TETRA TECH

Technical Memorandum

To: File

Cc: Troy Meyer (Tetra Tech)

From: Joel Carrasco

Project #: 114-320807-5.3

Subject: **Rosemont Heap Leach Drain Line Design**

Date: May 4, 2009

1.0 Introduction

This technical memorandum presents the leach pad drain pipe sizing results for the Phase 1 and Phase 2 Heap Leach Pads at the Rosemont Copper Project. The proposed leach pad phases will contain a piping network to accommodate a 100-year, 24-hour storm event in addition to flows from leaching activities. Drain pipe sizing calculations are provided in Attachment A. Drawings of the Heap Leach Facility, including the proposed piping network, are included in the Heap Leach Facility Permit Design Report (Tetra Tech, 2009a). The drain pipes are located within the free draining overliner drain fill material above the pad liner.

The Heap Leach Facility was designed to meet or exceed the Prescriptive Best Available Demonstrated Control Technology (BADCT) described in the Arizona Department of Environmental Quality (ADEQ) Arizona Mining BADCT Manual (ADEQ, 2004). Under the prescriptive BADCT criteria, engineering equivalents to specific elements are deemed acceptable as long as supporting evidence is provided to ADEQ.

2.0 Pad Drain Pipe Sizing Design

2.1 General

Phase 1 and Phase 2 of the Heap Leach Pad are designed to contain a network of pipes that will be distributed throughout the limits of the Heap Leach Pad and that will collect and convey pregnant leach solution (PLS) in addition to stormwater. The pipe network was designed to accommodate stormwater from a 100-year, 24-hour storm event in addition to 150% of the design capacity of the anticipated PLS solution flow (150% PLS flow + 100 year, 24 hour storm event).

2.2 Assumptions

The following parameters were used in the calculations for the Heap Leach Pad drain pipe design. These parameters were based on design criteria provided in the Rosemont Copper Heap Leach Facility Design Criteria (Tetra Tech, 2009b) and standard engineering practice.

- The leach solution application flow rate was estimated to be 0.0040 gpm/ft^2, with an active application surface area of 1,000,000 ft^2.
- Total flow capacity to be accounted for in the pad drain system by taking the design storm event plus 1.5 times the application flow rate (0.0060 gmp/ft^2). The 100-year, 24-hour storm precipitation is 4.75 inches (NOAA, 2008).
- Manning's "n" of 0.014 was selected for the N-12 perforated pipes to account for the manufactured perforations and wear over time.
- Flow conditions assumed pipes were 85% full for maximum conveyance under gravity.
- The drain system design requirement assumed no moisture absorption and retention losses in the ore material.

2.3 Overliner Drain Fill

The design criteria specified an overliner drain fill permeability to be equivalent to 1 x 10^{-2} cm/sec or greater under a 300 ft maximum ore heap load to ensure reasonable spacing of the drain pipes and to ensure fully drained heap conditions. The overliner drain fill thickness used was a minimum thickness of three (3) feet (loose lift) placed above the pad liner surface.

The overliner drain fill will be produced from the crushing of relatively clean ore materials. Some screening may be required to produce a free draining, non-plastic overliner drain fill material with a minus 1.5 inch maximum rock size, less than 20 percent passing the No. 4 ASTM sieve size, and less than 5 percent fines passing the No. 200 ASTM sieve size. The pad liner system requires complete coverage with overliner drain fill as soon as practical to avoid any potential wind or construction related damage.

2.4 Pad Drain Pipe

The pipe network to be constructed consists of a series of four (4) inch drain pipes arranged in a herringbone pattern that will collect and convey the fluid, i.e., PLS and stormwater flows, toward the center of the Heap Leach Pad. The four (4) inch drain pipes will be connected to a series of eight (8) inch primary pipes and 12 inch collector pipes. The 12 inch collector pipes will transmit fluid to 18 inch header pipes located at the toe of the Phase 1 and Phase 2 pads.

The 18 inch header pipes from the Phase 1 Pad will discharge fluids directly into the PLS Pond. The 18 inch header pipes from the Phase 2 Pad will connect to two (2) 18 inch HDPE solution pipes located in the collection ditch adjacent to the north of the Phase 1 pad. Solution from Phase 2 will be contained within the header pipes during normal operation. During storm events, fluid may be conveyed in the lined collection ditch to the PLS Pond and Stormwater Pond.

The heap leach pad drain pipes will consist of 4, 8, 12, and 18 inch diameter corrugated, dual wall, perforated ADS N-12 pipes. Each phase (Phase 1 and Phase 2) will contain two (2) 18 inch header pipes with a minimum grade of 3.0% sloped toward the PLS Pond where the fluid will be collected. Each phase was divided into two (2) areas for design purposes, Phase 1 North and South and Phase 2 North and South areas (see Figure 01).

3.0 Drain Sizing Calculations

1) Phase 1 was divided into two (2) areas using the natural ridgeline, North and South. Each of these two (2) areas were divided into an upper section and a lower section based on slope. Phase 2 was divided using the same procedure. Pad sizes for each area and minimum design pipe slopes are summarized in Table 3.1.

Table 3.1 – Pad Sizing Estimates

Phase	Location	Total Area (ft^2)	Minimum Design Slope (ft/ft)	Average Pipe Length (ft)
Phase 1 North	Upper	2,051,839	0.03	1800
	Lower			650
Phase 1 South	Upper	2,318,321	0.03	1400
	Lower			800
Phase 2 North	Upper	2,552,507	0.03	1525
	Lower			1095
Phase 2 South	Upper	1,658,770	0.03	950
	Lower			1275

2) Primary and collector pipe capacities were calculated using Manning's equation shown below (Chow, 1959). Pipe design slopes were obtained from design contours within the Heap Leach Pad limits.

$\mathbf{Q = (1.486/n) \times A \times (R)^{2/3} \times (S)^{1/2}}$ where:

Q = discharge (cfs)

n = Manning's roughness coefficient

A = cross sectional area of the pipe (ft^2)

$\mathbf{(R)^{2/3}}$ = hydraulic radius at 85% capacity

$\mathbf{(S)^{1/2}}$ = pipe slope (ft/ft)

3) The total flow for each area of Phase 1 and Phase 2 was calculated using 150% of the design PLS flow + stormwater generated from a 100-year, 24-hour event. The eight (8) inch primary pipes are located in the upper areas in each of the Phases. The 12 inch

collector pipes are located in the lower areas of the pad where the slopes are less steep. The total flows for each area are summarized in Table 3.2.

Table 3.2 – Summary of Total Flow

Phase	Location	Total Flow for 8" ø primary pipes (gpm)	Total Flow for 12" ø collector pipes (gpm)	Total Flow for 18" ø header pipes (gpm)
Phase 1 North	Upper	7,761	8,246	12,843
Phase 1 South	Upper	8,407	9,096	
Phase 2 North	Upper	8,515	9,450	12,825
Phase 2 South	Upper	6,785	7,875	

4) Drain pipe spacing was determined by the equation below for estimating the peak hydraulic head on the pad liner system between drain pipes (McWhorter and Sunada 1977).

$H = (L/2) \times (W / K)^{0.5}$ where:

H = maximum mid-point hydraulic head on liner (5 feet for a 2 feet overall head)

L = drain pipe spacing (to be determined)

W = application rate of 0.006 gpm/ft^2 (150% PLS)

K = hydraulic conductivity (permeability) of pad drain material (1 x 10^{-2} cm/sec)

4.0 Summary

The Heap Leach Pad drain pipe design has been designed to provide engineering equivalence to the prescriptive BADCT standards. The supporting evidence of engineering equivalents are documented herein (Section 3.0). Calculations are provided in Attachment A.

The results summarized in Table 4.1 are the minimum quantities of pipes needed to satisfy the design for each phase of the Heap Leach Pad.

Table 4.1 – Summary of Pipe Quantities

Phase	Quantity of 8" ø primary pipes	Quantity of 12" ø collector pipes	Quantity of 18" ø collector pipes
Phase 1 North	6	4	2
Phase 1 South	6	4	
Phase 2 North	7	4	2
Phase 2 South	5	4	

Prescriptive BADCT criteria for Heap Leach Pads specifies that the hydraulic head over a liner should be less than two (2) feet and no more than five (5) in order to drain the ore and minimize the potential for leakage through the pad liner system. Calculating the hydraulic head using the assumed values in Section 3.0 indicate that for an average overall head of two (2) feet on the liner, the four (4) inch drain pipe minimum spacing of 50 feet is required.

5.0 References

Arizona Department of Environmental Quality (2004). *Arizona Mining BADCT Guidance Manual, Aquifer Protection Program*. Publication TB-04-01. Phoenix, AZ: ADEQ.

Chow, V.T. *Open-Channel Hydraulics*, McGraw Hill, New York, 1959.

McWhorter, David B. & Sunada, Daniel K. *Ground-water Hydrology and Hydraulics*. Water Resources Publication, 1977.

NOAA Atlas 14 Vol. 1 Version 4- Precipitation-Frequency Atlas of the United States (NOAA, 2008); http://hdsc.nws.noaa.gov/hdsc/pfds/sa/az_pfds.html

Tetra Tech, (2009a) Rosemont Copper Heap Leach Facility Permit Design Report. Dated May 2009.

Tetra Tech, (2009b) Rosemont Copper Heap Leach Facility Design Criteria. Technical Memorandum dated May 4, 2009.

ATTACHMENT A

TETRA TECH

Client:	Rosemont Copper Company	Job No.:	114-320807
Subject:	Heap Leach Facility	By:	JAC
Details:	Pad Pipe Sizing	Date:	April 10, 2009

Slotted ADS Pipe

Mannings n: 0.014

Pipe Slope (m/m): 0.050

Pipe Inside Diameter (mm)	Flow (m^3/s)	Flow Depth (mm)	Flow Velocity (m/s)
75	0.005	65	1.28
100	0.011	85	1.55

Slotted ADS Pipe

Mannings n: 0.014

Pipe Slope (m/m): 0.100

Pipe Diameter (mm)	Flow (m^3/s)	Flow Depth (mm)	Flow Velocity (m/s)
75	0.007	65	1.81
100	0.016	85	2.20

Slotted ADS N12 Pipe

Mannings n: 0.014

Pipe Slope (m/m): 0.080

Pipe Diameter (mm)	Flow (m^3/s)	Flow Depth (mm)	Flow Velocity (m/s)
100	0.014	85	1.97
150	0.041	128	2.57
200	0.089	170	3.12
250	0.161	213	3.62
300	0.262	255	4.09
375	0.475	319	4.74
450	0.772	383	5.35
600	1.662	510	6.49
760	3.121	646	7.60

Mannings n: 0.014

Pipe Slope (m/m): 0.030

Pipe Diameter (mm)	Flow (m^3/s)	Flow Depth (mm)	Flow Velocity (m/s)
100	0.009	85	1.20
150	0.025	128	1.58
200	0.054	170	1.91
250	0.099	213	2.22
300	0.160	255	2.50
375	0.291	319	2.90
450	0.473	383	3.28
600	1.018	510	3.97
760	1.911	646	4.65

Mannings n: 0.014

Pipe Slope (m/m): 0.020

Pipe Diameter (mm)	Flow (m^3/s)	Flow Depth (mm)	Flow Velocity (m/s)
450	0.386	383	2.68

TETRA TECH

Client:	Rosemont Copper Company	Job No.:	114-320807
Subject:	Heap Leach Facility	By:	JAC
Details:	Pad Pipe Sizing	Date:	April 10, 2009

Avg. Solution Outflow Rate (m^3/hr): 681.4 3,000 gpm (From Design Criteria)
100-Year 24-Hour Precipitation (m): 0.121 4.75 inches (From NOAA Atlas 14)

	Total Area (m^2)	Total Area (ft^2)	Primary Pipe Design Slope (m/m)
Phase 1 - North Upper:	147,328	1,585,824	0.080
Phase 1 - South Upper:	176,521	1,900,057	
Total Phase 1:	**323,849**	**3,485,881**	
Phase 2 - North Upper:	181,403	1,952,603	0.080
Phase 2 - South Upper:	103,232	1,111,177	
Total Phase 2:	**284,634**	**3,063,780**	
Total Pad Upper Area:	**608,483**	**6,549,661**	

Primary Pipes

150% PLS Solution + 100-Year Storm Flow

Area	PLS Flow (m^3/hr)	Storm Flow (m^3/hr)	Total Flow (m^3/hr)	Total Flow (gpm)	No. Pipes	Pipe Diameter (mm)
Phase 1 - North Upper	1,022	741	1763	7761	6	200
Phase 1 - South Upper	1,022	887	1909	8407	6	200
Phase 2 - North Upper	1,022	912	1934	8515	7	200
Phase 2 - South Upper	1,022	519	1541	6785	5	200

Check Pipe Capacity **Secondary Pipes**

Calculated Pipe Spacing = 15 m (based on McWhorter equation)
Controlling Design Pipe Slope = 0.10 m/m

150% PLS Solution + 100-Year Storm Flow

Phase	PLS Flow (m^3/hr)	Storm Flow (m^3/hr)	Total Flow (m^3/hr)	Total Flow (gpm)	No. Pipes	Pipe Diameter (mm)
Phase 1 - North Upper	1,022	741	1763	7761	31	100
Phase 1 - South Upper	1,022	887	1909	8407	33	100
Phase 2 - North Upper	1,022	912	1934	8515	34	100
Phase 2 - South Upper	1,022	519	1541	6785	27	100

15m spacing ok for capacity

TETRA TECH

Client:	Rosemont Copper Company	Job No.:	114-320807
Subject:	Heap Leach Facility	By:	JAC
Details:	Pad Pipe Sizing	Date:	April 10, 2009

Avg. Solution Outflow Rate (m^3/hr): 681.4 3,000 gpm (From Design Criteria)
100-Year 24-Hour Precipitation (m): 0.121 4.75 inches (From NOAA Atlas 14)

	Total Area (m^2)	Total Area (ft^2)	Collector Pipe Design Slope (m/m)	Header Pipe Design Slope (m/m)
Phase 1 - North:	169,254	1,821,836	0.030	0.030
Phase 1 - South:	207,666	2,235,299		
Total Phase 1:	**376,920**	**4,057,135**		
Phase 2 - North:	223,628	2,407,107	0.030	0.030
Phase 2 - South:	152,506	1,641,557		
Total Phase 2:	**376,133**	**4,048,664**		
Total Pad Area:	**753,053**	**8,105,799**		

Header Pipes

150% PLS Solution + 100-Year Storm Flow

Area	PLS Flow (m^3/hr)	Storm Flow (m^3/hr)	Total Flow (m^3/hr)	Total Flow (gpm)	No. Pipes	Pipe Diameter (mm)
Phase 1	1,022	1895	2917	12843	2	450
Phase 2	1,022	1891	2913	12825	2	450

Collector Pipes

150% PLS Solution + 100-Year Storm Flow

Area	PLS Flow (m^3/hr)	Storm Flow (m^3/hr)	Total Flow (m^3/hr)	Total Flow (gpm)	No. Pipes	Pipe Diameter (mm)
Phase 1 - North	1,022	851	1873	8246	4	300
Phase 1 - South	1,022	1044	2066	9096	4	300
Phase 2 - North	1,022	1124	2146	9450	4	300
Phase 2 - South	1,022	767	1789	7875	4	300

TETRA TECH

CLIENT:	Rosemont Copper Company		
PROJECT:	Heap Leach Facility	JOB NO:	114-320807
SUBJECT:	Pad Pipe Sizing	BY:	JAC
DETAILS	Pipe Spacing - McWhorter & Sunada, 1977	Date:	April 10, 2009

Pipe Spacing		
Units:	English	
Application Rate:	12.43	ft^3/day/ft^2
Maximum Desired Head on the Liner:	5.0	ft
Hydraulic Conductivity:	28.35	ft/day
		0.0
Pipe Spacing:	49.5	ft
Average Hydraulic Head on Liner:	2.0	ft

Application Rate Converter		
Application Rate:	0.0060	gpm/ft^2
	14.6690	l/hr/m^2
	0.0147	m^3/hr/m^2
	0.35	m^3/day/m^2
	12.43	ft^3/day/ft^2

Hydraulic Conductivity Converter		
Hydraulic Conductivity	0.0100	cm/s
	28.35	ft/day
	8.64	m/day

$$H = \frac{L}{2} * \left(\frac{W}{K} \right)^{0.5}$$

Where:

H = Maximum Hydraulic Head on Liner at Midpoint between Pipes

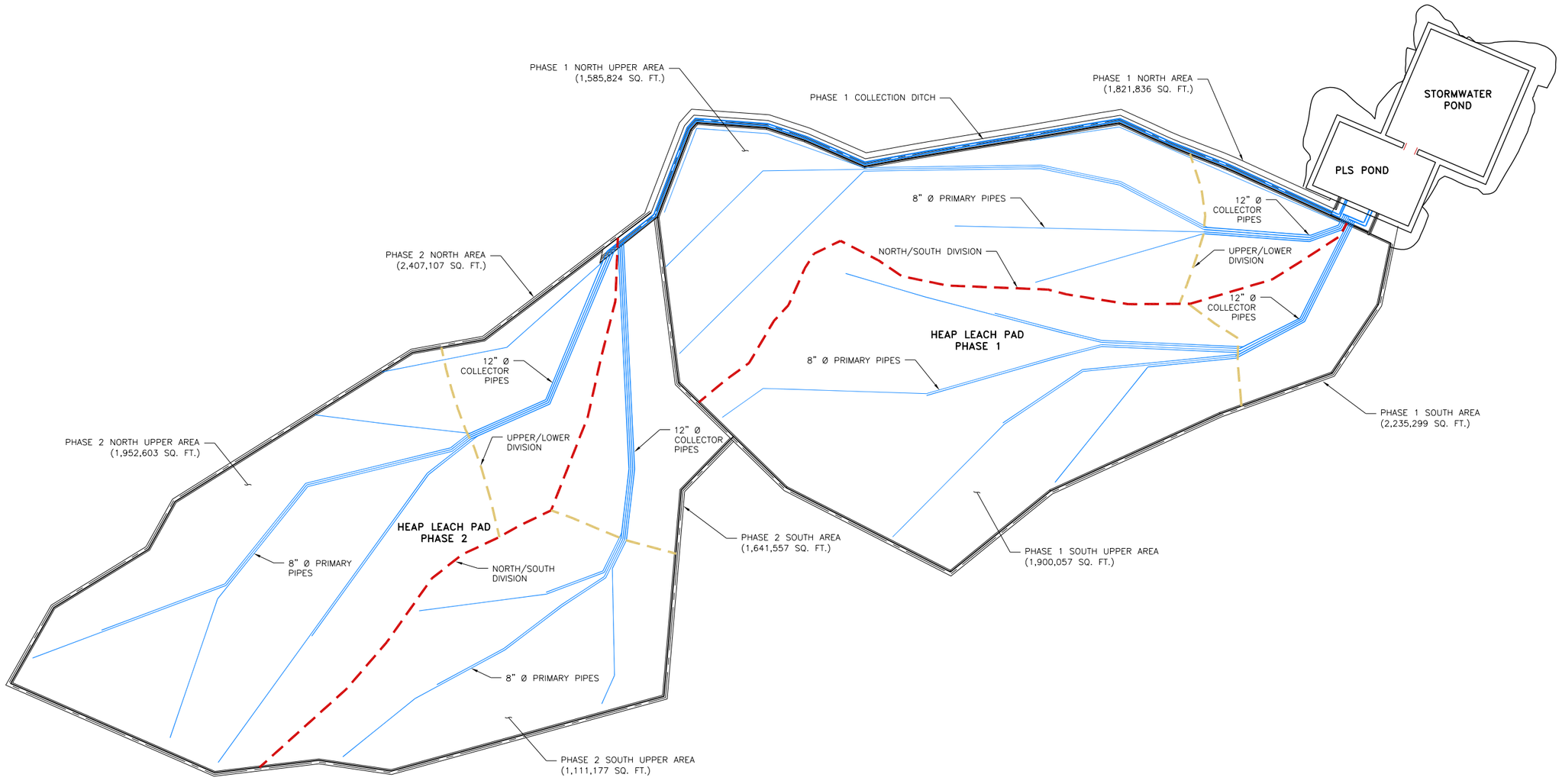
L = Drain Pipe Spacing

W = Application Rate

K = Hydraulic Conductivity

1) Permeability in drain layer of 1 x 10^{-2} cm/s for a fully loaded scenario with lift height at 300 feet (Design Criteria)

FIGURE



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HEAP LEACH PAD DRAIN PIPE LAYOUT

A REVISION

Project:	Project no.:	Figure no.:
ROSEMONT COPPER	320807	01
Location: PIMA COUNTY, ARIZONA	Date: 05/09	