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Technical Memorandum

To:	File	**From:**	Sean Jacquemin, EIT
Company:	Victoria Gold Corp	**Date:**	July 19, 2012
Re:	Eagle Gold Project – Heap Leach Facility Feasibility Design – Liner Leakage Analysis	**Doc #:**	058/12-201045X-5.3
CC:	Michael D. Thornbrue, P.E. Troy Meyer, P.E., P.Eng (Tetra Tech)		

1.0 Introduction

This Technical Memorandum demonstrates that a geosynthetic clay liner (GCL) provides a superior level of engineering control when compared to a soil liner that is 300 mm thick, compacted to achieve a maximum permeability of $1x10^{-6}$ cm/s. Additionally, this Technical Memorandum provides estimates of the amount of fluid that may leak through the four (4) lined Heap Leach Facilities (HLF) proposed for the Eagle Gold Project (Project) including:

- The Heap Leach Pad;
- The In-Heap Pond;
- Event Pond No. 1; and
- Event Pond No. 2.

2.0 Liner Leakage Equations

The calculations used in this memorandum are based on either Giroud's Equation, Bernoulli's Equation for free flow through an opening, and/or Darcy's Law.

2.1 Giroud's Equation

The leakage through a circular defect in a geomembrane liner system that includes a low permeability component GCL was estimated using Giroud's Equation (Giroud, 1997):

$$Q = 0.976 C_{qo} \left[1 + 0.1 \left(\frac{h}{ts} \right)^{0.95} \right] d^{0.2} h^{0.9} k_s^{0.74}$$

Where:

Q = Rate of liquid migration or potential leakage rate (PLR) (m^3/s/defect);

C_{qo} = Contact quality factor that represents the contact interface between the low permeability component and the geomembrane liner (dimensionless);

- Poor contact: 1.15; and
- Good contact: 0.21;

h = Height of liquid on top of geomembrane (m);

Giroud's Equation assumes that the hydraulic head on the liner to be less than or equal to three (3) meters. The empirical investigations published by Giroud and Bonaparte (1989) showed that permeation, leakage through a geomembrane liner without holes, may not be negligible in scenarios with more than three (3) meters of hydraulic head. Giroud's Equation does not take permeation into account.

t_s = Thickness of the low permeability component (m);

d = Diameter of circular defect (m); and

Giroud's Equation assumes a circular defect in the geomembrane liner having a diameter between 0.0005 m and 0.025 m.

k_s = Hydraulic conductivity of the low permeability component (m/s).

Once the PLR (m^3/s/defect) is determined, it is multiplied by the Lined Surface Area (LSA) of the pond and multiplied by the assumed defect rate to calculate the total potential leakage (TPL).

2.2 Bernoulli's Equation for Free Flow through an Opening

The PLR through a geomembrane liner that is not placed directly on a low permeability component can be calculated using Bernoulli's Equation for free flow through an opening.

$$Q = C_B a \sqrt{2gh_w}$$

Where:

Q = PLR through a geomembrane hole (m^3/s/defect);

C_B = Dimensionless coefficient related to the shape of the edges of the hole (for sharp edges C_B = 0.6);

a = Hole area (m^2);

g = Acceleration due to gravity (m/s^2); and

h_w = Liquid depth on top of the geomembrane (m).

Once the PLR (m^3/s/defect) is determined, it is multiplied by the LSA of the pond and by the assumed defect rate to calculate the TPL.

2.3 Defect Rate

Giroud's Equation and Bernoulli's Equation for free flow through an opening each require an assumed defect rate to determine the potential leakage through a liner.

A single, two (2) millimeter (mm) diameter [area (a) = 3.14 mm^2] hole per 4,047 m^2 represents defects in a geomembrane liner that still may exist after intensive quality assurance resulting from fabrication or installation factors.

Failure of the geomembrane due to poor design, or accidental punctures, may be represented by a single 11.3 mm diameter (a = 100 mm^2) hole per 4047 m^2 of liner (Giroud and Bonaparte, 1989).

2.4 Darcy's Law

The amount of permeation through a geomembrane liner without hole or a low permeability component can be calculated using Darcy's Law:

$$Q = \frac{k * A * h}{t}$$

Where:

Q = Rate of liquid migration (m^3/s);

k = Hydraulic conductivity (m/s);

t = Thickness (m);

A = Surface area of the liner; and

h = Height of liquid above the liner (m).

3.0 Demonstration of Superior Engineering Control with GCL

This demonstration considers two (2) ponds with areas of 1,000 m^2 that are lined with either low permeability soil (LPS) or a GCL. The total potential leakage (TPL) through an LPS layer or a GCL was calculated using Darcy's Law:

$$Q = \frac{k * A * h}{t}$$

Where:

Q = Rate of liquid migration (m^3/s);

k = Hydraulic conductivity of the low permeability component (m/s);

- k_{LPS} = 1x10^{-8} (m/s);
- k_{GCL} = 5x10^{-11} (m/s) (Cetco, 2009);

t = Thickness of the low permeability component (m);

- t_{LPS} = 0.300 (m);
- t_{GCL} = 0.006 (m) (Cetco, 2009);

A = Area of the pond = 1,000 (m^2); and

h = Height of liquid above the liner = five (5) meters.

The total potential leakage for each pond would be:

$$Q_{LPS} = \frac{k_{LPS} * A * h}{t_{LPS}} = \frac{1x10^{-8} * 1{,}000 * 5}{0.3} = \frac{1.667x10^{-4} m^3}{s} x \frac{1{,}000 L}{m^3} x \frac{86{,}400 s}{day} = 14{,}400 \left(\frac{L}{day} \right)$$

$$Q_{GCL} = \frac{k_{GCL} * A * h}{t_{GCL}} = \frac{5x10^{-11} * 1{,}000 * 5}{0.006} = \frac{4.167x10^{-5} m^3}{s} x \frac{1{,}000 L}{m^3} x \frac{86{,}400 s}{day} = 3{,}600 \left(\frac{L}{day} \right)$$

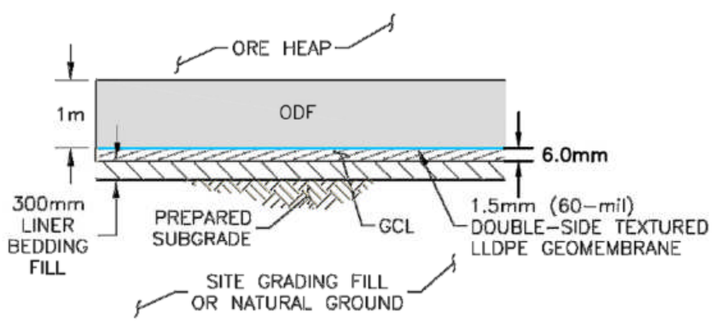
As shown above, GCL provides a superior level of engineering control when compared to a low permeability soil layer that is 300 mm thick with a maximum permeability of $1.0x10^{-8}$ m/s ($1.0x10^{-6}$ cm/s).

4.0 Heap Leach Pad

This section evaluates the TPL of the liner system proposed for Phases 1 through 3 of the Heap Leach Pad with the configuration shown in Illustration 1 and consists of the following from bottom to top:

- Prepared subgrade;
- A sodium bentonite GCL;
- 1.5mm double sided textured linear-low density, polyethylene (LLDPE) geomembrane liner; and
- One (1) meter of overliner drain fill (ODF).

Illustration 1 Heap Leach Pad Liner Detail



As demonstrated in Section 2.0, GCL provides a superior level of engineering control; therefore, GCL was selected for the low permeability component. Additionally, GCL provides superior puncture protection to the overlying geomembrane liner.

The TPL through the liner system for Phases 1 through 3 was estimated using Giroud's Equation (Giroud, 1997). To provide conservative leakage estimates, these calculations assume an average hydraulic head on the liner of one (1) meter and a defect rate of one (1) large (d=11.3mm) hole in every 4,047 m^2 of liner to account for potential punctures. Table 1 presents the calculations used to determine the PLR through the Phase 1 through 3 Heap Leach Pads liner system.

Table 1 PLR through Heap Leach Pad Liner

C_{qo} =	0.21	(dimensionless)
h =	1.00	(m)
d =	0.0113	(m)
t_s =	0.006	(m)
k_s =	5.0E-11	(m/sec)
Q =	2.77E-08	PLR (m^3/s/defect)

The calculations yielded a PLR of Q = 2.77E-8 m^3/s/defect. This can be converted to liters per day (Lpd) per defect as follows:

$$\frac{2.77E-8m^3/s}{defect}x\frac{1000Liters}{m^3}x\frac{60s}{\min}x\frac{60\min}{hr}x\frac{24hr}{day}=\frac{2.39Lpd}{defect}$$

To establish the TPL, the PLR was multiplied by the LSA for each Phase and by the defect rate.

Phase 1:

$$TPL=\frac{2.39Lpd}{defect}x\frac{1defect}{4046.86m^2}\times 207,000m^2=122.25Lpd$$

Phase 2:

$$TPL=\frac{2.39Lpd}{defect}x\frac{1defect}{4046.86m^2}\times 510,100m^2=301.26Lpd$$

Phase 3:

$$TPL=\frac{2.39Lpd}{defect}x\frac{1defect}{4046.86m^2}\times 144,100m^2=85.10Lpd$$

Phases 1, 2 and 3 of the Heap Leach Pad may discharge 122 Lpd, 301 Lpd, and 85 Lpd respectively. The cumulative PLR for Phases 1 through 3 is 508 Lpd. The maximum area under leach during operations is expected to be 277,000 m^2. This area would results in a TPL of 164 Lpd.

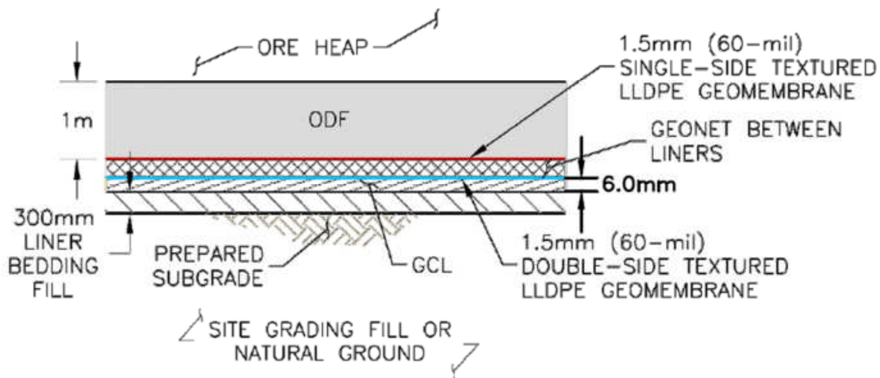
5.0 In-Heap Pond Calculations

The following evaluates PLR through the top liner of the proposed In-Heap Pond to determine appropriate leakage alert levels to indicate a malfunction of the liner system. The double lined system beneath the In-Heap Pond is shown in Illustration 2 and consists of the following components from bottom to top:

- Prepared subgrade;

- GCL;
- 1.5 mm double side textured LLDPE geomembrane (bottom liner);
- Geonet;
- 1.5 mm single side textured LLDPE geomembrane (top liner); and
- One (1) meter ODF.

Illustration 2 In-Heap Pond Liner Detail



The In-Heap Pond has a maximum depth of 41 meters and the LSA ranges from 1,050 m^2 to 180,000 m^2. The LSA and leachate depths were obtained from the In-Heap Pond Stage-Storage Elevation-Area Function calculations for the Eagle Gold Heap Leach Facility Project.

5.1 Alert Levels

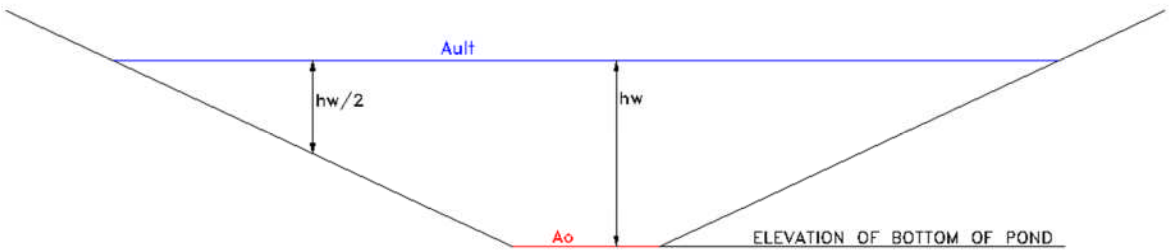
Alert Level 1 (AL1) provides a benchmark for liner performance in a double-lined pond under typical operating conditions using a defect rate one (1) small hole that is two (2) millimeter diameter per 4,047 m^2. AL1, as measured by the amount of fluid pumped by the pond's Leak Collection and Removal System (LCRS), is a low-level trigger that may indicate the presence of a small hole or defect in the top geomembrane.

Alert Level 2 (AL2) provides a high-level trigger that indicates serious malfunction of the liner system a single 11.3 mm diameter hole per 4,047 m^2. This criterion is used for AL2 with a factor of safety of 1.5 applied to the leakage rates.

Typically, the AL1 and AL2 are calculated using the total depth and total LSA of a double-lined pond. This approach provides accurate results for shallow ponds with a relatively flat bottom. However, the significant depth of the In-Heap Pond necessitates calculation of the PLR in steps using the differential LSA's and corresponding depths as the pond fills with leachate as shown in Illustration 3.

Additionally, because the In-Heap Pond is much deeper than ten (10) meters, permeation through the liner is not insignificant. Therefore, the permeation was calculated at each interval using Darcy's Law and the average head on the liner. Typical values of geomembrane permeability as measured by water-vapor transmission tests are in the range of $1x10^{-12}$ to $1x10^{-15}$ m/s (Koerner, 2005). To be conservative, a liner permeability of $1x10^{-12}$ m/s was used. The liner permeation was included in AL1 and AL2.

Illustration 3 Example of Liner Areas and Head Levels in Ponds



Therefore, the alert levels were calculated using a modified Bernoulli's Equation for free flow through an opening as follows:

$$TPL = C_b aA\sqrt{2gh_w} + \frac{k * A_{Ult} * h_w}{2 * t} = C_b a\sqrt{2g}\left(A_o\sqrt{h_w} + (A_{Ult} - A_0)\sqrt{\frac{h_w}{2}}\right) + \frac{k * A_{Ult} * h_w}{2 * t}$$

Where:

A_0 = LSA at bottom of pond;

A_{ult} = LSA at the filled elevation; and

t = The thickness of the LLDPE liner.

Table 2 presents the results of the calculation at five (5) meter increments within the pond:

Table 2 AL1 and AL2 for the In-Heap Pond

Elevation	Depth (Meters)	Area (m^2)	AL1 (Lpd)	AL2 (Lpd)	Pump Capacity (Lpd)
850	0	1,056.24	--		--
851	1	4,738.19	925	14,066	21,098
856	6	41,169.12	27,074	282,871	424,306
861	11	55,313.72	58,354	519,371	779,057
866	16	71,568.12	102,261	816,587	1,224,880
871	21	89,810.77	160,764	1,181,816	1,772,725
876	26	109,749.78	235,180	1,616,719	2,425,079
881	31	129,695.04	322,910	2,097,974	3,146,961
886	36	152,066.10	430,660	2,664,745	3,997,118
891	41	180,181.02	571,291	3,386,029	5,079,043

Attachment 1 provides the results of the calculation at one (1) meter increments

The system will be designed with the pumping capacity to accommodate the calculated leakage rate of 5,079,043 Lpd or 3,527 Lpm. However, the AL2 was lowered to provide a factor of safety of 1.5 as follows:

3,527 Lpm ÷ 1.5 = 2,351 Lpm

5.1.1 Summary

The Alert Levels for the In-Heap Pond, as measured by the amount of fluid pumped out of a LCRS were calculated to be:

- AL1 = 571,291 Lpd or 397 Lpm;
- AL2 = 3,386,029 Lpd or 2,351 Lpm; and
- Pumping Capacity = 5,079,043 Lpd or 3,527 Lpm.

If it is determined during normal operations that the amount of fluid pumped out of the LCRS exceeds AL1, the owner and/or operator should take action to determine the cause. This action may include physical inspection, mechanical leak detection, electric leak location, or other methods to determine what is causing the AL1 exceedance in order to maintain the liner integrity such that the AL2 is not exceeded.

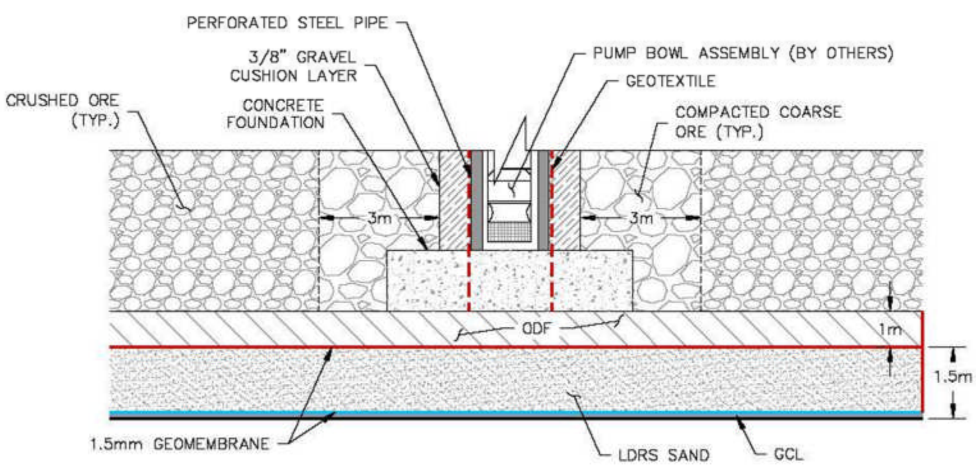
If it is determined during normal operations that the amount of fluid pumped out of the LCRS exceeds AL2, the owner or operator should implement a contingency plan for the facility.

5.2 Leakage through the Secondary Liner of the In-Heap Pond

This section evaluates the TPL through the bottom liner of the proposed In-Heap Pond.

The In-Heap Pond sump is located in the bottom liner system with the configuration shown in Illustration 4 consisting of a 1.5 mm double side textured LLDPE geomembrane over a GCL.

Illustration 4 In-Heap Pond Liner Detail



The TPL through the bottom liner of the sump was estimated using Giroud's Equation (Giroud, 1997) assuming that the sump contains one (1) small hole and the fluid on the bottom liner is contained within the sump with an average hydraulic head of 1.5 meters. This scenario assumes that the leachate efficiently drains to the sump, is efficiently pumped out of the sump, and is not hydraulically connected to the leachate fluid above the top geomembrane.

Table 3 presents the calculations used to determine the PLR through the bottom liner of the sump.

Table 3 PLR through the Bottom of the Evaporation Pond Sump using a GCL

C_{qo} =	0.21	(dimensionless)
h =	1.50	(m)
d =	0.002	(m)
t_s =	0.006	(m)
k_s =	5.0E-11	(m/sec)
Q =	4.05E-08	PLR (m^3/s/defect)

The calculations yielded a PLR of Q = 4.05E-8 m^3/s/defect. This can be converted to liters per day (Lpd) per defect as follows:

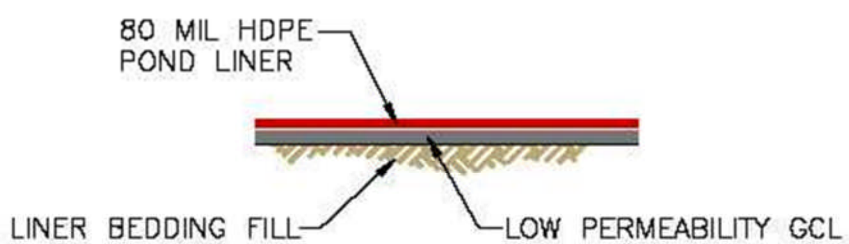
$$\frac{4.05E-8m^3/s}{defect} x \frac{1000Liters}{m^3} x \frac{60s}{\min} x \frac{60\min}{hr} x \frac{24hr}{day} = \frac{3.50Lpd}{defect} x1defect = 3.50Lpd$$

The calculations indicate that the In-Heap Pond sump could potentially discharge 3.5 Lpd. Leakage from the bottom liner of the In-Heap Pond above the sump is expected to be negligible provided the LCRS is functioning properly, resulting in negligible hydraulic head over the bottom liner.

6.0 Event Ponds

The following section evaluates the TPL through the liner systems of Event Ponds 1 and 2, as shown in Illustration 5, consisting of a GCL overlain by 2.0 mm (80-mil) HDPE geomembrane.

Illustration 5 Event Ponds Liner Detail



The TPL through the event pond liners was estimated using Giroud's Equation (Giroud, 1997) assuming the TPL assumes that the liner systems will contain one (1) defect per 4047 m^2 that is two (2) mm in diameter. Each event pond has a depth of ten (10) meters; therefore, Table 4 presents the PLR calculations for both ponds.

Table 4 PLR through the Event Ponds using a GCL

C_{qo} =	0.21	(dimensionless)
h =	10	(m)
d =	0.002	(m)
t_s =	0.006	(m)
k_s =	5.0E-11	(m/sec)
Q =	1.30E-06	PLR (m^3/s/defect)

The calculations yielded a PLR of Q = 1.30E-06 m^3/s/defect. This can be converted to liters per day (Lpd) per defect as follows:

$$\frac{1.30E-06m^3/s}{defect}x\frac{1000Liters}{m^3}x\frac{60s}{\min}x\frac{60\min}{hr}x\frac{24hr}{day}=\frac{112.32Lpd}{defect}$$

To establish the TPL, the PLR is multiplied by the defect rate and the LSA for each pond.

Event Pond 1:

$$TPL=\frac{112.32Lpd}{defect}x\frac{1defect}{4,046.86m^2}\times 17,904m^2=496.9Lpd$$

Event Pond 2:

$$TPL=\frac{112.24Lpd}{defect}x\frac{1defect}{4046.86m^2}\times 17,550m^2=487.1Lpd$$

Event Ponds 1 and 2 potentially discharge 497 Lpd and 487 Lpd respectively.

7.0 Regulatory Guidance

The liner systems described herein for the Heap Leach Pads, In-Heap Pond and Event Ponds at the Project were designed using the prescriptive design criteria developed by the Arizona Department of Environmental Quality (ADEQ) in the Best Available Demonstrated Control Technology (BADCT) Guidance Manual (ADEQ, 2004).

The Prescriptive BADCT design criteria for heap leach pads liner systems consist of a single geomembrane, at least 30-mil thick (or 60-mil for HDPE), over a minimum of twelve (12) inches of minus 3/8 inch native or natural material compacted to achieve a saturated hydraulic conductivity no greater than $1x10^{-6}$ cm/s.

The Prescriptive BADCT design criteria for process solution pond liner systems include a double liner system and an LCRS between the two (2) liners. The lower liner will be a composite liner consisting of a single geomembrane, at least 30 mil thick (or 60-mil for HDPE), over a minimum six (6) inches of minus 3/8 inch native or natural material compacted to achieve a saturated hydraulic conductivity no greater than $1x10^{-6}$ cm/s. The upper liner will be a single geomembrane, at least 30 mil thick (or 60-mil for HDPE) underlain by an LCRS.

The LCRS consists of a drainage layer of sand, gravel, geonet or other permeable material. The LCRS should be designed to result in minimal hydraulic head on the lower liner and provide for the removal of liquids between the upper and lower liners. The drainage layer media must achieve a flow capacity equivalent to a one (1) foot thick layer with a three (3) percent slope and hydraulic conductivity of $1x10^{-2}$ cm/s or greater. The LCRS should be equipped with a dedicated, automatic, fluid-level activated pump capable of pumping the necessary flow rate in order to maintain minimal head on the bottom liner.

The Prescriptive BADCT design criteria for non-storm water ponds liner systems include a single geomembrane, at least 30-mil thick (or 60-mil for HDPE), over a minimum of six (6) inches of minus 3/8 inch native or natural material compacted to 95% of the maximum dry density as determined by ASTM D 698.

8.0 Summary

This Technical Memorandum estimates of the total potential leakage (TPL) through various components of the proposed liner systems of the Heap Leach Facility for the Eagle Gold Project.

- Active Leach Area TPL = 164 Lpd;
- Phase 1 Heap Leach Pad: TPL = 122 Lpd;
- Phase 2 Heap Leach Pad: TPL = 301 Lpd;
- Phase 3 Heap Leach Pad: TPL = 85 Lpd;
- In-Heap Pond Sump: TPL = 3.5 Lpd;
- Event Pond 1: TPL = 497 Lpd;
- Event Pond 2: TPL = 487 Lpd; and
- Entire Heap Leach Facility: TPL = 1495.5 Lpd*.

* Entire Leach Pad will not be under leach at any given time.

Additionally, this Technical Memorandum provides Alert Levels to indicate potential malfunction of the In-Heap Pond primary liners.

- AL1 ranges from 925 Lpd to 571,291 Lpd; and
- AL2 ranges from 14,066 Lpd to 3,386,029 Lpd.

9.0 References

Arizona Department of Environmental Quality (ADEQ) (2004). Arizona Mining Best Available Demonstrated Control Technology (BADCT) Guidance Manual. Publication # TB-04-01.

Cetco Lining Technologies (2009). Claymax, Benomat, Properties, Panel and Roll Specifications: http://www.cetco.com/LT/GCL.aspx, Visited January 13, 2009.

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Giroud, J.P. (1997) Equations for Calculating the Rate of Liquid Migration Though Composite Liners Due to Geomembrane Defects. *Geosynthetics International 1997, vol. 4, nos 3-4*. pp. 335-348.

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ATTACHEMENT A

IN-HEAP POND
AL1 & AL2
ONE (1) METER INCREMENTS

Table A1 AL1 and AL2 for the In-Heap Pond

Elevation	Depth (Meters)	Area (m^2)	AL1 (Lpd)	AL2 (Lpd)	Pump Capacity (Lpd)
850	0	1,056.24	--		--
851	1	4,738.19	925	14,066	21,098
852	2	9,397.83	2,836	38,033	57,050
853	3	15,328.82	6,091	75,019	112,529
854	4	22,503.36	10,968	126,533	189,800
855	5	38,575.42	22,105	241,414	362,121
856	6	41,169.12	27,074	282,871	424,306
857	7	43,839.58	32,442	326,027	489,040
858	8	46,586.73	38,232	371,094	556,641
859	9	49,410.57	44,464	418,226	627,339
860	10	52,311.09	51,156	467,541	701,311
861	11	55,313.72	58,354	519,371	779,057
862	12	58,403.70	66,061	573,688	860,532
863	13	61,581.05	74,297	630,574	945,861
864	14	64,846.54	83,082	690,113	1,035,169
865	15	68,197.83	92,429	752,349	1,128,523
866	16	71,568.12	102,261	816,587	1,224,880
867	17	75,031.01	112,692	883,674	1,325,511
868	18	78,586.47	123,738	953,676	1,430,513
869	19	82,234.53	135,420	1,026,655	1,539,983
870	20	85,975.17	147,754	1,102,672	1,654,008
871	21	89,810.77	160,764	1,181,816	1,772,725
872	22	93,728.77	174,445	1,263,978	1,895,967
873	23	97,720.13	188,796	1,349,078	2,023,617
874	24	101,783.00	203,826	1,437,126	2,155,689
875	25	105,918.84	219,552	1,528,177	2,292,266
876	26	109,749.78	235,180	1,616,719	2,425,079
877	27	113,636.79	251,422	1,707,853	2,561,780
878	28	117,580.75	268,350	1,801,617	2,702,425
879	29	121,580.35	285,911	1,898,014	2,847,021
880	30	125,635.81	305,138	1,997,072	2,995,608
881	31	129,695.04	322,910	2,097,974	3,146,961
882	32	133,802.01	342,340	2,201,421	3,302,132
883	33	137,957.84	362,440	2,307,449	3,461,174
884	34	142,162.46	383,218	2,416,074	3,624,111
885	35	146,784.74	405,702	2,533,663	3,800,495
886	36	152,066.10	430,660	2,664,745	3,997,118
887	37	157,424.23	456,537	2,799,483	4,199,224
888	38	162,975.38	483,693	2,939,998	4,409,997
889	39	168,653.13	511,964	3,085,197	4,627,796
890	40	174,488.42	541,470	3,235,721	4,853,582
891	41	180,181.02	571,291	3,386,029	5,079,043