements.

Legend
Proposed pipelines
Mine Features
TYPE
Adit
Pit
Shaft
Showing
Mine Features
TYPE
Open Pit
Settling Pond
Disturbance
Detention Structure
pipeline
sludge pipeline
Lower Sime Open Pit
Upper Sime Open Pit
Quonset Hut
Settling Pond
Original Clarifier Shed
New Clarifier
Rapid Mix Tank
bypass pipeline
sludge/settling pond pipeline
Floc Shed
300 Level
Sludge Pumps
Sludge Settling Pond
N
ERDC
ACCESS
CONSULTING GROUP
KENO HILL SILVER DISTRICT
GK300 SITE MODIFICATIONS MAY 2009
GALKENO 300
SITE PLAN
SCALE: 1:1,000
0 10 20 40 60 80 Meters
DRAWN BY: TL
DATE: 07/May/2009
Figure 17

Figure 18: Galkeno 300 Treatment System Modifications



3.9. Sludge Closure

This plan does not detail a strategy for closure of the sludge stored in the VTA or Sime open pit. It does however provide a plan to handle and store sludge that will be produced for at least the next eight years and longer should the Sime Open Pit be used in concert with the Valley Tailings location. While it is recognized that the Sime Open Pit constitutes a new location for sludge storage, ERDC considers the use of this pit as the most viable storage option for Galkeno 300. The vast majority of the sludge currently stored in the VTA was deposited before the issuance of QZ06-074 and closure options for sludge storage will be a topic in the ESM Reclamation plan currently under development and required to be submitted to the Yukon Water Board by December 31, 2008.

There are identifiable options for closure of the sludge in the Sime Pit once it is no longer active. Covering the decanted sludge with a waste rock cover is one available option. Another consideration is that the current placement of sludge in the Valley Tailings may have the effect of delaying final closure of that portion of the tailings for an extended period of time. As long as the Valley Tailings Area sludge storage cell remains open due to continued use, that area cannot be closed. Since the majority of sludge being deposited into the VTA comes from Galkeno 300, alternative storage locations should serve to expedite complete closure of the VTA. Keeping the sludge within its source area is more in line with best practices for closure, and preserves at the lowest total cost the option of eventual deposition of treated sludge deep within the Hector or Sime/McLeod systems as this may ultimately prove to be the best long-term disposal option for Galkeno 300 sludge. Final closure options for the Sime Pit sludge will be incorporated into the closure option assessment and final plan currently being developed for the entire district, similar to the sludge being deposited into the Valley Tailings.

One of the closure planning alternatives for Galkeno 300 may include a possibility of a concrete plug in the Galkeno 300 adit but this plug would contain a pipe and valve to allow the Galkeno 300 adit water to discharge. As long as water treatment is required at Galkeno 300 then a system to allow the adit to free drain and be collected and treated will still be required. If the adit is completely plugged from an engineered bulkhead then that presumably means that active catchment and lime treatment is no longer required and therefore the Sime Pit is no longer needed for sludge storage since no additional sludge is being generated. We do not contemplate any closure scenario that would include both a sealed Galkeno 300 adit that does not allow water to drain and the ongoing need for water treatment and sludge deposition at the Sime Pit.

3.10. Monitoring and Mitigation

There are a number of monitoring and mitigation measures that can be implemented to demonstrate and determine the effectiveness of the sludge storage program at the Sime Pit. The following measures will be implemented during the duration of active sludge storage and operation in the Sime Pit:

- sludge volumes will be recorded on the operators log located at the Galkeno 300 clarifier building;
- daily samples will be taken from the Galkeno 300 adit and analyzed for pH and zinc using on-site instrumentation. Visual inspection for TSS will also provide an immediate indication if solids are migrating back into the underground workings;

- a mass balance estimating the amount of decant solution re-entering the Galkeno 300 adit will be updated based on the daily and monthly analysis;
- visual inspections will be conducted for seeps in the immediate vicinity of the Galkeno 300 treatment system that may provide an indication of decant water from the Sime pit. Any new identified seeps can be monitored and analyzed for water quality parameters including pH and zinc. A seep survey around the Galkeno 300 vicinity was previously completed by Access Mining Consultants Ltd. in 2005. This survey can serve as a baseline indication of additional seeps resulting from sludge deposition into the Sime open pit;
- a diversion ditch or berm will be constructed around the perimeter of the Sime Pit to reduce and minimize the amount of fresh water entering the pit during spring freshet;
- a berm will be constructed on the western end (discharge end) of the pit to reduce any fresh water entering the pit during spring freshet as well as ensuring no uncontrolled release of pit water occurs;
- a sample of the surface water in the Sime Pit will be taken during the months of Apri/May/June/October and analysed for total and dissolved metals;
- a minimum freeboard of 1.0 meter below the decant point of the Sime Pit will be maintained;
- in the event the operation and performance of the Sime Pit sludge location is not acceptable and must be curtailed, the sludge stored in the pit will be covered with a suitable material (i.e. waste rock, local borrow);
- a recording device including either a flow totalizer on the discharge pipe, a staff gauge within the pit or a load count (if trucks are hauled) will be implemented to record the amount of sludge and water deposited into the pit. This information will used to determine the overall infiltration rate of decant water;
- a photo log will be maintained to document the changes in pit water volume; and
- the above information will be included in the Company's monthly report to the Yukon Water Board as well as summarized in the Annual Report.

3.10.1 CONTINGENCY MONITORING IF THE UPPER SIME PIT IS USED

As part of the Contingency Monitoring, the following will be undertaken:

Notification will be provided to a Yukon Government, Water Resources Inspector that the Upper Sime pit will be used as a contingency storage and treatment facility to address flows in excess of the G300 treatment system capacity.

The following measures will be implemented during the duration of active sludge storage and operation in the Upper Sime Pit:

- Sludge volumes will be recorded for both the Lower and Upper Sime Pits on the operators log located at the Galkeno 300 clarifier building;
- Daily samples will be taken from the Galkeno 300 adit and analyzed for pH and zinc using on-site instrumentation. Visual inspection for TSS will also provide an immediate indication if solids are migrating back into the underground workings;
- A mass balance estimating the amount of decant solution re-entering the Galkeno 300 adit will be updated based on the daily and monthly analysis;

- Visual inspections will be conducted for seeps in the immediate vicinity of the Galkeno 300 treatment system that may provide an indication of decant water from the Sime pits. The inspection will include along the Upper Sime pit, in the diversion ditch of the Lower Sime Pit and the high back wall of the Lower Pit. Seepage in the lower diversion ditch or out of the high wall of the Lower Sime Pit would indicate water decanting from the Upper Pit. Any new identified seeps can be monitored and analyzed for water quality parameters including pH and zinc. A seep survey around the Galkeno 300 vicinity was previously completed by Access Mining Consultants Ltd. in 2005 and will be done again in 2009. This survey can serve as a baseline indication of additional seeps resulting from sludge deposition into the Sime open pits;
- A diversion ditch or berm will be constructed around the perimeter of the Upper Sime Pits to reduce and minimize the amount of fresh water entering the pit during spring freshet;
- A berm less than 1 m high may be constructed in the Upper Sime Pit on the northeast end (discharge end) of the pit to reduce any fresh water entering the pit during spring freshet;
- A sample of the surface water in the Lower and Upper Sime Pits (if used) will be taken during the months of April/May/June/October and analysed for total and dissolved metals;
- A minimum freeboard of 1.0 meter below the decant point of the Lower and Upper Sime Pits will be maintained;
- In the event the operation and performance of the Lower and Upper Sime Pits sludge location is not acceptable and must be curtailed, the sludge stored in the pit will be covered with a suitable material (i.e. waste rock);
- Recording devices including sludge pumping records, a staff gauge within the pit and load counts (if trucks are hauled) will be implemented to record the amount of sludge and water deposited into the Lower and Upper Sime Pits. This information will used to determine the overall infiltration rate of decant water.
- A photo log will be maintained to document the changes in the Lower and Upper Sime Pits water volumes; and
- The above information will be included in the Company's monthly report to the Yukon Water Board as well as summarized in the Annual Report.